# Monetary sterilization and dual nominal anchors: some Caribbean examples

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**Abstract**

This paper notes that a high sterilization coefficient plus a *de facto* pegged exchange rate indicates the existence of dual nominal anchors. The econometric evidence presented shows that several Caribbean economies with fixed exchange rate regimes also possess high sterilization coefficients. Given open capital accounts in the various economies, the paper argues that this finding contravenes the money neutrality thesis, which holds that only one nominal anchor can prevail in the long-term. The paper presents a simple theoretical model to explain this phenomenon. The model combines the liquidity preference of commercial banks with an augmented uncovered interest parity equation.

**Key words**: sterilization coefficient, dual nominal anchors, foreign exchange regime

## 1. Introduction

The purpose of this study is twofold. Firstly, it estimates the sterilization coefficients for several Caribbean countries. This has not been done except for a recent paper by Jara and Tovar (2008). However, above mentioned paper reports a single index of sterilization for the entire Caribbean in order to facilitate comparison with Latin America. Our study would therefore extend the literature by providing estimates of the sterilization coefficients for countries in the Caribbean Region. The findings may also be of interest to academics and practitioners since the magnitude of the sterilization coefficient encodes information on the central bank's monetary policy stance. For instance, a coefficient of -1 implies all foreign exchange market interventions are neutralized by the central bank. In this case, the central bank is keen to maintain a monetary target. On the other hand, a sterilization coefficient of 0 implies all changes in the central bank's net foreign reserves are reflected in the monetary base. Thus, a foreign exchange target would tend to be the monetary objective.

Secondly, the study will also contribute to the literature by providing a conceptual framework for understanding why regional economies with fully pegged exchange rate regimes have not allowed the money supply to be endogenous to capital flows[1]. Specifically it would offer a possible explanation as to why some Caribbean economies were able to pursue two nominal anchors in spite of theoretical consensus. According to the literature, mini-states (like those in the Caribbean) would not be able to pursue an independent monetary policy in light of capital flows (Khatkhate and Short, 1980). Obstfeld and Rogoff (1995) also noted the tendency for capital flows to complicate monetary policy. Moreover, they noted that in a fixed exchange rate regime economy with perfect capital mobility the domestic money supply becomes passive or endogenous. Yet the estimated sterilization coefficients portray evidence of active sterilization (acts to insulate the monetary base from the effects of foreign exchange market interventions) by the central banks in economies with fixed exchange rate regimes[2]. This is indicative of the existence of dual nominal anchors, which contravenes the money neutrality thesis in an open economy setting[3]. Two simultaneous conditions must be present in order for dual

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[1] Data on capital flows are provided in Appendix 1 (Tables A2, A3 and A4); Jara and Tovar (2008) also provided a rich set of data for the Caribbean and Latin America.

[2] It should be noted that Boamah *et al* (2005) noted the complete liberalization of the capital account for Guyana, Jamaica and Trinidad and Tobago. Worrell *et al* (2008) noted that there are no controls on capital inflows into Barbados and the regulation on outflows is "more liberal in practice than is intended to be, because of the fungibility of finance."

[3] For an excellent explanation of the money neutrality thesis in an open economy context in which exchange rate policy matters see Montiel (2003, chapter 17). Montiel emphasized that money neutrality holds regardless of the degree of capital mobility.

anchors to exist: (i) there must be a high sterilization coefficient; and (ii) the country must have at least a *de facto* pegged exchange rate. We use the IMF's classification of exchange rate regimes in order to establish the existence of a *de facto* pegged rate. The two conditions, moreover, must hold in a regime of capital account liberalization.

In order to explain the existence of long-term dual anchors, this paper submits the thesis of oligopolistic interest rate formation by private commercial banks, the dominant financial institutions in the Caribbean. The thesis holds that private oligopolistic banks mark-up interest rate above a foreign benchmark interest rate – thus preventing the central bank's monetary policy actions from engendering offsetting capital movements as predicted by the uncovered interest parity (UIP) theory and the IS-LM-BP model. The model combines the mark-up interest rate and an aggregate bank liquidity preference curve (given the stylized facts). At the mark-up interest rate the liquidity preference curve is horizontal. This allows us to model the aggregate liquidity demand function as a reciprocal equation, which when combined with an augmented UIP (with a mark-up term) enables us to analyze the effect of monetary policy on the exchange rate.

The sterilization coefficient is estimated for each of the following countries: the Bahamas, Barbados, Belize, Guyana, Jamaica, Suriname and Trinidad and Tobago and the Eastern Caribbean Currency Union (ECCU), which comprise of Antigua and Barbuda, Anguilla, Dominica, Grenada, Montserrat, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines[4]. These economies are all members of the Caribbean Single Market and Economy (CSME).

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[4] There is a large literature which focuses on the effectiveness of sterilization in light of the pursuit of an independent monetary policy in a world of rapid capital flows. See for instance Obstfeld (1982), Frankel (1997), Sarno and Taylor (2001), Disyatat and Galati (2005) and Mohanty and Turner (2005).

The rest of the paper is organized as follows. Section 2 presents background data that are essential to the analysis in later sections. Section 3 describes the econometric methodology. Section 4 presents the empirical findings. Section 5 outlines the analytical framework and section 6 concludes.

**2. Background Information**

The central bank's balance sheet constraint necessitates that[5] $NDA + NFA = RM$ (where $RM$ = reserve money or the monetary base). Thus a change in net domestic assets (*NDA*) or net foreign assets (*NFA*) would be reflected as a change in *RM*. Therefore, given a constant money multiplier (the money multiplier is simply broad money divided by *RM*) this change will be reflected in a change in the level of money (M1 and M2)[6]. Therefore, if the central bank wants to maintain a monetary target it must intervene in the domestic money market to neutralize any changes in *NFA* owing to prior foreign exchange market interventions. In other words, when the central bank accumulates foreign assets it must first purchase the foreign currencies by using the domestic currency.

When $\Delta NFA > 0$ the monetary base would increase; the central bank could then sell domestic assets (its own sterilization bonds or government Treasury bills) from its stock of domestic assets (or *NDA*). When the $\Delta NDA$ is exactly equal to the $\Delta NFA$ there is complete neutralization or sterilization, and the $\Delta NFA$ has no effect on the monetary base. In this case the sterilization coefficient is equal to -1. A coefficient of 0 implies the changes in international reserves are completely reflected in the money supply; while a

[5] Assume net worth = 0 for simplicity.

[6] The direction of causation could be reversed in the case of endogenous money (Goodhart, 2009).

value between 0 and -1 signals partial sterilization. Should the central bank be concerned with only an exchange rate target, its reaction function should possess a low sterilization coefficient. However, should the central bank have both an exchange rate and a money supply (or policy interest rate) target it would maintain high sterilization activities, which will show up as a high absolute coefficient value. Therefore, for dual anchors to exist there must be a high sterilization coefficient and a *de facto* exchange rate peg.

Table 1, presenting the IMF (2006) classification of exchange rate regimes, shows that each country maintains a *de facto* pegged exchange rate. Jamaica is classified as a managed float. Interestingly, however, Guyana's nominal exchange rate (G$/US$) has demonstrated noticeable changes since 1993, whereby the rate has tended to depreciate more than appreciate. The IMF, nevertheless, classifies Guyana's exchange rate as a fixed peg. The likely reason for this has to do with the remarkable stabilization of the rate since 2004 (relative to the earlier period 1993 to 2003). In 2004 the largest state owned commercial bank was privatized and merged with another large private commercial bank, thus forming the largest commercial bank and institutional foreign exchange trader. Therefore, it could be that the seemingly 'fixed peg' is due to trader market power since a few commercial banks are the dominant foreign exchange market dealers in Guyana[7].

Moreover, Guyana, Jamaica and Trinidad and Tobago are often seen in the Caribbean as economies with managed floats (Worrell, 2003). In addition, Worrell acknowledges that Trinidad and Tobago provides the Caribbean's example of the phenomenon known as "fear of floating." As a result, there is substantial intervention by

[7] This issue is beyond the scope of this paper and it is the subject of a separate research project.

the Central Bank of Trinidad and Tobago in the domestic foreign exchange market. Worrell further noted that the Bahamas, Barbados, Belize and the ECCU have acted as quasi-currency boards since the 1970s.

Table 1. *De facto* classification of exchange rate and monetary regimes

| | | Monetary policy framework | |
|---|---|---|---|
| | Exchange rate regime | Monetary aggregate target | Other monetary policy framework |
| The Bahamas | Fixed peg | _ | _ |
| Barbados | Fixed peg | _ | _ |
| Belize | Fixed peg | _ | _ |
| ECCU | Currency board - fixed peg | _ | X[1] |
| Guyana | Fixed peg[2] | X | _ |
| Jamaica | Managed float | X | _ |
| Suriname | Fixed peg | X | _ |
| Trinidad and Tobago | Fixed peg[3] | _ | _ |

[1] Grenada, a member of the ECCU, has an IMF supported monetary program
[2] Prior to 2004 the exchange rate demonstrated relatively more flexibility, although it tended to depreciate more than appreciate.

[3]Caribbean economists tend to recognize the Trinidad and Tobago and Guyana currency regimes as a managed float (Worrell, 2003).
Source: IMF (2006)

Table 2 shows that the eight Caribbean central banks have accumulated foreign exchange reserves over the period 1993 to second quarter 2008. This is consistent across all eight countries. Buoyed by high oil prices, Trinidad and Tobago has seen significant reserve accumulation. There has also been a substantial accumulation of foreign reserves in the Bahamas, Barbados, the ECCU and Jamaica. For the purpose of this article, however, we would like to know to what extent the increase in foreign reserves is allowed to be reflected in the monetary base. In other words, has each territory pursued an active policy to neutralize the monetary effects of foreign exchange reserve accumulation?

Table 2. Foreign exchange reserves minus gold (US$ millions) – selected years

| | 1993 | 1995 | 1997 | 2000 | 2002 | 2005 | 2008: Q2 |
|---|---|---|---|---|---|---|---|
| The Bahamas | 172.3 | 179.2 | 227 | 349.6 | 380.6 | 586.3 | 685.1 |
| Barbados | 150.4 | 219.1 | 264.9 | 472.7 | 668.5 | 603.4 | 888.6 |
| Belize | 38.7 | 37.6 | 59.4 | 122.9 | 114.5 | 71.4 | 138 |
| ECCU | 261.1 | 312.9 | 307.8 | 386.4 | 508.2 | 600 | 799.4 |
| Guyana | 247.4 | 268.9 | 315.8 | 304.9 | 284.4 | 251.9 | 381.4 |
| Jamaica | 417.1 | 681.3 | 682.1 | 1053.7 | 1645.1 | 2169.8 | 1917.5[a] |
| Suriname | 17.7 | 132.9 | 109.1 | 63 | 106.1 | 125.8 | 445.3 |
| Trinidad and Tobago | 206.3 | 358.2 | 706.4 | 1386.3 | 3168.2 | 4960.8 | 8776.3 |

[a] 2007: Q4
Source: IMF, *International Financial Statistics*

## 3. Methodology and Data Issues

When estimating the central bank's reaction function it is important to note that the potential exist for simultaneity bias if domestic monetary operations engender an "offset" of net foreign assets (Kouri and Porter, 1974). The hypothesized empirical reaction function, represented by a distributed lag model, is specified by equation 1, which is similar to the one used by previous authors (Aizenman and Glick, 2008; Siklos, 2000; Kouri and Porter, 1974). In an economy with developed capital and money markets and rapid capital flows, $\Delta NFA$ is likely to be endogenous and therefore correlated with the error term $\varepsilon_t$. In a developed financial market system, according to Kouri and Porter (1974) and Herring and Marston (1977), the $\Delta NDA$ leads to net offsetting portfolio changes in the international reserves position and the balance of payments (thus $\Delta NFA$). The $\Delta NFA$ is also likely to be endogenous when domestic and foreign assets are perfect substitutes or at least highly substitutable. However, this depends on the degree of capital account openness, the level of financial sophistication, and the risk profile of the economy under study.

$$\Delta NDA_t = \alpha_0 + \sum_{i=0}^{n} \beta_i \Delta NFA_{t-i} + \gamma' Z + \sum_{k=1}^{p} \theta_k \Delta NDA_{t-k} + \varepsilon_t \qquad (1)$$

Where $Z = \begin{pmatrix} p \\ g_S \\ D_i \end{pmatrix}$

The sterilization coefficient is denoted by $\beta_0$ which assume values ranging from 0 to -1. The vector $Z$ includes other exogenous variables in the reaction function to which the central bank reacts by varying *NDA*. The term $p$ represents the rate of inflation; while $g_S$ denotes the rate of growth of the nominal exchange rate[8]. $D_i$ denotes seasonal dummy variables. $\gamma$ is a row vector of coefficients. The coefficients on $p$ and $g_S$ are expected to be negative, signaling that the central bank contracts monetary policy when the inflation and/or nominal exchange rate increases. The study also examines whether the central banks respond to the inflation gap $p - p^*$; where $p^*$ represents the trend rate of inflation which is extracted using the Hodrick-Prescott filter. The coefficients on the quarterly dummies are expected to take positive or negative values.

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[8] The output gap is sometimes included in the reaction function (see Sarno and Taylor, 2001). Kouri and Porter (1974) include the change in aggregate output. However, we are unable to do so because quarterly GDP data are unavailable.

In view of potential simultaneity bias, several researchers have used two-stage least squares (2SLS) to estimate the sterilization coefficient and an offset coefficient, simultaneously, by inverting equation 1 to make $\Delta NFA$ the subject of the equation. This strategy was adopted by Cumby and Obstfeld (1984), Obstfeld (1982), and Brissimis, Gibson and Tsakalatos (2002). Recently, however, several authors have estimated the sterilization coefficient with OLS (see for instance Aizenman and Glick, 2008; Jara and Tovar, 2008; and Kwack, 2001), while others have estimated the coefficient using both 2SLS and OLS (see Siklos, 2000).

In this article it is not taken as given that $\Delta NFA$ is endogenous to domestic monetary policy. There are good reasons to believe that capital flows and thus $\Delta NFA$ are exogenous to domestic policy[9]. Firstly, domestic and foreign securities are not perfect substitutes. One study, Birchwood and Seerattan (2006), has confirmed the previous point. Birchwood and Seerattan found that uncovered interest parity (UIP) does not hold for three Caribbean economies – Guyana, Jamaica and Trinidad and Tobago – vis-à-vis the US dollar. This condition is unlikely to prevail when commercial banks mark-up domestic interest rates over a foreign rate. Secondly, domestic financial markets (both money and capital markets) are underdeveloped and as a result monetary policy is not likely to transmit into immediate rapid changes in short-term and long-term interest rates (Ramlogan, 2004).

Given the above we will test whether $\Delta NFA$ is indeed endogenous in the reaction function. In this regard, we follow a test outlined by Wooldridge (2009) to determine whether 2SLS is appropriate. The test involves estimating a reduced-form regression for

[9] Kwack (2001) also made the point that capital flows are exogenous to domestic monetary policy in the case of Korea.

$\Delta NFA$ and testing the null hypothesis that $\Delta NFA$ in not endogenous in this regression. The basic idea of the test holds that if $\Delta NFA$ is endogenous in equation 1, then $\hat{v}_t$ must be correlated with $\Delta NDA$. Thus, if we reject this hypothesis that $\Delta NDA$ is endogenous then 2SLS must be utilized.

We utilize a reduced-form equation, given by equation 2, similar to Huang (1995). This model can be estimated efficiently with OLS since it is a reduced-form model. The variable $r_D - r_F$ reflects the differential between domestic and foreign interest rates. It is also an ad hoc proxy of the opportunity cost of holding international reserves. The variable $\Delta X$ reflects the change in exports and it acts as the proxy for the scale variable in the absence of quarterly GDP data for each country under study. The error term ($v_t$) and its estimated values ($\hat{v}_t$) is inserted into equation 1 and the coefficient on this variable is tested using a t-test to determine whether the $\Delta NDA$ is endogenous.

$$\Delta NFA_t = b_0 + b_1(r_D - r_F)_t + b_2\Delta X_t + v_t \qquad (2)$$

The data series are sourced from the *International Financial Statistics* (IFS). Since we are applying a time series model, we tested for unit roots for $\Delta X$, $\Delta NFA$ and $\Delta NDA$, $p$ and $r_D - r_F$. The Augmented Dickey-Fuller test reveals that except for $r_D - r_F$ all the data series are I (0) at least at the 10 percent significance level (see Appendix 1). However, we wish to note that the unit root tests should not take precedence over the theoretical notion that interest rates have to be anchored at a long-term natural rate. It simply means the sample period is not long enough to reflect this anchoring. In addition, the article proposes a model which takes as given the notion of a theoretically stable relationship between the domestic and foreign interest rates. For each central bank, except for the ECCU and Suriname, the domestic interest rate is measured by the 3-month Treasury bill rate. Given the difficulty in obtaining the Treasury bill rate for Suriname, we use the domestic money market rate. For the same reason we employ the 3-month deposit rate for the ECCU (obtained from the *Annual Financial Statistical Yearbook*). In order to proxy the foreign interest rate for each country, the 3-month US Treasury bill rate is used.

The estimation for each economy, except Guyana, is done for the period 1993:Q1 to 2008:Q2. For Guyana the sample starts at 1994:Q1 owing to missing CPI data in the IFS electronic data set. This sample period is chosen to maximize observations and also capture the post 1990 period of financial openness and reform in the various territories. Following Aizenman and Glick (2008), $\Delta NDA$ and $\Delta NFA$ are scaled by $RM$. In addition, using the first difference of the two asset classes reduces the likelihood of spurious regression problem. As noted earlier, the distributed lag model is utilized to model the reaction function. Therefore, in order to select the parsimonious model Wald F-tests and t-tests were used to simplify a general model with four quarter lags of each variable, except the seasonal dummy variables. The Ramsey RESET specification test is also used – before variables were eliminated – to determine whether any independent variable should enter the model with cubic and quadratic terms. We test for heteroskedasticity and first and second order serial correlation using the Breusch-Godfrey LM and LM tests respectively. If heteroskedasticity is only found, the White heteroskedasticity-consistent standard errors are computed. If both heteroskedasticity and serial correlation are found then the Newey-West heteroskedaticity and autocorrelation consistent (HAC) standard errors are computed[10]. The final models are then selected once they satisfy the various diagnostic tests.

**4. Estimation Results**

Table 3 reports the estimated coefficient along with diagnostic tests for each economy. It is important to note that our t-test test shows no statistically significant correlation between the estimated errors of the reduced form equation 2 and $\Delta NDA$. Thus we continue the estimation exercise with OLS estimation rather than 2SLS.
The results indicate a noticeable variation in sterilization policy across the Caribbean. Three of the Caribbean's more successful fixed exchange rate regimes – the Bahamas (-0.62), Barbados (-0.83) and Belize (-0.83) – have pursued some form of consistent sterilization policy. Guyana appears to sterilize approximately 100% of capital flows. This amounts to the highest coefficient for the region. The lagged dependent variable is also statistically significant in the model for Guyana; however, this variable is not statistically significant for the other economies (for Trinidad and Tobago this variable is significant at the 7% level). Suriname has more of an intermediate strategy with a coefficient of -0.5. Trinidad and Tobago, classified by the IMF as a pegged exchange rate regime, sterilizes on average 70 % of capital inflows.

[10] See Verbeek (2004) for discussion of the technical details of White heteroskedasticity-consistent standard errors and the HAC standard errors.

Table 3. Estimation of the sterilization coefficients

| Country | Estimation results |
|---|---|
| **The Bahamas** | $\Delta NDA/RM = \underset{(p-val=0.662)}{0.003} - \underset{(p-val=0.000)}{0.62}\,\Delta NFA/RM + \underset{(p-val=0.032)}{0.05}\,D_4$<br>Endogeneity test for $\Delta NFA$: t-stat = -1.35 (p-val = 0.181)<br>Ramsey RESET: F-stat = 0.78 (p-val = 0.382)<br>Adj-$R^2$ = 0.71<br>Newey-West HAC standard errors were used because both error serial correlation and heteroskedasticity were found. |
| **Barbados** | $\Delta NDA/RM = \underset{(p-val=0.270)}{-0.01} - \underset{(p-val=0.000)}{0.83}\,\Delta NFA/RM - \underset{(p-val=0.033)}{0.75}\,p - p^{*} + \underset{(p-val=0.000)}{0.09}\,D_4$<br>Endogeneity test for $\Delta NFA$: t-stat = -0.02 (p-val = 0.950)<br>Ramsey RESET: F-stat = 2.07 (p-val = 0.155)<br>Adj-$R^2$ = 0.75<br>Serial corr. LM test (1st ord.): n × $R^2$ = 0.16 (p-val = 0.688)<br>Serial corr. LM test (2st ord.): n × $R^2$ = 1.00 (p-val = 0.606)<br>White heteroskedasticity-consistent standard errors were used because error heteroskedasticity was present. |
| **Belize** | $\Delta NDA/RM = \underset{(p-val=0.123)}{0.02} - \underset{(p-val=0.000)}{0.83}\,\Delta NFA/RM$<br>Endogeneity test for $\Delta NFA$: t-stat = -0.92 (p-val = 0.114)<br>Ramsey RESET: F-stat = 1.49 (p-val = 0.226)<br>Adj-$R^2$ = 0.65<br>Newey-West HAC standard errors were used because both error serial correlation and heteroskedasticity were found. |
| **ECCU** | $\Delta NDA/RM = \underset{(p-val=0.840)}{-0.001} - \underset{(p-val=0.026)}{0.18}\,\Delta NFA/RM - \underset{(p-val=0.039)}{0.02}\,D_3 + \underset{(p-val=0.000)}{0.03}\,D_4$<br>Endogeneity test for $\Delta NFA$: t-stat = -0.05 (p-val = 0.937)<br>Ramsey RESET: F-stat = 0.19 (p-val = 0.657)<br>Adj-$R^2$ = 0.30<br>Newey-West HAC standard errors were utilized. |
| **Guyana** | $\Delta NDA/RM_t = \underset{(p-val=0.037)}{0.05} - \underset{(p-val=0.000)}{1.03}\,\Delta NFA/RM_t - \underset{p-val=0.000}{2.69}\,g_S - \underset{(p-val=0.000)}{0.07}\,\Delta NDA/RM_{t-1}$<br>Endogeneity test for $\Delta NFA$: t-stat = -0.03 (p-val = 0.975)<br>Ramsey RESET: F-stat = 0.1 (p-val = 0.684)<br>Adj-$R^2$ = 0.90<br>Serial corr. LM test (1st ord.): n × $R^2$ = 1.5 (p-val = 0.215)<br>Serial corr. LM test (2st ord.): n × $R^2$ = 1.53 (p-val = 0.466)<br>Breusch-Godfrey LM test: n × $R^2$ = 0.49 (p-val = 0.919) |
| **Jamaica** | $\Delta NDA/RM = \underset{(p-val=0.003)}{0.04} - \underset{(p-val=0.072)}{0.16}\,\Delta NFA/RM - \underset{(p-val=0.031)}{0.02}\,D_1$<br>Endogeneity test for $\Delta NFA$: t-stat = -0.03 (p-val = 0.975)<br>Ramsey RESET: F-stat = 0.17 (p-val = 0.685)<br>Adj-$R^2$ = 0.12<br>Serial corr. LM test (1st ord.): n × $R^2$ = 0.09 (p-val = 0.767)<br>Serial corr. LM test (2st ord.): n × $R^2$ = 0.09 (p-val = 0.767)<br>Breusch-Godfrey LM test: n × $R^2$ = 0.94 (p-val = 0.625) |

| | |
|---|---|
| **Suriname** | $\Delta NDA/RM = \underset{(p-val=0.025)}{0.04} - \underset{(p-val=0.001)}{0.50} \Delta NFA/RM - \underset{(p-val=0.021)}{0.26} p$<br>Endogeneity test for $\Delta NFA$: t-stat = 0.23 (p-val = 0.735)<br>Ramsey RESET: F-stat = 0.38 (p-val = 0.536)<br>Adj-$R^2$ = 0.31<br>Serial corr. LM test (1st ord.): n × $R^2$ = 1.44 (p-val = 0.229)<br>Serial corr. LM test (2st ord.): n × $R^2$ = 1.68 (p-val = (0.431)<br>White heteroskedasticity-consistent standard errors were estimated. |
| **Trinidad and Tobago** | $\Delta NDA/RM_t = \underset{(p-val=0.626)}{0.01} - \underset{(p-val=0.001)}{0.70} \Delta NFA/RM_t - \underset{(p-val=0.081)}{0.07} D3 - \underset{(p-val=0.070)}{0.2} \Delta NDA/RM_{t-1}$<br>Endogeneity test for $\Delta NFA$: t-stat = 0.18 (p-val = 0.670)<br>Ramsey RESET: F-stat = 2.4 (p-val = 0.140)<br>Adj-$R^2$ = 0.40<br>Serial corr. LM test (1st ord.): n × $R^2$ = 0.22 (p-val = 0.642)<br>Serial corr. LM test (2st ord.): n × $R^2$ = 0.22 (p-val = (0.642)<br>Breusch-Godfrey LM test: n × $R^2$ = 5.3 (p-val = 0.147) |

In the case of Jamaica – which was classified as a managed float – the coefficient turned out to be the lowest estimate of -0.16. This result suggests that the Bank of Jamaica is more concerned with an exchange rate rather than a money anchor. The ECCB, which maintains another very successful peg in the region, neutralizes on average 18% of capital flows. The result for the ECCB is more in line with expectation that the money supply in a fixed exchange rate currency board arrangement ought to be endogenous. For Barbados while the inflation term was statistically insignificant, we found the inflation gap – actual ($p$) minus trend ($p$*) – to be statistically significant with the correct sign.

A simple average of the region's sterilization coefficient would equal -0.58, which is higher than the approximately 35% index reported for the Caribbean by Jara and Tovar (2008). However, these findings are, on average, lower than the estimates reported by Aizenman and Glick (2008) for several large emerging economies.

## 5. Dual Nominal Anchors?

One can conclude from our empirical results that Barbados, Belize, Guyana, Trinidad and Tobago, and to a lesser extent, the Bahamas, pursue two nominal anchors. On the other hand, the ECCU takes the money supply as endogenous to the exchange rate target. This result is not surprising because the ECCU maintains a currency board arrangement. The results raise the question as to how it is possible for highly open economies to maintain two anchors over a fairly long period. The money neutrality thesis tells us that both the real exchange rate and the real money supply are independent of the nominal exchange rate and the nominal money supply in the long-run (Montiel, 2003). Khatkhate and Short (1980), relying on the standard Mundell-Fleming model, noted that monetary policy in mini states would not be independent as it engenders interest rate changes that lead to counteracting financial flows. Similar arguments were also made by Obstfeld (1982) and Obstfeld and Rogoff (1995).

We conjecture that an analysis of the apparent puzzle should focus on the rigidity of interest rate in the presence of monetary shocks. This stems from the oligopolistic nature of the banking system. Typically the main participants in the domestic and capital markets are oligopolistic commercial banks, which have the ability to determine deposit and lending rates relative to a foreign benchmark interest rate. Data taken from the World Bank's Financial Structure Dataset (2010) suggests high bank asset concentration in the economies under study. The 3-bank asset concentration ratios are as follows: 0.94 (the Bahamas), 0.96 (Barbados), 0.96 (Belize), 0.94 (Guyana), 0.91 (Jamaica) and 0.84

(Trinidad and Tobago).[11] The uncompetitive nature of the banking systems in the Caribbean is also highlighted in Moore and Craigwell (2002) who reported evidence of the importance of oligopoly market power in determining interest rate spreads in the Region.

The analytical framework presented herein is a simple model of interest rate pass-through from monetary policy to domestic interest rates that precludes the offsetting capital movements predicted by the UIP theory and the IS-LM-BP model. Monetary policy would not have the necessary interest rate pass-through when the aggregate bank liquidity preference curve is flat. Commercial banks are known to hold foreign assets in addition to domestic assets such as private loans, government securities and bank reserves (required and excess). Therefore, the foreign interest rate – for example the risk free US Treasury bill rate – will become the benchmark rate when banks need to decide on investing in domestic versus foreign assets.

The paper proposes the notion that the domestic mark-up interest rate is identified by an aggregate commercial bank liquidity preference curve that is flat (see Appendix 1 for evidence of flat aggregate bank liquidity preference curves). For instance, imagine graphing non-remunerated bank reserves against a domestic rate (such as the Treasury bill rate). At the point where the curve is horizontal it signals that non-remunerated reserves and the domestic government security are perfect substitutes. They become perfect substitutes because a threshold minimum rate has been reached. We conjecture that this threshold rate is a mark-up rate above a benchmark risk-free foreign rate. When the threshold rate is binding, the banking system accumulates excess reserves in domestic currencies rather than even purchase government securities, let alone lend to the private

[11] Data for Suriname and the ECCU as a whole are unavailable.

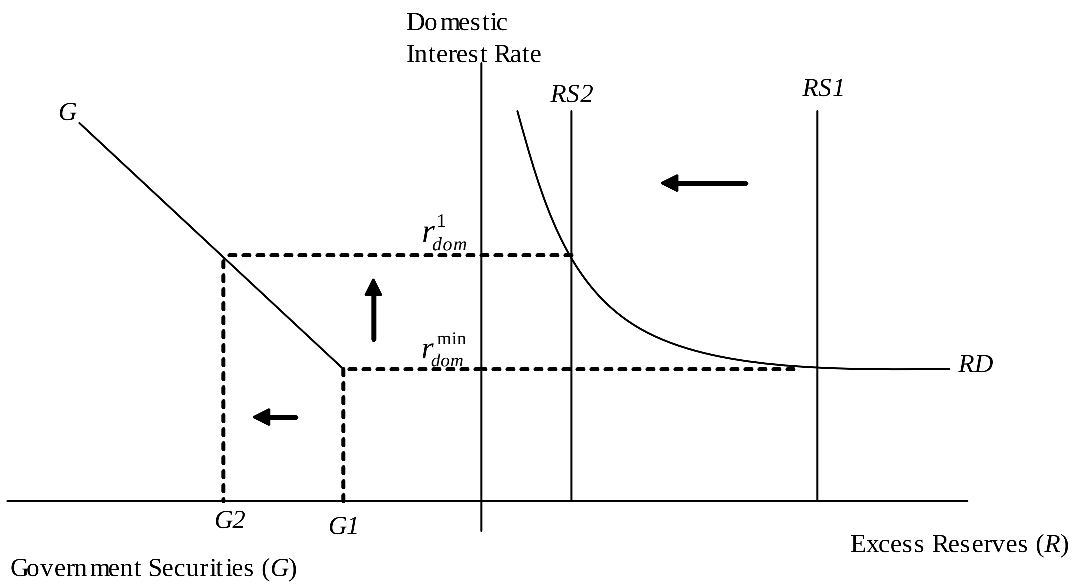
sector. At this point the banks prefer to invest all excess reserves into a safe foreign asset. But not all is invested as there could be a shortage in foreign exchange in the domestic foreign exchange market. The shortage could occur in spite of the fact that commercial banks are major participants in the domestic foreign exchange market. Thus excess liquidity is accumulated voluntarily and this is signified as a flat bank liquidity demand curve at the interest rate threshold or mark-up rate.

While the hypothesis of a flat liquidity preference curve is akin to the classic liquidity trap, money and the government security are not perfectly substitutable at zero interest rate as Keynes had postulated the thesis in 1936 [see Keynes (1936: 207-208) reprinted 1994]. Instead the threshold rate occurs above zero, thus signaling it is a minimum rate the banks require before they can invest in the domestic government security. Although not identical to the thesis of this paper, a similar idea was presented by Frost (1971). However, Frost proposed a stable bank excess reserves curve that is kinked at a Treasury bill rate close to zero (that is between 0.3 and 0.5 percent). According to Frost, profit-maximizing banks incur brokerage fees (or transaction costs) which are higher than the market rate earned on Treasury bills – thus the curve is kinked at this point to signal a more elastic accumulation of excess reserves.

The domestic threshold rate is given by the simple equation $r_{dom}^{\min}(1+m)=r_F$; whereby $r_{dom}^{\min}$ = the domestic minimum rate that is reached at the flat curve, $m$ = the mark up factor that could be determined by bank preferences, risk, market power and other factors, and $r_F$ is the foreign risk-free rate that serves as the benchmark for Caribbean economies. The basic idea is sketched in figure 1, which shows that when the threshold rate ($r_{dom}^{\min}$) is binding an expansion of bank reserves (by the central bank) along the flat liquidity preference curve (*RD*) – to the right of *RS1* – would have no effect in driving down this rate. In addition, the threshold rate is assumed to be set favorably relative to $r_F$ in order to prevent a flight of capital by the public as the banks would prefer to mobilize such funds (in the form of deposits) for themselves to invest in foreign assets. Commercial banks would also seek to mobilize foreign exchange from the domestic market to meet the foreign exchange needs of long established business customers (especially those who have outstanding business loans and exposure to international trade). On the other hand, should the central bank contract bank reserves by selling to banks government securities (*G*), then the domestic rate may increase above the threshold to $r^1_{dom}$. In this case there is the concomitant effect of an increase in government securities held by the banks from *G1* to *G2*.

The essence of figure 1 is this – the domestic banking system, owing to its oligopolistic nature, determines interest rate in such a manner that the rate is favorable relative to the foreign benchmark rate. The banks are able do this because one of their core business operations involves foreign exchange trading (in the domestic foreign exchange market in which a finite quantity of hard currencies is bought and sold on any trading day), which is used by the banks to invest in foreign financial assets. In other words, the deposit rate would be set in such a manner to encourage the public to deposit domestic currencies into the banks. These funds are then allocated as domestic loans, government securities, and importantly in our context foreign assets.

Figure 1. Monetary policy and the threshold rate




The diagrammatic framework could be looked at more formally. Equation 3 is the augmented UIP, whereby $s$ = the spot exchange rate.

$$r_{dom}(1+m)-r_F=s \qquad (3)$$

Given the nature of the liquidity preference curves in Appendix 1, it is possible to write the liquidity demand curve as a reciprocal function in which the threshold rate is the asymptote. $R^*$ represents the equilibrium level of excess reserves at the point where $RD=RS$. $\beta$ is the coefficient in the function where $\beta>0$ and $r_{dom}^{\min}>0$.

$$r_{dom}=r_{dom}^{\min}+\beta R^{*-1} \qquad (4)$$

Substituting equation 4 into 3 gives

$$(r_{dom}^{\min}+\beta R^{*-1})(1+m)-r_F=s \qquad (5)$$

Therefore,

$$\frac{ds}{dR^*} = -(1+m)\beta R^{*-2} \qquad (6)$$

The derivative suggests that as $R^* \to \infty$ the term $\frac{ds}{dR^*} \to 0$ once the threshold rate is binding.

**6. Conclusion**

This study estimates the sterilization coefficient for several Caribbean economies. Our results show that several highly open economies with pegged exchange rate regimes possess high sterilization coefficients. In other words, these Caribbean countries maintain both money and foreign exchange targets. This finding is intriguing since theory suggests it is not possible to have two nominal anchors in the long-term.

It is well established that several Caribbean economies have successfully maintained fixed exchange rate regimes since the 1970s (see for instance Worrell, 2003). Our study finds that three of these economies – Barbados and Belize and to a lesser extent the Bahamas – were engaged in active sterilization over the review period. We also find a similar result for Trinidad and Tobago. Guyana, a country with a supposed managed float (Guyana was recently classified by the IMF as an economy with a fixed peg), has the most active sterilization regime as suggested by the econometric results. The estimated sterilization coefficient for Jamaica, the ECCU and Suriname was relatively lower. This suggests that Jamaica's central bank is more concerned with a money target. On the other hand, in the ECCU the exchange rate target is paramount. This is not surprising as a currency board arrangement is maintained by the Eastern Caribbean Central Bank. As an explanation of the puzzle, the article propose the notion that commercial banks with market power set interest rates in such a manner that it precludes the central bank's monetary policy from engendering offsetting capital movements.

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**Appendix 1**

Table A1. Unit root tests – Augmented Dickey-Fuller

| | $\frac{\Delta NFA}{RM}$ | $\frac{\Delta NDA}{RM}$ | Inflation | Interest rate | Growth of exchange rate |
|---|---|---|---|---|---|
| The Bahamas | -4.0** | -3.7** | -6.2* | -2 | _ |
| Barbados | -8.5* | -4.0** | -6.9* | -2 | _ |
| Belize | -3.7** | -6.9* | -5.3* | -1.7 | _ |
| ECCU | -3.9** | -5.8* | _ | -2.11 | _ |
| Guyana | -3.9** | -4.4* | -3.2** | -1.9 | -2.81*** |
| Jamaica | -6.4* | -8.3* | -3.9* | -1.6 | -6.4* |
| Suriname | -6.1* | -3.5** | -2.9*** | _ | _ |
| Trinidad and Tobago | -3.8** | -3.5** | -1.0 | -2.0 | -3.2** |

* = significance at 1 percent; ** = significance at 5 percent; *** = significance at 10 percent.
Optimal lag lengths were chosen by AIC. Interest rate is domestic rate minus foreign rate.

## Table A2. Foreign Direct Investment – selected years

| Foreign Direct Investment<br>Current US$ | 1998 | 2000 | 2002 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Antigua and Barbuda | 22,774,074 | 43,115,926 | 65,865,065 | 80,366,585 | 213,555,967 | 374,375,900 | 390,946,346 |
| Barbados | 14,800,000 | 18,350,000 | 16,950,000 | NA | 52,800,000 | NA | NA |
| The Bahamas | 145,900,000 | 250,250,000 | 152,790,000 | 273,600,000 | 563,414,700 | 706,390,000 | 713,340,000 |
| Belize | 13,150,000 | 23,340,762 | 25,386,720 | 111,431,922 | 125,927,476 | 103,256,902 | 125,994,928 |
| Dominica | 6,511,111 | 17,596,296 | 20,110,637 | 26,173,948 | 19,235,559 | 26,777,878 | 46,424,234 |
| Grenada | 48,685,185 | 37,407,407 | 54,488,889 | 65,014,333 | 70,157,130 | 85,170,044 | 139,502,464 |
| Guyana | 44,000,000 | 67,100,000 | 43,600,000 | 30,000,000 | 76,800,000 | 102,390,000 | 152,400,000 |
| Jamaica | 287,100,000 | 394,000,000 | 407,200,000 | 541,644,805 | 581,470,000 | 796,780,000 | 751,496,215 |
| St. Kitts and Nevis | 31,925,926 | 96,214,815 | 79,771,689 | 46,141,844 | 92,994,489 | 110,415,633 | 142,595,605 |
| St. Lucia | 83,396,296 | 53,748,148 | 51,935,415 | 76,520,285 | 78,233,430 | 233,934,815 | 260,932,784 |
| St. Vincent and the Grenadines | 88,951,852 | 37,744,444 | 34,048,256 | 65,686,167 | 40,087,315 | 109,112,344 | 91,644,831 |
| Trinidad and Tobago | 729,767,481 | 654,300,035 | 684,300,000 | 1,123,500,000 | 1,280,700,000 | 1,550,000,000 | NA |

Source: World Development Indicators

## Table A3. Workers remittances – selected years

| Workers Remittances<br>Current US$ | 1998 | 2000 | 2002 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Antigua and Barbuda | 12,000,000 | 10,000,000 | 6,000,000 | 20,900,000 | 22,000,000 | 23,000,000 | 23,512,000 |
| Barbados | 76,000,000 | 102,000,000 | 109,000,000 | 109,300,000 | 140,000,000 | 140,000,000 | 140,000,000 |
| The Bahamas | NA | NA | NA | NA | NA | NA | NA |
| Belize | 23,000,000 | 22,000,000 | 29,000,000 | 34,960,000 | 46,100,000 | 65,490,000 | 74,800,000 |
| Dominica | 3,000,000 | 3,000,000 | 4,000,000 | 23,150,000 | 24,978,000 | 25,371,000 | 25,978,000 |
| Grenada | 20,000,000 | 22,000,000 | 23,000,000 | 72,192,000 | 51,567,000 | 53,941,000 | 55,416,000 |
| Guyana | 15,000,000 | 27,000,000 | 51,000,000 | 153,000,000 | 201,300,000 | 218,080,000 | 278,496,000 |
| Jamaica | 654,700,000 | 789,500,000 | 1,130,600,000 | 1,465,796,250 | 1,621,220,000 | 1,769,390,000 | 1,964,319,819 |
| St. Kitts and Nevis | 4,000,000 | 4,000,000 | 3,000,000 | 31,304,000 | 33,522,000 | 36,239,000 | 37,252,000 |
| St. Lucia | 3,000,000 | 3,000,000 | 2,000,000 | 28,650,000 | 29,460,000 | 30,308,000 | 31,087,000 |
| St. Vincent and the Grenadines | 3,000,000 | 3,000,000 | 4,000,000 | 25,517,000 | 26,486,000 | 29,728,000 | 30,548,000 |
| Suriname | NA | NA | 15,000,000 | 9,100,000 | 3,900,000 | 2,100,000 | 139,900,000 |
| Trinidad and Tobago | 45,000,000 | 38,000,000 | 79,000,000 | 86,900,000 | 92,400,000 | 92,400,000 | 92,400,000 |

Source: World Development Indicators

## A4. Portfolio investments

| Portfolio Investments<br>Current US$ | 1998 | 2000 | 2002 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|---|---|
| Antigua and Barbuda | (285,185) | 2,340,741 | (2,171,037) | 12,099,778 | 10,528,400 | 24,783,866 | (6,012,015) |
| Barbados | (54,650,000) | 71,100,000 | (33,600,000) | (68,150,000) | 21,850,000 | NA | NA |
| The Bahamas | NA | NA | NA | NA | NA | NA | NA |
| Belize | NA | NA | NA | NA | NA | 40,000,000 | NA |
| Dominica | 529,630 | 13,629,630 | 12,109,104 | (2,466,086) | 3,783,185 | (103,232) | 2,476,192 |
| Grenada | 30,000 | 19,450,000 | 107,670,000 | 30,040,000 | 17,800,000 | (750,000) | 650,000 |
| Guyana | NA | NA | NA | NA | NA | NA | NA |
| Jamaica | 7,000,000 | (64,100,000) | (195,500,000) | 96,000,000 | (126,000,000) | (128,520,000) | (640,440,000) |
| St. Kitts and Nevis | 2,233,333 | 4,996,296 | 30,362,897 | (9,839,259) | (15,024,104) | (20,964,030) | (19,190,652) |
| St. Lucia | 3,322,222 | 28,385,185 | 16,866,674 | 16,288,887 | 24,045,374 | (2,964,316) | (2,584,235) |
| St. Vincent and the Grenadines | (114,815) | 1,444,444 | 1,002,963 | 33,171,155 | (8,194,323) | 12,511,213 | (1,511,704) |
| Trinidad and Tobago | (396,932) | (30,000,002) | (70,100,000) | (690,100,000) | (258,200,000) | NA | NA |

Source: World Development Indicators

Aggregate bank liquidity preference curves

In order to extract the liquidity preference curves, we utilize a technique outlined by Cleveland (1993). The technique is that of locally weighted least squares regressions. Robust weights were utilized to minimize the effects of outliners on the curve. A smoothing parameter of 0.4 was used for all the economies. Figures A1 to A5 report the extracted aggregate liquidity preference curve for five economies. We did not report the curves for the ECCU and Suriname because the Treasury bill rate is unavailable; however, while the rate is available for Belize for much of the sample period it is fixed at 3.5 percent and 6 percent. Thus the curve for the Belize banking system could not be obtained.

The extracted curves suggest that the threshold rate for Guyana equals approximately 4 percent, Jamaica 16 percent, Barbados 3.5 percent, The Bahamas 1.5 percent, and Trinidad and Tobago 6 percent.

Figure A1. Guyana: bank liquidity preference curve (1994:Q1 – 2008: Q2)

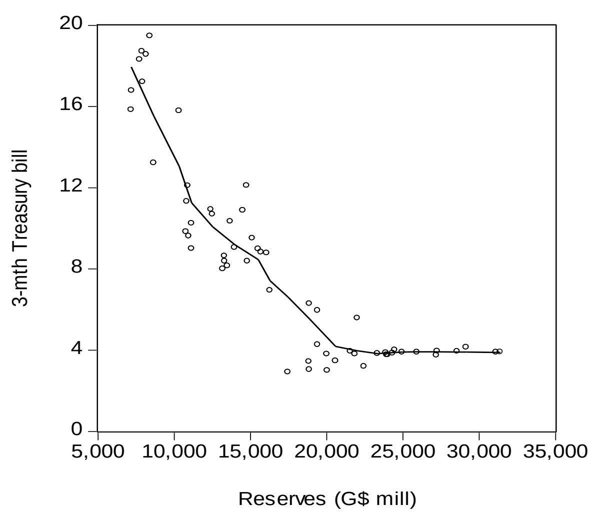

Figure A2. Jamaica: bank liquidity preference curve (1993:Q1 – 2008: Q2)

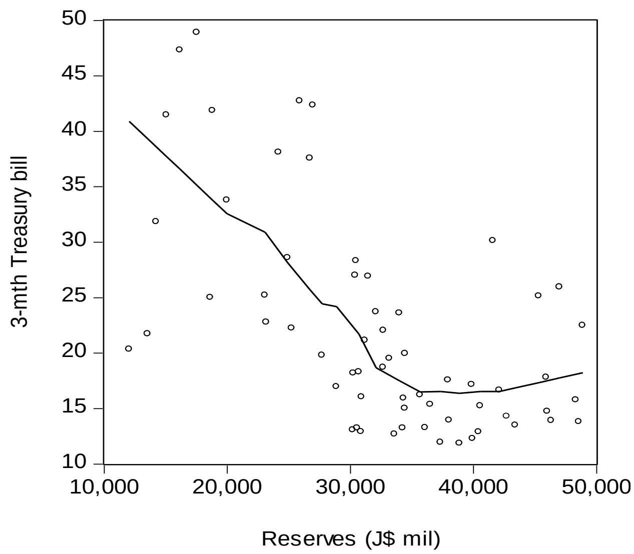


Figure A3. Barbados: bank liquidity preference curve (1993:Q1 – 2008: Q2)

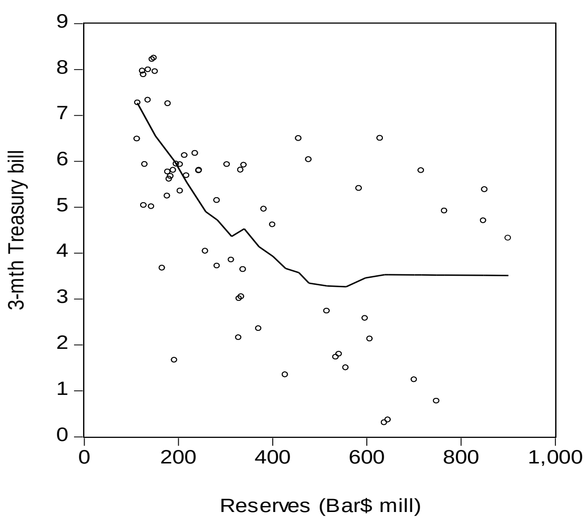

Figure A4. The Bahamas: bank liquidity preference curve (1993:Q1 – 2008: Q2)

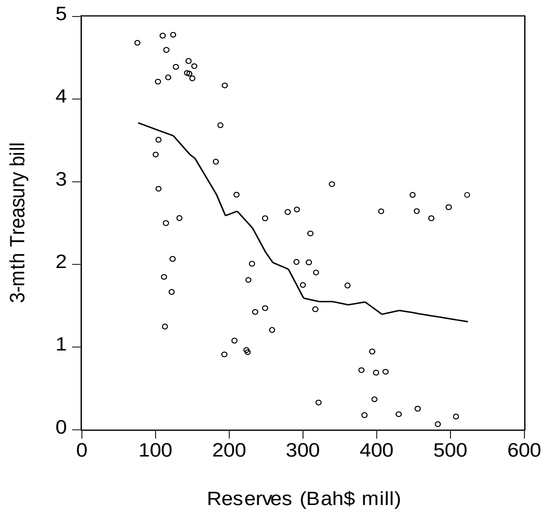


Figure A5. Trinidad and Tobago: bank liquidity preference curve (1993:Q1 – 2008: Q2)