A THEORETICAL AND EMPIRICAL ANALYSIS OF THE BARBADOS BALANCE OF PAYMENTS SITUATION

by

Christopher W.F. Crowe
Country Economist
Caribbean Development Bank

Presented at the Annual Review Seminar, Research Department,
Central Bank of Barbados
July 27 - 30, 1999

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Paper Submitted To CBB Annual Review Seminar, June 1999

*The author is Country Economist for Barbados at the Caribbean Development Bank. I wish to acknowledge assistance in formulating my ideas from a number of my Colleagues in the Economics and Programming Department at the Bank. Errors and omissions are of course the responsibility of the author alone. The views expressed in the paper are those of the author and do not necessarily reflect those of CDB.

EXECUTIVE SUMMARY

Maintenance of the fixed exchange rate against the US dollar has been central to Barbados's macroeconomic strategy since the mid-1970s. Whilst there has been a consensus that the fixed exchange rate has been a guarantor of stability and prosperity, its defence has been characterised by periods of painful macroeconomic adjustment, particularly in the early 1980s and 1990s.

Interest in the issue of currency crises grew as the Bretton Woods system of fixed pegs broke down in the 1970s and a number of developing countries underwent periods of disequilibrium and adjustment in the 1980s. 'First generation' models of such crises stress the role of domestic credit expansion which runs down reserves and undermines the authorities' attempts to defend the fixed parity. According to these models, speculative behaviour leads to a currency crisis and a breakdown of the fixed parity before reserves are totally depleted, as the private sector anticipates the devaluation and wipes out the remaining reserves to avoid holding a depreciating asset.

Later 'second generation' models approach the issue from a political economy perspective, and argue that currency crises are a result of inconsistencies between domestic and external policy objectives generally. These models are less mechanistic than their 'first generation' counterparts, and allow for the existence of multiple equilibria driven by the expectations of the private sector.

In this paper a model is presented which modifies the 'first generation' analysis by introducing capital market imperfections in order to model for the effects of exchange controls and other more intrinsic impediments to free capital movements. The model is estimated using monthly data for Barbados over the 1976-98 period. The results indicate that unbridled speculative behaviour would on a number of occasions have dislodged the currency from its US dollar peg. The maintenance of strict exchange controls has thus been central to the continued defence of the Barbados dollar.

If, as at present, domestic credit is allowed to grow at a rate inconsistent with balance of payments equilibrium, the retention of exchange controls is to be recommended. The empirical results are also supportive of the generally-held conviction that the present degree of domestic credit expansion is likely to lead to a 'crisis' some time in the not-too-distant future: this paper therefore supports measures to constrain domestic credit growth in order to protect the foreign exchange position. The paper notes the strong complementarities between Barbados's exchange rate policy and incomes policy as mutually reinforcing anti-inflationary strategies. Finally, the continuation of the fixed exchange rate is recommended, as it facilitates the adoption of policies aimed at maintaining macroeconomic balance.

INTRODUCTION

It would be fair to characterise the defence of the 2:1 Barbados/ US dollar exchange rate parity as *the* central pillar of Barbados's macroeconomic strategy over the past two decades. While some other regional economies (Guyana, Jamaica and Trinidad and Tobago) have opted for various strategies of staged devaluation and managed or 'dirty' floating, Barbados has successfully maintained its fixed exchange rate since 1975, following a short period of devaluation as the currency moved from its peg against sterling to its current US dollar peg. However, the maintenance of this policy has not been without episodes of crisis and painful macroeconomic adjustment.

In this paper I examine the rationale behind Barbados's exchange rate policy and experience of its implementation and results. In particular, I analyse two periods of crisis and adjustment which occurred in 1982 and 1991, and attempt to model the crises and examine whether they conform to the pattern identified in the model. Section I outlines the theory of exchange rate crises and Barbados's experience of maintaining its fixed parity. Section II introduces a formal model derived from the basic monetary approach to the balance of payments, similar to models discussed by Flood and Garber (1984) and Obstfeld (1986). However, the model explicitly allows for capital market imperfections which give the government some freedom to determine domestic interest rates despite the fixed exchange rate regime. In section III I calibrate a money demand function for Barbados, using monthly data over the 1976-98 period, in order to derive parameters necessary to analyse the model in the Barbados context. Section IV offers an interpretation of the results and discusses the implications for policy in the light of Barbados's present Balance of Payments situation.

I. FIXED EXCHANGE RATES AND BALANCE OF PAYMENTS CRISES: THEORY AND PRACTICE

1. The Rationale for a fixed exchange rate

Maintaining a fixed exchange rate parity is not a cost-less strategy. If the domestic country is less successful in combating inflation than the country against whose currency the domestic currency is fixed, then the domestic economy will face a deterioration in the competitiveness of its exports as the price levels in the two countries diverge. With export prices held down by competition in world markets, exporting firms will find it difficult to compete for factor inputs, particularly labour, with firms producing goods for domestic consumption. Whilst firms producing for domestic markets can match inflationary pay demands by raising their product prices, exporting firms, facing competition from foreign firms which do not face inflationary pressures, cannot. Effectively, the differing rates of inflation in domestic and external prices drives a wedge between the real wages in export sectors viewed from the perspective of the workers (denominated in domestic prices) and from the employers' perspective (in terms of their own product prices). The extent of misalignment can be inferred from the change in the real exchange rate (RER), measured as the price ratio for non-tradable and tradable goods. The RER for Barbados appreciated by almost 60% between 1975 and 1991, although it has depreciated since then due to the wage restraint policy adopted following the 1991 crisis (Bynoe-Mayers (1997) p.62). Because it involves changing only one relative price, devaluation is often presented as a 'painless' means of correcting this misalignment.

However, there are several advantages of maintaining a fixed exchange rate parity which, in the case of Barbados, have generally been considered to outweigh the disadvantages. A fixed parity reduces exchange rate risk and therefore aids foreign investment in the domestic economy. It also provides an anchor for inflationary expectations and introduces credibility to monetary policy. This point is reinforced by the experience of other CARICOM countries which have seen the benefits of devaluation squandered by higher inflation (Bynoe-Mayers (1997) p.66; Rolle (1994) pp.163-5).[1] Finally, popular support for the fixed parity, as a symbol of 'stability', enables difficult but necessary macroeconomic adjustments to be sold to the public. This point is discussed further in section IV.

2. First and Second Generation models of exchange rate crises

Economies which maintain a fixed exchange rate regime usually find that macroeconomic dis-equilibria (caused by, variously, inappropriate monetary or fiscal policies, external shocks or price rigidities) find their ultimate expression in exchange rate or balance of payments crises. Following the first OPEC oil price shock in 1973 and the subsequent break-up of the Bretton

[1] The impact on domestic inflation which erodes the impact of devaluation on the real exchange rate indicates that, without domestic price restraint, a nominal devaluation is not sufficient to generate an improved external position. That it is not necessary is indicated by evidence presented in Milesi-Feretti and Razin (1998), which, based on a sample of low and middle income countries, shows that less than a third of

Woods adjustable peg exchange rate system, interest in the dynamics of exchange rate crises grew. 'First generation' models, such as those examined by Krugman (1979), Flood and Garber (1984), Obstfeld (1986) and Dornbusch (1987), tend to focus on inappropriately expansionary fiscal policy fuelling domestic credit growth as the essential cause of balance of payment crises. Excessive growth in domestic credit in relation to the private sector's demand for domestic monetary assets leads to a run-down of reserves. The key insight offered by these models is that speculative behaviour leads to an abandonment of the exchange rate peg *before* the government runs down its reserves to the level at which it is no longer prepared to defend the currency. Suspecting a future devaluation, the private sector becomes unwilling to hold domestic currency and the government's remaining reserves are wiped out in a speculative attack, thereby causing a devaluation and ratifying the expectations which led to the attack. This process is examined further in section II.2.

Later 'second generation' models have attempted to approach the issue of currency crises from a political economy perspective. Krugman (1998) outlines the two key elements behind the 'second generation' story. First, a tension should exist between domestic and exchange rate policy. Such a tension is usually generated by some form of nominal price rigidity which introduces real costs to the nominal exchange rate anchor. For instance, if nominal wages are sticky then the option of reducing unemployment in export sectors by cutting real wages through a reduction in nominal wages will not be available. However, the same outcome could be achieved by devaluing the currency and hence increasing the price of export goods in domestic currency. This is essentially the argument discussed in the previous section, that in an economy with nominal price rigidities it is easier to change the relative price of foreign exchange than to change the price of labour in every exporting firm.

Second, the costs of maintaining the exchange rate parity should be increasing as the private sector's belief in the government's willingness to defend the parity wanes. This means that a fall in confidence, caused by a belief that the government will be unwilling to bear the costs of a fixed exchange rate over the long term, increases these costs and thus accelerates the fall in confidence still further.

large corrections in the current account deficit were preceded or accompanied by a significant currency realignment. Barbados's improved external position since 1991 is a further example.

Box 1: A political economy perspective on the 1931 Sterling Devaluation and Exit from the Gold Standard

An obvious illustration of the second generation account of currency crises is offered by the UK's exit from the Gold Standard in 1931. Ramsay MacDonald's Labour government faced a tension in its macroeconomic objectives, between dealing with massive unemployment in export sectors on the one hand and a desire to demonstrate monetary 'prudence' by adhering to the Gold Standard at an overvalued parity on the other. The government was adamant that it would not devalue, however gold continued to drain from the Bank of England's coffers. Moreover, as the private sector's confidence in the currency waned, monetary policy became ever tighter as the Bank of England sought to stem the outflow of gold, thus fulfilling Krugman's second condition that as confidence falls the costs of maintaining a fixed parity should increase. Eventually the Labour government fell apart, and MacDonald and Chancellor Philip Snowden formed a 'national' government consisting mainly of Conservatives. Shortly afterwards the pound left the gold standard, devalued significantly and unemployment started to fall.[2]

Belief amongst Labour MPs that the entire episode had been a 'Bankers' Ramp' (ie a money-making scheme by which speculators force a change in government policy and profit by pocketing the government's gold reserves in the process) may have been partially justified in the sense that such crises can be self-fulfilling at a proximate level. A collapse in confidence causes a devaluation and thus provides an ex-post justification of the belief that the devaluation will occur. However, at a more fundamental level the crisis was not self-fulfilling, but predetermined by the over-valuation of the currency. Because the pound was over-valued, it could only devalue if it were allowed to float freely, so that speculating against it offered potential gain but no risk of losses. Once speculators realised this, devaluation became inevitable.

Interest in second generation models has grown in recent years with the unfolding of the financial crisis in East Asia. In particular, the existence of self-fulfilling crises caused by 'herd behaviour' on the part of investors has been demonstrated, for many observers, by the forced devaluation and financial collapse of countries experiencing strong levels of growth and following conservative fiscal and monetary policies (Radelet and Sachs (1998)). In this account of the Asian crisis, un-hedged short-term lending to East Asian financial institutions, based on expectations of

[2] Similar events forced the pound out of the European Exchange Rate Mechanism (ERM) in 1992. With the then Chancellor Norman Lamont said to have been 'singing in the bath' as the pound plummeted, the adage that history repeats itself, first as tragedy and then as farce, was reconfirmed.

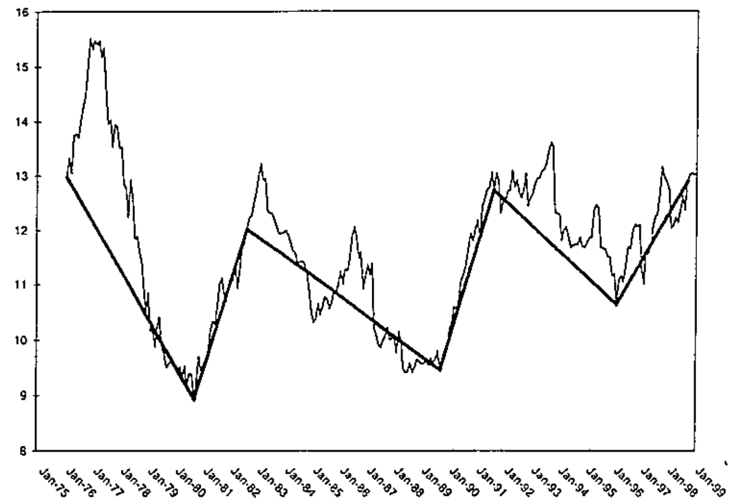
continuing economic growth and the maintenance of the managed exchange rate regime, led to acute vulnerability to shifts in investor confidence. As the current account deficits of the East Asian countries grew ever wider, western investors became jittery, leading to a self-fulfilling spiral of capital outflows, falling exchange rates and financial sector insolvency. Essentially, one can think of two equilibria, a 'good state' where investor confidence remains high, justified by continued growth, and a 'bad state' where investor confidence collapses, justified by the subsequent financial sector chaos and slump in the wider economy. The crucial determinant of which equilibrium the economy arrives at is the state of 'animal spirits' or investor confidence. However, as with the UK in 1931, the more fundamental cause of the crisis lay with real rather than expectational factors. In this case the real factor was the weakness of financial institutions, which meant that once a currency crisis occurred a financial sector collapse and wider economic meltdown was guaranteed.[3]

3. The Barbados Experience of Maintaining a Fixed Exchange Rate

In the light of this analysis the continuing relevance of earlier models may be in doubt. However, in the context of Barbados the first generation models offer some useful insights. The two episodes of 'crisis' (1982 and 1991) were characterised by prolonged periods of excessive growth in domestic credit and a depletion of foreign reserves, as in the first generation models.[4] Moreover while the second generation models offer an interesting political economy perspective on the government's policy objectives, it is difficult to analyse them quantitatively because of the essentially intangible nature of the concepts involved.

Barbados has twice experienced balance of payments difficulties, around September 1982 and again in September 1991, although in both cases the currency was successfully defended through the 11th hour adoption of adjustment policies. Both periods were characterised by a slowdown of activity in foreign-exchange earning sectors coupled with a widening fiscal deficit and an accelerated growth in domestic credit. In this environment a run-down of reserves was more or less inevitable, and in both cases reserves fell to extremely low levels before the negotiation of a Standby Arrangement with the IMF and the implementation of a structural adjustment programme stabilised the situation. Dalrymple (1995) argues that while the 1982 'crisis' was primarily due to problems in the foreign exchange earning sectors (with sugar production and tourist arrivals falling), the 1991 problems were a result of excessive fiscal expansion funded by domestic borrowing. To what extent one attributes each 'crisis' to domestic or external factors is largely a matter of degree. In the analysis of Section II both periods are modelled as essentially monetary phenomena, whereby a run-down in reserves is occasioned by an accelerated expansion in domestic credit. This domestic credit expansion can be thought of as the monetary manifestation of an excess of absorption over output, whether caused by excessively lax fiscal policy or a deterioration in export earnings. Reference to Chart 1 will confirm that such a credit expansion (in relation to GDP) did occur on both occasions.

Chart 1: Domestic credit as a proportion of nominal income (d in equation 3), actual and trended.



II. THE MODEL

1. Outline of a modified First Generation Model

First generation models of exchange rate crises are based on the monetary approach to the balance of payments. The essential element of this approach is the determination of the stock of international reserves as a residual from the independent processes generating money demand and

[3] For further discussion of currency crises from a political economy perspective, including case studies from Latin America and Europe, see Obstfeld and Rogoff (1995).

[4] I place 'crisis' in inverted commas because although both periods were crises in the general sense, in each case the 11th hour adoption of adjustment policies meant that devaluation was averted. Therefore a crisis as defined in the first generation model (run-down of reserves⇒speculative attack⇒devaluation) never occurred.

domestic credit expansion. Real factors, particularly the trade balance, are ignored, as are possible linkages between the three monetary aggregates (the money supply, domestic credit and foreign reserves) other than those posited in the model. However econometric studies of the Barbados foreign exchange situation have tended to broadly support the monetary theory of the balance of payments (Coppin (1994) p.83; Looney (1991) p.130), so that its use in the Barbadian context is valid.

First generation models presented in the literature are highly stylised, and in particular abstract away from capital market imperfections which allow some leeway for monetary policy intervention and make the domestic interest rate an endogenous variable. In Obstfeld's (1986) paper, representative of the first-generation literature, a demand for money function is presented relating real balances (M/P) to the domestic interest rate, r, and the domestic interest rate is then related to the foreign interest rate, r*, and the expected rate of depreciation in the currency, by an Uncovered Interest Parity (UIP) condition. The growth performance of domestic credit, D, is specified, and the domestic and foreign price levels, P and P* respectively, are related through an assumption of Purchasing Power Parity (PPP).

The model outlined below is an extension of Obstfeld's (1986) model, which is itself derived from Flood and Garber's (1984) paper. However I introduce three innovations in order to make the model more realistic and therefore suitable for estimation. Firstly I allow for income growth and changes in the foreign price level. Second, I assume that capital market imperfections allow some room for government intervention in the financial market so that the simple UIP condition no longer holds. Third I relax the PPP condition to allow for sluggish adjustment in the domestic price level. These are detailed below.

$$k_t \equiv \frac{M_t}{P_t y_t} = \alpha - \beta r_t + \varepsilon_{1t}; \qquad \alpha, \beta \geq 0; \qquad \varepsilon_{1t} \sim iid(0, \sigma_1^2) \tag{1}$$

$$M_t \equiv D_t + R_t \tag{2}$$

$$\Delta d_t \equiv \Delta\left(\frac{D_t}{P_t^{*\gamma} e_t^{(\gamma-1)} P_{t-1}^{(1-\gamma)} y_t}\right) = \mu + v_t; \qquad v_t \sim iid\ (0, \sigma_v^2) \tag{3}$$

$$r_t^L = g_0 + g_1\left(r_t^* + E_t\left[\frac{\Delta e_t}{e_t}\right]\right) + f(\varepsilon_{1t}) + \varepsilon_{2t}; \qquad \varepsilon_{2t} \sim iid(0, \sigma_2^2) \tag{4}$$

$$P_t = (P_t^* e_t)^\gamma P_{t-1}^{(1-\gamma)} \exp(u_t)$$

$$\Rightarrow \quad \ln P_t = \gamma \ln(P_t^* e_t) + (1-\gamma)\ln P_{t-1} + u_t; \qquad u_t \sim iid(0, \sigma_u^2) \tag{5}$$

Equation (1) relates k, the inverse of the income velocity of circulation, to the domestic nominal interest rate r, postulating a simple linear relationship. Equation (1) is essentially a Keynesian demand for money function, with the inverse velocity of circulation, the ratio of money (M) to nominal income (Py), negatively related to 'the' rate of interest. It is assumed that a higher rate of interest on financial assets will increase the opportunity cost of holding 'money', hence reduce the quantity of money as a proportion of nominal income that the private sector wishes to hold. Reference to equation (4) indicates that the domestic interest rate is assumed to be endogenous and contemporaneously correlated with the error term ε_{1t}, hence (1) is estimated using Instrumental Variables (IV) methodology in order to correct for the endogeneity problem. The US interest rate is used as the appropriate instrument, following from equation (4). This is discussed further in the Appendix.

Equation (2) is a standard money-market equilibrium condition, stating that the demand for money equals the supply of monetary assets, which is by identity made up of domestic credit, D, and foreign reserves, R. Equation (3) gives the growth path of domestic credit. The particular specification given here is intended to simplify the analysis of the model, however the general proposition, that domestic credit as a proportion of nominal income follows a random walk with drift, is entirely palatable. As is shown in the statistical appendix, it is consistent with the data. The drift term, μ, is assumed to be constant over the medium term, and determined by the government. The intuition behind the specification of d_t and other aspects of this equation are discussed in depth in the Appendix.

Equation (4) is the interest rate determination function, with the L superscript denoting a long-run relationship. As discussed in the Appendix, a dynamic version of this equation is estimated in order to deal with problems of serial correlation; the long run parameters are calculated from short-run coefficients in the usual way. (4) is essentially a modified UIP condition, with capital market imperfections (and particularly exchange controls administered by the Central Bank) allowing the government some ability to determine interest rates.[5] Hence the domestic interest rate, with the exchange rate e fixed, is no longer the same as the foreign or 'world' rate r^*. The government is assumed to follow a policy rule of changing interest rates in response to shocks to k: these shocks are assumed to be random and are given by the error term ε_{1t} in (1). The nature of the feedback rule $f(\varepsilon_{1t})$ is not of concern to this paper and is not explored further. (5) gives the price formation equation, with the speed of adjustment to PPP indexed by the parameter γ.

2. Anatomy of an exchange rate crisis

As outlined in section I.2 above, the essential cause of the crisis in the first generation accounts is a policy of domestic credit growth inconsistent with the structural demand for monetary assets in the economy. The government depends on a stock of foreign reserves to defend the exchange rate parity: the promise to meet 'reasonable' requests for foreign exchange at the given parity by the monetary authorities is what maintains the currency's value. Given that the government is committed to the existing parity, denoted $\bar{e}$, it will run down its reserves, R, until they reach some point $\bar{R}$ representing the lower bound on reserves, as the excess growth in domestic assets is accommodated by private sector portfolio adjustment. Given capital market imperfections and the political costs of seeking assistance from International Financial Institutions (IFIs), this lower bound is unlikely to be significantly below zero; conversely it may be positive if the government were unwilling to give up all of its reserves. In order to simplify the analysis I set $\bar{R}$ to zero.

An important tool in analysing periods of crisis is the notion of a 'shadow' exchange rate, which is defined as the *hypothetical floating rate* which would pertain *if a crisis were to occur in period t* and reserves were to be reduced to $\bar{R}$ (zero by assumption) by a speculative attack. Substitution of equations (2), (4) and (5) into equation (1), with error terms set to their expectation, zero, for all t, gives equation (6) below, an expectational difference equation in the 'shadow' exchange rate, $\tilde{e}_t$. Since there are no reserves following an attack, M_t is given by D_t (generally, $D_t + \bar{R}$).

$$\frac{D_t}{(P_t^*\tilde{e}_t)^{\gamma} P_{t-1}^{(1-\gamma)} y_t} = \alpha - \beta\left(g_0 + g_1\left(r_t^* + E\left[\frac{\Delta\tilde{e}_t}{\tilde{e}_t}\right]\right)\right)$$

$$\Rightarrow \quad \frac{1}{\alpha - \beta(g_0 + g_1 r_t^*)}\left(d_t + \beta g_1 E[\Delta\tilde{e}_t]\right) = \tilde{e}_t \qquad (6)$$

Following Flood and Garber (1984), we can conjecture a solution of the form $\tilde{e}_t = \lambda_0 + \lambda_1 d_t$ and use the method of undetermined coefficients and the fact that $E[\Delta d_t] = \mu$ to arrive at the solution given in (7)[6].

$$\tilde{e}_t = \frac{d_t}{\alpha - \beta(g_0 + g_1 r_t^*)} + \frac{\beta g_1 \mu}{(\alpha - \beta(g_0 + g_1 r_t^*))^2} \qquad (7)$$

Obstfeld (1986) proves that as soon as the floating exchange rate becomes higher than the fixed rate ($\tilde{e}_t \geq \bar{e}$) then the monetary authorities see their reserves reduced to $\bar{R}$ (zero) and the currency floats at the 'shadow' value. It is clear that as soon as the shadow value reaches the fixed parity, then a speculative attack *can* occur. Remember that $\tilde{e}_t$ is the value which would pertain *if* the currency were to float in period t. Then if agents in the economy were to believe that the currency would be allowed to float in period t, they would purchase the government's reserves, causing a crisis and devaluation (increase in e), and enjoy a capital gain. Thus if an attack did occur, the beliefs that underlie it would be ratified by subsequent events. Of course when the shadow exchange rate is below the existing fixed parity, then no agents would participate in a speculative attack *even if they believed it would occur.* This is because the subsequent floating rate would be below the existing parity and they would record a capital loss by buying the official reserves. Hence an attack can occur only when $\tilde{e}_t \geq \bar{e}$. Obstfeld (1986) shows that the condition that a crisis *can* occur is not sufficient to indicate that it *will*- to

[5] Agénor et al. (1992) use a similar method to account for exchange controls (see their equation 24), although they do not include a constant term or stochastic element. The constant term in our equation can be thought of as a combination of a risk premium, compensation for higher transaction costs engendered by the small size of the Barbados economy, and a dead-weight loss associated with exchange controls. The stochastic element represents changing perceptions of risk and swings in investor sentiment.

[6] As Flood and Garber (1984) note, this solution is a specific case of a more general dynamic law in which the post-devaluation exchange rate follows a speculative bubble. I restrict my attention to the case where the floating rate will depend only upon economic 'fundamentals', in order to make the analysis more simple and because the retention of exchange controls in Barbados limits the degree to which speculative activity in significant quantities of money is possible.

demonstrate that a crisis will occur when the shadow floating rate becomes higher than the fixed parity requires further analysis which I will not go into here.[7]

The key insight of this model is that *speculative behaviour on the part of the private sector leads to a crisis before reserves are reduced to* $\overline{R}$. As long as the shadow floating exchange rate follows the dynamic law given in (7), then the excess in reserves over $\overline{R}$ when the crisis occurs (in other words the quantity of reserves which are wiped out in a speculative attack before the currency is allowed to float) is given by (8).

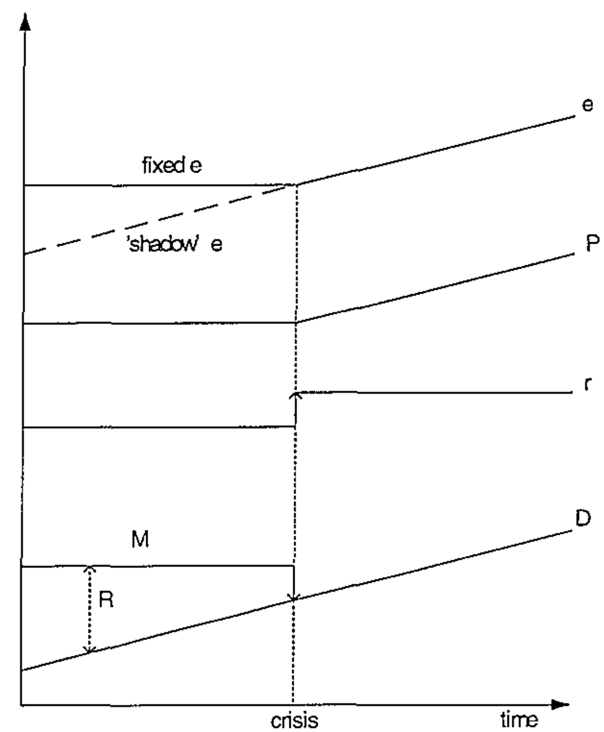
$$R_t - \overline{R} = \frac{P_t^{*\gamma} e_t^{(\gamma-1)} P_{t-1}^{(1-\gamma)} y_t \beta g_1 \mu}{\alpha - \beta\left(g_0 + g_1 r_t^*\right)} \geq 0; \quad \text{if } \beta,\ g_1,\ \mu,\ (\alpha - \beta\ (g_0 + g_1 r_t^*)) \geq 0 \qquad (8)$$

Equation (8) indicates clearly that the excess in reserves over $\overline{R}$ when the crisis occurs is due to the positive growth in d (μ>0) creating the expectation of a continuing currency devaluation if the fixed parity is abandoned. With μ>0, the increasing supply of domestic credit implies that if the level of credit is to remain consistent with the structural demand for monetary assets, then the domestic and foreign price levels must be diverging. With the domestic price level increasing faster than the foreign price level, the demand for nominal money can increase at a rate sufficient to match the growth in domestic credit. With this divergent inflationary performance, the exchange rate is expected to continue to devalue in order to maintain the modified PPP condition. If the dynamic path of $\tilde{e}_t$ is dependent not only on fundamentals but can follow a speculative bubble then (8) will not hold and a speculative attack could happen at any time, depending on the magnitude of the bubble. This eventuality can be discounted for Barbados as argued in footnote 6.

The time-path of key variables around the time of the crisis is given in figure 1 below. To simplify the analysis, real GDP (y), foreign prices (P*) and the foreign interest rate (r*) are held constant; stochastic shocks are set at zero, and the degree of sluggishness in the price adjustment process, (1-γ), is assumed to be zero (that is, PPP holds). Domestic credit expansion (increasing D) leads to a fall-off in reserves (R) as the money supply (M), determined by demand, remains constant since interest rates are constant. With reserves falling and the domestic credit expansion expected to continue, the shadow exchange rate is depreciating (increasing). When the reserves fall to the level given in equation (8), the shadow exchange rate reaches the fixed level $\bar{e}$, the reserves are wiped out and the currency floats. It then depreciates as the inflationary expansion in the money supply (now determined by the expansion in domestic credit) leads to increasing domestic prices, and the depreciating currency increases domestic interest rates.

[7] See Obstfeld (1986) Theorem 1 and Proof.

FIGURE 1: TIME-PATH OF A CRISIS



3. Exchange Controls and Speculation

As discussed above, the existence of capital market imperfections is modelled for by modifying the traditional Uncovered Interest Parity (UIP) condition through the addition of a monetary feedback mechanism (equation (4)). The existence and comparatively effective implementation of exchange controls offers a plausible motivation for the assumption of capital market imperfections.[8] The prevention of uninhibited cross-border financial transactions allows the government to set interest rates different from the 'world' rate, even allowing for expected exchange rate movements.

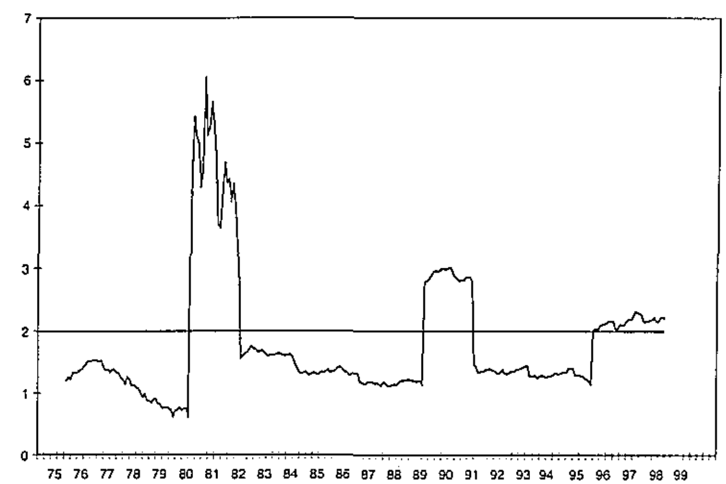
Moreover, exchange controls imply that the model, which is *predicated on the existence of speculative arbitrage in the foreign exchange markets*, will tend to exaggerate the degree to which a currency crisis can occur. This is because exchange controls prevent large-scale speculation against the currency, although leakage will occur and a degree of speculation will be possible if a parallel market in foreign exchange is allowed to develop as the public loses faith in the government's resolve. Countries which have liberalised their capital account and removed exchange controls have found it difficult if not impossible to prevent speculative attacks on their currencies. As Obstfeld and Rogoff (1995; p.77) argue,

As countries began lifting exchange controls and deregulating financial markets to varying degrees in the late 1950s, weak currencies became much more vulnerable to shifting global capital flows, and it became impossible to operate Bretton Woods as an avowed adjustable peg system. A massive series of speculative attacks swept it away between 1971 and 1973. During its early years, the EMS [European Monetary System, the system of exchange rate bands which later evolved into full monetary union or EMU] *was similarly shielded by capital controls, notably in France and Italy. As controls were shed during the late 1980s in pursuit of Europe's single-market ideal, the system became much more vulnerable to speculative attack on a massive scale.*[9]

In fact the model outlined in Sections II.1-2 does not offer a prediction of what *should* have occurred to the Barbados fixed currency regime, but rather what *would* have happened had speculative arbitrage been possible. It is plausible to imagine a situation in which the government has abandoned full exchange controls but maintains some freedom to set monetary policy: Jamaica is a case in point. Capital market imperfections engendered by more intrinsic factors than exchange controls can allow government some lee-way in its interest rate policy even if the lack of exchange controls means that the government is unable to defend the currency against a speculative attack. The model's predictions therefore offer a plausible counterfactual picture of what would have happened to the Barbados dollar if the government had dismantled the protective barrier offered by its restrictions on large-scale foreign exchange dealings.[10]

III. ESTIMATION OF THE MODEL FOR BARBADOS, 1976-1998

Chart 2: shadow Exchange Rate



The first step in analysing the model given in equations (1)-(5) econometrically is to estimate the demand for money, interest rate determination and price formation functions given in (1), (4) and (5) respectively. The estimated parameters can then be utilised to calculate a shadow exchange rate using Equation (7), and the 'predictions' of the model can be compared to Barbados's exchange rate experience. The details of the estimation procedures and data proxies used are discussed in the appendix, and the results of estimating (1), (4) and (5) are given in Tables 1-3. Estimates for α, β, g_0, g_1 and γ are 12.0184, 982.7077, .002987, .4124 and .042674 respectively.

[8] See IMF (1996) for a summary of the exchange control measures administered in Barbados.

[9] During the 1992 ERM (Exchange Rate Mechanism) crisis Ireland, Portugal and Spain all introduced (temporary) exchange controls in order to bolster their currencies. In fact these moves only postponed the devaluation of their currencies rather than prevented it (Buiter et al., 1998; p.25)

[10] A interesting extension of this research would be to estimate for Barbados a model incorporating the effects of capital controls explicitly (beyond merely modifying the UIP condition) and see whether this model successfully predicts the outcome of the 1982 and 1991 'crisis' periods, namely the avoidance of devaluation but a perceived need for adjustment. Wyplosz (1986) outlines a theoretical model of currency crises in the presence of exchange controls, in which restrictions on the currency dealings of residents allow the authorities to delay the crisis. Effectively, it is the speculative activity of non-resident holders of the domestic currency, using only their present holdings of the currency, which eventually causes the crisis. This places limits on the speculative resources available and allows the currency to be defended for longer.

The time-path of $\tilde{e}_t$ can now be estimated by substituting these estimates, the estimates for μ over the various sub-periods given in Table 4, and data on d and r* into equation (7). This is presented in Chart 2.

IV. DISCUSSION

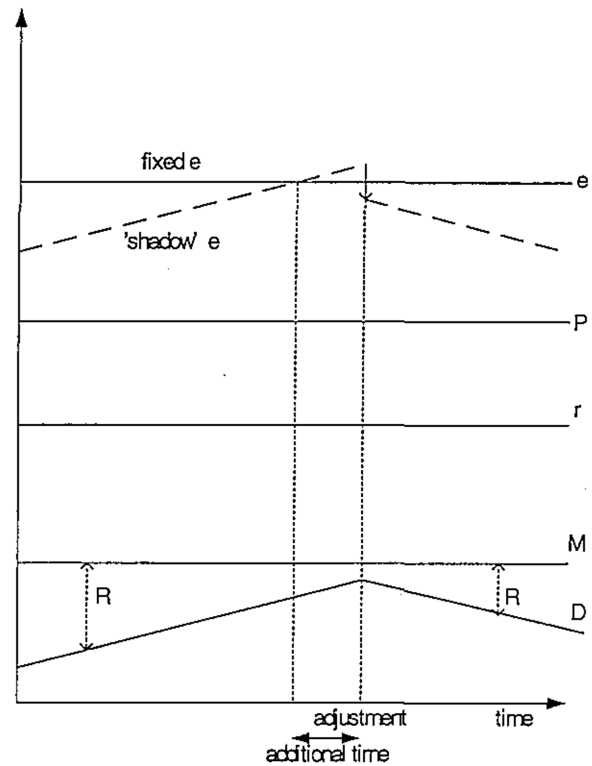
1. Results

It is said of economic forecasts that economists have successfully predicted ten of the last three recessions, and the model discussed in this paper is true to the spirit of this observation. The Barbados currency is 'predicted' by the model to devalue three times, whereas in reality the parity has been defended successfully since 1975. Returning to the discussion in section II.3 above, this result can be interpreted as implying that the inhibition of speculative arbitrage in the foreign exchange market by the retention of exchange controls was central to the defence of the Barbados currency.

Exchange controls, by preventing large-scale speculation against the currency, allow the authorities a window of opportunity to correct external imbalances once balance of payment problems have become apparent. Without speculative arbitrage, the shadow exchange rate can depreciate to above the fixed rate without immediately triggering a crisis. Meanwhile, the monetary authorities can head off the impending crisis by making the necessary adjustment to policy (reducing the expansion in domestic credit). This is illustrated in figure 2 below.

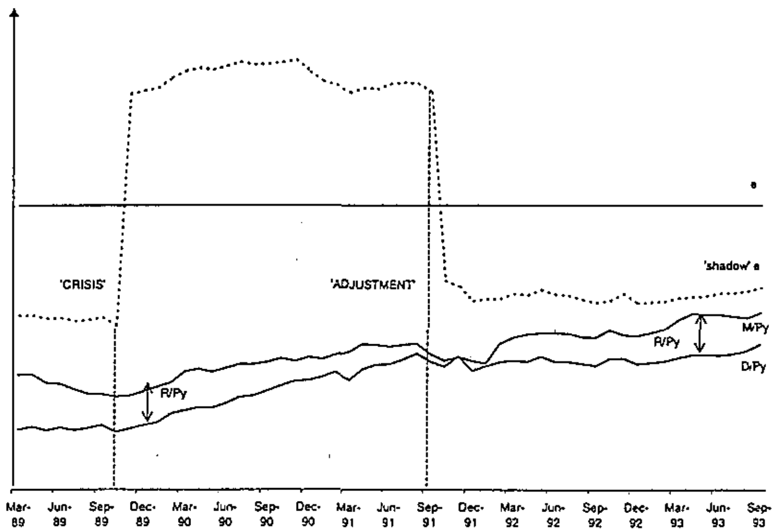
In reality, there is likely to be foreign exchange hoarding and attempts to circumvent the Central Bank's regulations on foreign exchange dealings. In other words, small-scale speculative activity will occur, so there is likely to be some acceleration in the slippage in reserves. Hence the true picture will be a compromise between figures 1 and 2. The money supply will start to fall as foreign exchange leaks out of the system, thus reducing the authorities' window of opportunity and hastening the need for policy intervention. Chart 3 presents a close-up view of the 1991 'crisis' in terms of monetary aggregates (in proportion to nominal income) and the shadow exchange rate. An accelerated slippage in reserves is discernible from the early summer of 1991.

FIGURE 2: TIME-PATH OF CRISIS AVOIDANCE



A further effect of exchange controls is to force residents to purchase real assets as opposed to restricted financial assets (foreign currency or foreign bonds) when faced with a potential devaluation and capital loss on holdings of domestic currency. Essentially, the drop in the demand for money is matched by an increase in imports rather than in capital outflows (Agénor et al., 1992; p.376). This allows the explanation of a deteriorating current account deficit by a purely monetary theory of the balance of payments, reversing the causal link often advanced. Rather than ascribing the slippage in reserves and contraction in the money supply to an exogenous surge in import demand, this account explains the increase in imports as a result of money market developments. Specifically, the expected devaluation leads domestic agents to swap domestic currency for safer assets (imported goods), in response to legal constraints on purchases of foreign financial assets.

Chart 3: Time-Path of Crisis Avoidance: the 1991 Adjustment



However, this emphasis on exchange controls in accounting for the difference between the predictions offered by chart 2 and Barbados's actual experience can be challenged. A number of alternative explanations are discussed below.

Firstly, there is the question of whether the expected post-crisis policy regime is correctly specified. As outlined in section II.2, the expected post-crisis domestic credit expansion, which determines the floating exchange rate, is hypothesised to be simply a continuation of the present policy. Suppose that instead agents expect that in subsequent periods the government will in fact reign in domestic credit growth so that $\mu=0$. In this case there is no crisis as long as the authorities maintain some reserves, essentially because agents perceive that, given the occurrence of a crisis, there will not be an inflationary domestic credit expansion, prices will not rise and the exchange rate will not depreciate. Thus there will be no capital gain from an attack, so that no attack is made and the currency peg will survive. [11]

This account links into ideas of 'reputation' and could help explain why no significant parallel market in foreign exchange emerged in the 1991 crisis. Barbadians, it is argued, simply did not believe that the authorities would allow the currency to devalue, and expected remedial measures to be taken before a full-blown crisis emerged. However, this account must be questioned in the Barbados context because it would require agents' beliefs about the authorities' monetary policies to be consistently wrong. They would, for periods of two years or more, be expecting the government to reign in domestic credit expansion when in fact domestic credit continued to grow.

A second explanation derives from the impact of uncertainty over the authorities' policy parameters. As outlined in Flood and Garber's (1984) stochastic model, the stochastic error term in the domestic credit growth path implies that, given a sufficiently large realisation of the 'innovation' to domestic credit, a crisis could be triggered in any period. This implies that there is always some non-zero probability of a crisis occurring which in turn implies that the expected devaluation is always non-zero. This helps to explain a stylised fact, namely that as periods of 'crisis' draw near a positive nominal interest rate differential tends to emerge between the domestic and world economies. This is because as the supply of international reserves is depleted, the 'innovation' to domestic credit necessary to trigger a crisis becomes smaller and a crisis therefore becomes more likely. Concurrently, the expected rate of depreciation grows and the interest rate differential therefore increases to maintain the UIP condition. Such an interest rate differential was apparent in the case of Barbados in 1982 and 1991. The random element to domestic credit formation also explains the gradual slippage in reserves over the rate of expansion in domestic credit which tends to occur in the run-up to a crisis and was in evidence in Barbados during 1991 (chart 3, above). As the probability of a crisis grows and the domestic interest rate increases, the demand for money is choked off and this is reflected in a more rapid depletion of reserves.

However, the stochastic element does not explain the central stylised fact in the Barbados case, namely that a devaluation failed to occur. As long as the shadow exchange rate given in equation

[11] Conversely, even if present domestic credit growth is not expansionary but agents expect the government to follow an expansionary policy and allow the currency to devalue *if* the exchange rate peg is destroyed, then an attack can occur (see Obstfeld, 1986 and Agénor et al., 1992). This is discussed further in the final section.

(7) (which incorporates the realisation of the random innovation to domestic credit and therefore allows for the impact of stochastic shocks) is above the fixed rate, the currency should be forced to devalue. Thus although a more explicit examination of the implications of the stochastic model gives some interesting insights, it does not account for the failure of the Barbados dollar to devalue as predicted.

2. Relevance for Policy

Two periods of 'crisis' in Barbados's Balance of Payments position are referred to in the literature (Dalrymple (1995)) and in political discourse on the country's exchange rate position. It is generally believed that devaluation was only narrowly avoided in 1991, and that the successful avoidance of devaluation in September 1991 and subsequently was due to the adoption of macroeconomic adjustment policies and a 'social compact' reducing inflationary pressures in the economy. These adjustment policies included tax increases and cuts in public sector pay and employment. However, the results of this paper indicate that for almost two years prior to the 1991 'crisis', as well as during other periods, a devaluation 'should' have occurred by the predictions of the model. The avoidance of devaluation can be ascribed to the maintenance of exchange controls.

With regard to future policy, this paper points to a number of conclusions. Firstly, the maintenance of exchange controls will be necessary if Barbados is to continue to pursue policies of domestic credit expansion over the medium term inconsistent with Balance of Payments equilibrium. Of course a first-best position may be to avoid excessive domestic credit expansion in the first place. However, the extra lee-way which controls give enables the authorities to pursue domestic policy considerations (maintaining economic growth, reducing unemployment), without the external constraint binding, for a longer period of time. Given hysteresis effects (the position of the economy today being dependent on its position in previous periods), this may have lasting welfare-improving effects. Controls may also give the authorities more time to react to unpredictable shocks. Offset against these benefits must be the costs to business of bureaucratic controls over their foreign exchange dealings.

Secondly, a high level of reserves notwithstanding, the ongoing economic expansion is reflected in domestic credit growth which will eventually lead to a similar position as that experienced in 1991. The fall in reserves experienced around the start of 1999 confirms the picture given by chart 2, namely that the shadow exchange rate is at a potentially dangerous level. Barbados may well be passing through the additional period of adjustment given in figure 2; the May 1999 decision of the authorities to tighten monetary policy may reflect a similar diagnosis on their part.

Thirdly, as discussed in the previous section, when agents do not automatically expect the present domestic credit growth path to continue in a post-devaluation environment, then the occurrence of a crisis comes to depend on the nature of the private sectors' expectations. Even when *present* domestic credit growth is consistent with balance of payments equilibrium, if the private sector expects the authorities to follow an inflationary policy of credit expansion after the currency moves to a floating regime (in order to stimulate the economy), then this can lead to a crisis. This strengthens the argument for maintaining exchange controls even when the authorities are pursuing a policy of domestic credit growth consistent with external balance.

It further implies that although the exchange rate peg is the central anchor for inflationary expectations, if the peg is to be defended it requires that the private sector expects a low-inflation credit policy to continue *even if the currency were to float*.[12] This is particularly true if further liberalisation of exchange controls limits the cushioning impact these have on the level of international reserves. One credible low-inflation policy instrument in a floating exchange rate environment is an independent central banker as outlined by Rogoff (1985) and Walsh (1995). However an alternative instrument which has proved successful in the Barbados context is an incomes policy. Therefore the complementarity between the fixed exchange rate and the ongoing incomes policy is bi-directional. Not only does the exchange rate peg facilitate the social compact by guaranteeing the purchasing power of the Barbados dollar, but the social compact bolsters the exchange rate peg through the expectations mechanism outlined above.

Finally one can use the spirit of the 'second generation' political economy models to argue for the maintenance of a fixed exchange rate in Barbados. In these models, as argued in section I.2, a critical factor determining the inevitability of devaluation is that the costs of defending the existing parity should increase as the exchange rate comes under pressure. One can argue that in Barbados the converse may be true, that the painful macroeconomic adjustment necessary to

[12] The importance of 'out of equilibrium' beliefs in sustaining equilibrium outcomes is central to Game Theoretic analyses of behaviour under uncertainty. Definition of a *Perfect Bayesian Equilibrium* requires the specification of players' beliefs which are compatible with equilibrium, even when these beliefs refer to outcomes off the equilibrium path. Thus upholding a 'no devaluation' equilibrium requires that beliefs

maintain the fixed parity only becomes palatable when the exchange rate is threatened. However, since an exchange rate crisis is merely the manifestation of general macroeconomic imbalance, measures to protect the 2:1 parity are in fact measures to maintain macroeconomic balance in general. Thus the fixed rate has value in Barbados partly because it is perceived to do so by the public. It is a political 'untouchable,' the protection of which renders palatable austerity measures which the public would not accept otherwise.

about policy in an alternative 'devaluation' outcome are consistent with the equilibrium, *even though the beliefs refer to an outcome which will not occur in equilibrium.*

BIBLIOGRAPHY

Agénor, P., J. Bhandari and R. P. Flood (1992), "Speculative Attacks and Models of Balance of Payments Crises," *IMF Staff Papers* 39.2 pp.357-394

Buiter, W. H., G. M. Corsetti and P. A. Pesenti (1998), "Interpreting the ERM Crisis: Country-Specific and Systemic Issues," *Princeton Studies in International Finance* 84

Bynoe-Mayers, N. (1997), "Measuring the Real Exchange Rate using GDP Deflators," *Central Bank of Barbados Economic Review*, June pp. 57-67

Central Bank of Barbados (1976-1998), *Economic and Financial Statistics*, Various Issues

Central Bank of Barbados (1997), *Annual Statistical Digest 1997*

Coppin, A. (1994), "The Determinants of International Reserves in Barbados: A Test of the Monetarist Approach," *Social and Economic Studies* 43.2, pp.75-90

Dalrymple, K. (1995), "Balance of Payments Crisis and Policy Options: The Case of Barbados," *Central Bank of Barbados Working Papers*, pp. 288-297

Dornbusch, R. (1987), "Collapsing Exchange Rate Regimes," *Journal of Development Economics* 27 pp.71-83

Flood, R. and P. Garber (1984), "Collapsing Exchange Rate Regimes: Some Linear Examples," *Journal of International Economics* 17, pp. 1-14

Hamilton, J. D. (1994), *Time Series Analysis*, Princeton, New Jersey: Princeton University Press

International Monetary Fund (1996), *Exchange Arrangements and Exchange Restrictions Annual Report* (Washington D.C.: IMF)

Krugman, P. (1979), "A Model of Balance-of-Payments Crises," *Journal of Money, Credit and Banking*, 11.3, pp. 311-325

Krugman, P. (1998), *Currency Crises*, mimeo., Cambridge, Massachusetts: MIT (Available on web.mit.edu/krugman/www/crises.html)

Lewis, D. (1997), "A Quarterly Real GDP Series for Barbados, 1974-1995: A Sectoral Approach," *Central Bank of Barbados Economic Review*, June pp. 17-56

Looney, R. E. (1991), "A Monetary Approach to Movements in Caribbean Balance of Payments," *Social and Economic Studies* 40.1, pp.105-32

Milesi-Ferretti, G. M. and A. Razin (1998), *Current Account Reversals and Currency Crises: Empirical Regularities*, IMF Working Paper WP/98/89, Washington DC: IMF

Obstfeld, M. (1986), "Rational and Self-Fulfilling Balance-of-Payments Crises," *American Economic Review* 76.1 pp. 72-81

Obstfeld, M. and K. Rogoff (1995), "The Mirage of Fixed Exchange Rates," *Journal of Economic Perspectives* 9.4 pp.73-96

Radelet, S. and J. Sachs (1998), *The East Asian Financial Crisis: Diagnosis, Remedies, Prospects* April 20 (Cambridge, Mass.: Harvard Institute for International Development)

Rogoff, K. (1985), "The Optimal Degree of Commitment to An Intermediate Monetary Target," *Quarterly Journal of Economics* 50, pp.1169-1189

Rolle, J., (1994), "Fixed Exchange Rates and Exchange Controls," *Social and Economic Studies*, 43.4 pp. 157-182

Walsh, C. E. (1995), "Optimal Contracts for Central Bankers," *American Economic Review* 85.1, pp.150-167

Wyplosz, C. (1986), "Capital Controls and Balance of Payments Crises," *Journal of International Money and Finance* 5, pp.167-179

APPENDIX

The Purpose of this appendix is to deal with a number of technical and econometric issues touched upon in the text.

i. Estimation of (1), (4) and (5)[13]

The domestic interest rate is an endogenous variable determined (in part) by the government, and is by assumption contemporaneously correlated with ε_{1t}. Hence OLS estimation of equation (1) without taking into account the feedback mechanism would lead to inconsistent parameter estimates. This can be corrected for by the use of Instrumental Variable (IV) estimation, using as an instrument some variable which is correlated with the domestic interest rate but related to k_t only indirectly through its impact on r_t. Given the theoretical link established in equation (4) between the domestic rate of interest and the US rate r_t^*, the latter variable is a sensible choice of instrument. The constant term is also included as an instrument for itself.

Table 1: IV Estimation of Equation (1)

273 Observations from February 1976 to October 1998

Coefficient	Estimate	t-statistic [pr.]
α	12.0184	6.3868 [.000]
$-\beta$	-982.7077	-2.7017 [.007]
Adjusted GR-Squared	**Serial Correlation $\chi^2(12)$ [pr.]**	**Heteroskedasticity $\chi^2(1)$ [pr.]**
.34094	16.7855 [.158]	13.1976 [.000]

The results of IV estimation of equation (1) are reported in Table 1. Microfit's diagnostic test statistics indicate that while serial correlation in the residuals is not a problem, the null hypothesis of no heteroskedasticity can be rejected. Hence while the estimated coefficients on the independent variables are likely to be unbiased the standard errors and t-statistics derived from them will be incorrect. Hence the reported t-statistics are derived from heteroskedasticity-adjusted standard errors based on the White method [see Hamilton (1994) pp. 218-220].

[13] All econometric analysis is undertaken using Microfit 4.0 for Windows

OLS regression of the Barbadian interest rate on the US rate indicates the presence of strong residual serial correlation. In order to purge the residuals of the autocorrelation a dynamic equation can be estimated in VECM form including sufficient lagged dependent variables. Experimentation with the lag structure yields equation (9) as the superior specification, which is estimated by OLS. The results are reported in Table 2: the diagnostic test for heteroskedasticity is ambiguous so both standard and White-adjusted t-statistics are given.

$$r_t = \delta_0 - \delta_1 r_{t-1} - \delta_2 r_{t-2} - \delta_3 r_{t-3} - \delta_4 r_{t-4} + \gamma_0 r_t^* + \gamma_1 r_{t-1}^* + \varepsilon_{2t}$$

or (9)

$$\Delta r_t = b_0 + b_1 \Delta r_{t-1} + b_2 \Delta r_{t-2} + b_3 \Delta r_{t-3} + b_4 r_{t-1} + b_5 \Delta r_t^* + b_6 r_{t-1}^* + \varepsilon_{2t}$$

Table 2: OLS Estimation of Equation (9)

270 Observations from May 1976 to October 1998

Coefficient	Estimate	t-statistic [pr.]	
		Standard	White
b_0	.0001362	1.8335 [.068]	1.3156 [.189]
b_1	.27966	4.7502 [.000]	2.3535 [.019]
b_2	.16559	2.7251 [.007]	1.5601 [.120]
b_3	.17329	2.8800 [.004]	1.7768 [.077]
b_4	-.045598	-4.2209 [.000]	-2.7777 [.006]
b_5	-.11216	-2.4873 [.013]	-1.7684 [.078]
b_6	.018806	1.9941 [.047]	1.5563 [.121]
Adjusted R-Squared	**Serial Correlation $\chi^2(12)$ [pr.]**	**Heteroskedasticity $\chi^2(1)$ [pr.]**	
.24968	12.3429 [.419]	6.3656 [.012]	

The implied long run effect from r_t^* to r_t given in equation (4), g_1, can be derived from (9) as $-b_6/b_4 = .4124$. The long run constant term g_0 is given by $-b_0/b_4 = .002987$.

Equation (5) is estimated in logarithmic form as in (10) below, which embodies the restriction imposed by the condition that the coefficients on $\ln(P^*_t e_t)$ and $\ln P_{t-1}$ in (5) sum to unity. Although the constant term is significantly different from zero, it is nevertheless close to zero and is therefore assumed to be zero in the analysis. The results of estimating (10) are given in table 3 below. Given the evidence of heteroscedasticity, White adjusted t-statistics are given.

$$\Delta \ln P_t = \tau + \gamma(\ln P_t^* e_t - \ln P_{t-1}) + u_t \qquad (10)$$

Table 3: OLS Estimation of (10)

274 Observations from February 1976 to November 1998

Coefficient	Estimate	t-statistic [pr.]
τ	.0037058	6.4607 [.000]
γ	.042674	3.8832 [.000]
Adjusted R-Squared	**Serial Correlation $\chi^2(12)$ [pr.]**	**Heteroskedasticity $\chi^2(1)$ [pr.]**
.079661	11.3881 [.496]	5.9872 [.014]

ii. Data Selection

Because the precise timing of the crises is important, estimation using anything less frequent than monthly data would be devoid of purpose. Monthly series for money (total monetary liabilities, comprising the money supply, quasi-money and foreign currency accounts of non-residents), domestic credit and the net foreign assets of the banking system are available in The CBB's *Economic and Financial Statistics* Monetary Survey (Table C2), and are used as proxies for M, D and R respectively.[14] Since the money aggregate includes interest-bearing deposits, the applicability of equation (1), with a negative relationship between the inverse velocity and the interest rate, may be in doubt. However in general money has advantages in liquidity over other assets, which are offset by lower rates of return, so that although the relationship posited in (1) may be blunted by the inclusion of interest-bearing monetary assets, it is unlikely to be entirely negated.

It must be noted that the domestic credit and foreign reserve variables identified above, being counterparts of a broad monetary aggregate, reflect the domestic credit creation and foreign asset position of the financial sector *as a whole*. An alternative approach would be to define D and R as

[14] Since the condition M=D+R is not exactly met in the data, the condition is enforced by using the sum of domestic credit and foreign assets to measure the broad money stock.

the counterparts of the monetary *base*, so that they would measure the domestic credit creation and foreign assets of the monetary authorities alone. In the foregoing analysis R was identified as the reserve position of the monetary authorities, and domestic credit was implicitly equated to credit creation within the government's direct control, so this approach would have some merit.

However, since the money base and those monetary assets included in the broad monetary aggregate but outside base money are likely to be close substitutes, it is necessary to use the broad measure for estimating a meaningful demand for money function. This implies that in order to derive the relationship between domestic credit creation and foreign reserve depletion based on an exogenous demand for money function, we have to specify some money-multiplier relationship between the broad and narrow aggregates. This introduces new problems, as the value of the multiplier is likely to vary over time and may not be policy invariant. Moreover, it is valid to use the reserve and credit position of the financial system as a whole to proxy for R and D in the model. Government policy will impact on overall credit creation by changing private sector behaviour. Furthermore, total foreign assets are dominated by the net foreign reserves of the monetary authorities, with commercial banks holding only a fraction of the financial sector's total international reserves (CBB *Economic and Financial Statistics* Table H1).

The choice of interest rate is problematic. Monetarist criticism of the Keynesian position relating the demand for money to 'the' interest rate must be borne in mind. Why should the demand for money depend on the rate of return on one particular financial asset (say, government bonds) but not on others? It is difficult to defend the choice of one particular interest rate over another, however in order to maintain the tractability of the model it is important to specify the demand for money function in simple terms. Hence I include only the interest rate on 3-month Treasury Bills, on the basis that the series is conducive to econometric analysis. That is to say a complete series is available for the time period under consideration, and there is a good deal of variability in the rate over time. The rate is converted to a monthly (1-period) rate in order meet the specifications of the model. Estimation of equations (10) and (11) requires the use of the 'foreign' interest rate: since the Barbados dollar is fixed against the US currency, the yield on 3-month US Treasury Bills is the obvious choice. The US interest rate is available in electronic format from the Federal Reserve Bank of St Louis' *FRED* database on its web-site (www.stls.frb.org).

Price data for the US and Barbados are available on a monthly basis. The Barbados RPI is tabulated in the CBB *Economic and Financial Statistics* Table I1; the US CPI is available on *FRED*. As both series are purely nominal, it is necessary to normalise them. Following equation (5), PPP is expected to hold on average, therefore the Barbados price series is normalised so that the sample mean, over the period of estimation, is equal to the sample mean for the US price series multiplied by the fixed exchange rate, ie 2.

Arriving at a suitable income proxy is the most problematic area in the data selection process. The obvious complication is that estimates of real GDP are only available on a quarterly basis (presented in Lewis (1997)), and even these are only approximate estimates reflecting a paucity of data. However a further problem is presented by the theoretical challenge of the permanent income approach to the consumption. It is generally believed that consumption will be more responsive to changes in income which are perceived to be permanent than to transitory fluctuations, reflecting a degree of consumption smoothing on the part of consumers. This implies that the transactions demand for money is likely to be more elastic with respect to permanent changes in income as opposed to more transitory ones. In fact this added difficulty may be something of a blessing in arriving at a suitable proxy for the income term in our estimation. Assuming that consumers adjust their money balances on the basis of updated information about their permanent income, then a suitable income proxy for use in estimating monthly money demand would be one that fulfils two conditions:

i. It is highly correlated with income over the long term, so that it is a good predictor of permanent income.
ii. Information which allows consumers to update their expectations of present permanent income is available monthly.

A data series which fulfils both these conditions is monthly tourist arrivals. Correlation between annual arrivals and annual real GDP (the latter series is estimated by the CBB and presented in their *Annual Statistical Digest* Table I1) is around 97% over the 1976-1997 period. It is assumed that every month the private sector updates their expectation of present permanent income by noting that month's tourist arrivals and using the data to update their beliefs noting the strong long-term correlation between income and tourist arrivals. Data on monthly tourist arrivals is presented in *Economic and Financial Statistics* Table H9. The proxy is constructed by taking a 12 month moving average for the preceding 12 months and then normalising by dividing through by the average for the entire period. Using a 12 month average removes the problem of seasonality and represents a trade-off between the need to reflect an updating of beliefs (using the most recent information) and the need to reflect *permanent* rather than transitory factors (and hence averaging over a longer time period).

iii. Stationarity and Cointegration

Conventional estimation and inference techniques rely upon stationarity in the underlying data. However, even when two (or more) data series are non-stationary, it may be that the series are cointegrated, implying that the non-stationarity in one series is effectively driven by the non-stationarity in the other. Despite the non-stationary nature of the series, there nevertheless exists a long-run relationship between the data. If this is the case, then estimation and inference can still be undertaken.

To verify our estimates from (1), (9) and (10) we must first assess whether the variables P_t, P^*_t, k_t, r_t and r_t^* are stationary, and if not, if a cointegrating relationship exists for each equation. Essentially, one can approach the question of stationarity from a number of directions. We can utilise a priori information about the data, based on economic theory or experience. Alternatively, we can assess the available data, both graphically and by formal econometric analysis.

A priori, *one would expect interest rates and the velocity of circulation to be stationary.* Both series are likely to be bounded from above and below, and therefore cannot follow a random walk indefinitely.

However, one would equally expect both to exhibit strong serial correlation, so that it will be difficult to formally reject the hypothesis that the underlying data generating process (DGP) is non-stationary, even if the data is in fact I(0) (stationary, or integrated of order zero). Indeed, with a finite sample size, for any unit root process there exists a stationary autoregressive process which is indistinguishable from it (Hamilton (1994) pp.444-447). On the other hand we are able to test whether the data conforms to a *specific* unit root process as opposed to a *specific* stationary process.

A standard test for stationarity is the Dickey-Fuller test. Consider the following DGP for a random variable x_t:

$$x_t = \rho x_{t-1} + \upsilon_t; \qquad \upsilon_t \sim \text{iid}\ (0, \sigma^2_\upsilon) \tag{11}$$

Alternatively:

$$\Delta x_t = \rho^* x_{t-1} + \upsilon_t; \qquad \rho^* \equiv \rho - 1 \tag{12}$$

Testing whether x_t is I(1) or I(0) is equivalent to testing the null hypothesis $\rho^* = 0$ against the alternative that $\rho^* < 0$: an appropriate test statistic is the Dickey-Fuller statistic $\tau = \frac{\hat{\rho}^*}{\hat{\sigma}_{\hat{\rho}^*}}$.

However, since x_t is non-stationary under the null, then the standard t-statistic critical values, which rely on stationarity, are invalid. Alternative critical values for the Dickey-Fuller test depend on the specification of the null and alternative hypotheses: specifically, they depend on whether the null hypothesis posits a non-zero mean and a drift term in the random walk. Graphical examination of the data as well as economic theory suggest that for the series under consideration here the appropriate case is where there is no drift term but the expected value is non-zero. Hence, with the maintained hypothesis given by (12) with the addition of a constant term, the test for stationarity is formally given below:

H_0: $\rho^* = 0$ vs. H_1: $\rho^* < 0$; decision rule: reject H_0 if $\tau <$ critical value.

Critical values are tabulated in Hamilton (1994) p.763; the appropriate 5% critical value for the test where x_t has a non-zero mean is –2.88. Test statistics for $x_t = (k_t, r_t, r_t^*)$ are –2.1726, -1.6853, and –1.6117 respectively. Hence, in each case we are unable to reject the null hypothesis of a random walk. The Dickey-Fuller test can be augmented by the addition of lagged values of Δx_t to give ADF(n) statistics, where n is the highest order of the lag process. For r_t and k_t the null hypothesis is rejected for ADF(2) and ADF(12) respectively; for r_t^* the unit root hypothesis is robust up to ADF(12), the highest order ADF statistic calculated by Microfit. Hence, depending on the lag process hypothesised, the econometric evidence is supportive of the unit root hypothesis, to a greater or lesser degree, for all three variables.

Summarising our previous discussion, whilst the evidence is in favour of non-stationarity, theory and experience suggests that strong serial correlation, empirically indistinguishable from a random walk given the constraint of a limited sample size, is more likely than actual non-stationarity. However, in order to show the validity of our results even if we accept the evidence for non-stationarity, we need to demonstrate evidence of cointegration between the variables. If the series are cointegrated then we can be confident that the derived results are indicative of a long-term relationship rather than the spurious co-movement of two serially correlated but unrelated series.

By definition, if x_t and z_t are both I(1) random variables, then if there exists a cointegrating relationship $x_t=\lambda_0+\lambda_1 z_t+\eta_t$, with η_t a random error term, then η_t will be I(0).[15] Hence a test for cointegration can be undertaken by undertaking the Dickey-Fuller procedure discussed above on the OLS residuals from the regression of x_t on a constant and z_t. The null hypothesis of no cointegration can be rejected if the test statistic τ is less than the appropriate critical value. To test whether the results from (1) and (9) represent cointegrating relationships between k_t and r_t and r_t and r_t^* respectively, we need to analyse the residuals obtained from our previous estimation and ascertain whether they exhibit stationarity.

The appropriate 5% critical value (distributed differently from the standard Dickey-Fuller statistic, given in Hamilton (1994) p.766) depends on the number of non-constant regressors in the original cointegrating regression. For 1 regressor (as in equation (1)) the value is –3.37; for 5 regressors (approximating to the 6 regressors in equation (9)), the value is –4.71.[16] The appropriate test statistics from undertaking the DF/ADF procedure on the residuals from (1) and (9) depend on the order of ADF undertaken. Given that there is likely to be a seasonal component in the demand for money it seems appropriate to utilise the ADF(12) statistic in order to allow for monthly dynamics: this statistic is –3.39 so that the null hypothesis of no cointegration may marginally be rejected. Conversely one might wish to limit the degree of serial correlation allowed for in the residuals from (9), and the null hypothesis of no cointegration is strongly rejected for low orders of ADF, and rejected at the 5% level for the DF statistic and the ADF statistic up to ADF(9). Hence if we accept that the variables are non-stationary, there is some evidence that (1) and (9) describe cointegrating relationships.

The evidence for equation (10) is more straightforward. ADF tests of P_t and P^*_t indicate that both are I(1). Conversely, ADF tests on the residuals from equation (10) indicate that the null hypothesis of no cointegration can be rejected using DF and ADF(1)-(12). Therefore we can be extremely confident that equation (5) represents a long term price adjustment equation relating the Barbados and US price levels.

iv. Explanation of d and estimation of μ

The growth path of domestic credit specified in equation (3) is given in terms of d_t, nominal domestic credit denominated by a complex expression involving income, prices and the exchange rate. From (3), d_t is given as (13) below:

$$d_t = \frac{D_t}{P_t^{*\gamma} e_t^{(\gamma-1)} P_{t-1}^{(1-\gamma)} y_t} = \frac{D_t}{P_t^* y_t}\left(\frac{P_t^* e_t}{P_{t-1}}\right)^{(1-\gamma)} \tag{13}$$

If PPP were to hold exactly (γ=1), then the last fraction in (13) would collapse to unity and d_t would be equal to domestic credit denominated solely by the level of income and the foreign price level. This means that, controlling for increases in credit necessary to cover exogenous shifts in prices and income, the 'excessive' inflationary increase in domestic credit would be given by (on average) μ. As D increases, reserves are run down until the currency floats and the equilibrating role between the supply and demand for money is switched to the domestic price level and the nominal exchange rate. The reason why d is not given by D denominated by the product of real income and the *domestic* price level (even in a PPP environment), is that once a devaluation occurs the domestic price level will start to increase. This implies that the increase in D necessary to maintain a constant growth in d (ie μ) will increase, so that the domestic credit regime is no longer exogenous and independent of whether a devaluation occurs.

With PPP relaxed, the last fraction in (13) can be thought of as an index of price misalignment, with greater misalignment given by greater divergence from unity (in either direction). The numerator gives the 'optimal' level for domestic prices, the denominator the 'drag' on prices caused by the autocorrelation with last period's price level. The degree of misalignment is greater when the numerator and denominator differ more and for levels of (1-γ) closer to 1 (representing slower price adjustment). The last fraction is necessary because exogenous shifts in P* no longer pass through to P instantaneously, and therefore denominating D in terms of foreign prices and domestic real income no longer accurately reflects domestic credit holding exogenous factors

[15] The definition of cointegration is that for x_t and z_t both I(1) random variables, there exists some cointegrating vector $\theta_0 x_t + \theta_1 z_t = y_t$, where θ_0 and θ_1 are constants and y_t is an I(0) random variable. Define $\theta_0\equiv 1$ and $\theta_1\equiv -\lambda_1$; then clearly $y_t\equiv\lambda_0+\eta_t$. Hence if there exists a cointegrating vector $\theta_0 x_t + \theta_1 z_t = y_t$ with y_t I(0), then by substituting for θ_0 and θ_1 we have $[\lambda_0+\eta_t]$ defined as I(0). Since the sum of two I(0) variables is also I(0) and λ_0 is a constant and hence I(0), then η_t must also be I(0).

[16] The critical values are for a sample size of 500 which is approximately double what we have, reflecting the asymptotic nature of the test when the ADF procedure is undertaken.

constant. A justification for this apparently arbitrary adjustment is that as the foreign price level rises, the real exchange rate depreciates (domestic goods become cheaper) as a result of sluggish pass-through to domestic prices. With this improvement in the economy's competitiveness, the monetary authorities will see less need to stimulate the economy and will increase nominal domestic credit less than proportionately to the increase in world prices P*. Hence the growth rate in domestic credit ΔD_t will be constant given exogenous shifts in world prices, domestic real income *and shifts in competitiveness.*

To derive an estimated series for $\tilde{e}_t$ we need to estimate μ, the expected growth in d, which we have assumed to be fixed by the government over the medium term. This is achieved by dividing the period into a series of sub-periods during which μ is assumed to be fixed. Equation (3) is then estimated by substituting for the (T x 1) vector of 1s a (T x n) matrix of dummy variables S, with s_{it} set equal to 1 over sub-period i and 0 otherwise. In order to keep the analysis simple and capture the essential elements of the model and the data, six sub-periods of consecutively low and high μ are identified. The cut-off dates are assigned on the basis of a priori information and graphical analysis. The end of 'μ=high' periods 2 and 4 can be identified as September 1982 and September 1991 respectively, when IMF stabilisation programmes based on fiscal retrenchment were introduced. The end of 'μ=low' periods 1, 3 and 5 are identified graphically by reference to Chart 1: they are assessed as occurring in October 1980, October 1989 and March 1996 respectively. μ_i for i=1,...,6 are derived by the estimation of (3) modified as described above. The resulting equation is given in (14) below:

$$\Delta d_t = \mu_1 s_{1t} + \mu_2 s_{2t} + \mu_3 s_{3t} + \mu_4 s_{4t} + \mu_5 s_{5t} + \mu_6 s_{6t} + v_t; v_t \sim iid(0, \sigma_v^2) \qquad (14)$$

The results of OLS estimation of (14) and a number of test statistics are presented in Table 4. The diagnostic tests reported below indicate that due to the evidence of serial correlation in the residuals the parameter estimates may be biased, they are still likely to be consistent (that is, asymptotically unbiased). The test-statistic for the hypothesis that the mean growth rate in d is constant, against the alternative hypothesis that the mean growth rate is different in six distinct sub-periods as hypothesised in equation (13) indicates that the null can be rejected. That is, the data is broadly supportive of the domestic credit regime indicated by equation (14) and the derived parameter values $\hat{\mu}_i$.

TABLE 4: OLS Estimation of (13), Diagnostic Tests and Wald Test of the Hypothesis that the Mean Growth Rates is Constant over the Period.

272 Observations from March 1976 to October 1998

Coefficient	Estimate	t-statistic [pr.]
μ_1	-.072168	-1.8818 [.061]
μ_2	.13412	2.2413 [.026]
μ_3	-.030191	-.96988 [.333]
μ_4	.14230	2.3779 [.018]
μ_5	-.038806	-.99363 [.312]
μ_6	.072594	1.4084 [.160]
Adjusted R-Squared	**Serial Correlation $\chi^2(12)$ [pr.]**	**Heteroskedasticity $\chi^2(1)$ [pr.]**
.063809	31.5060 [.002]	.60281 [.438]
Wald Test Statistic of H_0: $\mu_i=\mu$ ∀i=1, ..., 6: $\chi^2(5)$ [pr.]		
19.3916 [.002]		