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THE FIXED EXCHANGE RATE IN BARBADOS: Crisis and Adjustment

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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 crisis and 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.

In this paper a model is presented which modifies the 'first generation' analysis by introducing capital market imperfections and allowing dynamic adjustment to equilibrium. The model is estimated using monthly data for Barbados over the 1976-98 period. The results indicate the sensitivity of the model's predictions to changes in the specification of the equations' dynamics. The estimated dynamic model performs well in pin-pointing periods when a devaluation seemed potentially imminent.

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. In the analysis of these models, the process of devaluation is caused by the interaction between the political and economic costs of defending the parity and the private sector's belief that the government is willing to shoulder these costs. This paper outlines a qualitative second generation model, in which the pattern of crisis and adjustment is described in terms of movements in the cost of the peg and the degree of speculative pressure in response to shifts in fundamentals and confidence. It is shown that during both the periods of crisis and adjustment, proxies for the cost and speculation variables moved in the manner predicted by the model.

Both the models indicate the degree of danger to the currency anchor to have been greater in 1991 than in 1982. The first generation model suggests that the recourse to International Monetary Fund assistance in September 1991 was truly an "eleventh hour" intervention. The second generation model implies that following the first period of crisis the underlying fundamentals and level of confidence were weakened, which suggests that crises may have long-term negative effects.

Both models predict that had Barbados's capital market been more developed, less constrained by administrative barriers to foreign exchange dealings and better integrated with world capital markets, the currency anchor would have come under greater pressure and devaluation would therefore have been more likely. This suggests that exchange controls and the comparative underdevelopment of financial markets in Barbados probably helped to protect the currency anchor in 1982 and 1991. This paper is, therefore, supportive of the view that capital account liberalisation, exchange rate stability and an autonomous monetary policy are not simultaneously attainable. Significant relaxation of exchange controls and greater integration with world capital markets, whilst desirable in their own right, imply either the loss of the currency anchor or diminished monetary autonomy. Or possibly both.

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.

This paper examines the rationale behind Barbados's exchange rate policy and its implications for broader macroeconomic management. Of particular interest are two periods of crisis and adjustment, which occurred in 1982-4 and 1991-3. Section I outlines the theory of exchange rate crises and Barbados' 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 'first generation' models discussed by Flood and Garber (1984) and Obstfeld (1986). Section III presents the results of estimating the parameters of the model using monthly data over the 1976-99 period. The implications of the model differ significantly depending upon the specification of dynamics in the underlying behavioural equations. Section IV outlines a qualitative 'second generation' model based on a political economy analysis of the problems facing a government attempting to peg the currency. In qualitative terms the Barbados data is supportive of this 'second generation' account. Section V discusses the implications of the paper's findings.

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

A. 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. 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.

B. First and Second Generation Models of Exchange Rate Crises

Economies which maintain a fixed exchange rate regime usually find that macroeconomic dis-equilibria find their ultimate expression in exchange rate or balance of payments crises. '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

[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 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.

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.

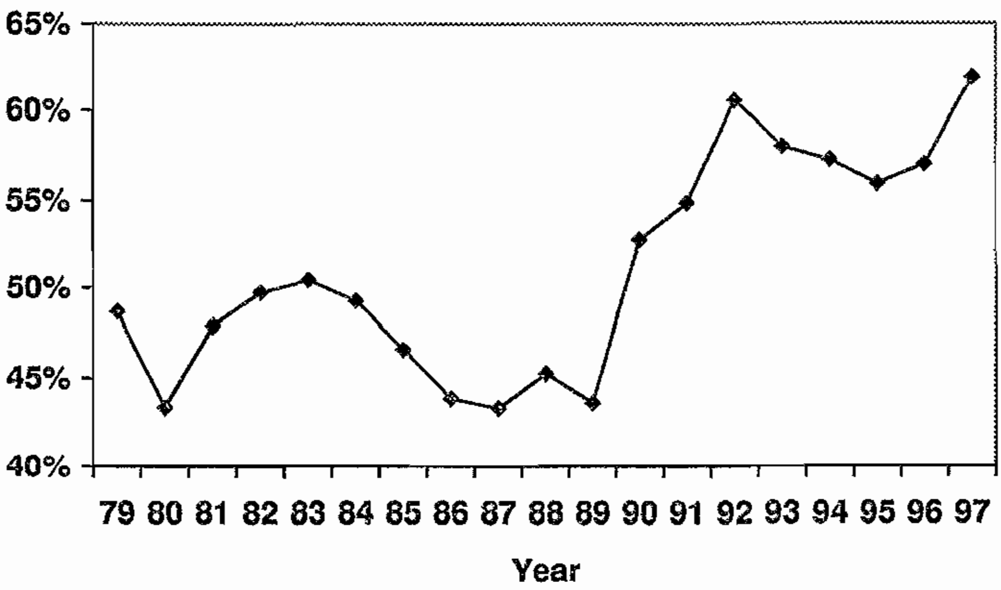
Later 'second generation' models have attempted to approach the issue of currency crises from a political economy perspective. Krugman (1998) outlines the two key elements behind the 'second generation' story. First, a tension should exist between domestic and exchange rate policy. Such a tension is 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. 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. The dynamic process of spiralling economic costs of maintaining the currency regime and declining confidence in the government's willingness to bear these costs is modelled explicitly in section IV.

C. The Barbados Experience of a Fixed Exchange Rate

Barbados has twice experienced balance of payments difficulties, in 1982 and again in 1991, although in both cases the currency was successfully defended through the eleventh 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 context of the 'first generation' crisis models, both periods can be 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 Figure 1 will confirm that such a credit expansion (in relation to GDP) did occur on both occasions.

FIGURE 1: DOMESTIC CREDIT AS A PROPORTION OF NOMINAL GDP



Domestic Credit as a proportion of GDP at current market prices. Source: CBB *Annual Statistical Digest 1998*, Tables C2 and I2.

II. FIRST GENERATION MODEL

A. 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 domestic credit expansion. Real factors, particularly the trade balance, are ignored, as are possible linkages between the three monetary aggregates (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 ignore 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, three innovations are introduced in order to make the model more realistic and therefore suitable for estimation. First, income growth and changes in the foreign price level are accommodated. Second, the presence of capital market imperfections allow some room for government intervention in the financial market so that the simple UIP condition no longer holds. Third, lag structures are introduced to the equations governing the behaviour of interest rates, prices and the demand for money. As will be evident from the results, the results of the model are extremely sensitive to the restrictions placed on the parameters determining the dynamics of the model.

$$[1-A(L)]k_t \equiv [1-A(L)]\left(\frac{M_t}{P_t y_t}\right) = b_0 + b_1 r_t + \varepsilon_{1t}; \qquad \varepsilon_{1t} \sim iid(0,\sigma_1^2) \tag{1}$$

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

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

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

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

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

Equation (1) relates a lag function in 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).

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. The drift term, μ, is assumed to be constant over the medium term, and determined by the government.

Equation (4) is 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.[2] 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. Equation (4) also includes lagged values of r_t, to allow for slow adjustment to equilibrium values. (5) gives the price formation equation, with the speed of adjustment to PPP indexed by the parameter γ.

B. 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 $\overline{e}$, it will run down its reserves, R, until they reach some point $\overline{R}$ 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 $\overline{R}$ is set 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 $\overline{R}$ (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

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[2] 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, lagged dependent variable 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. The lagged Barbados interest rates allow for slow rather than immediate adjustment from previous levels.

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, $D_t + \overline{R}$).[3]

$$\frac{D_t}{(P_t^*\tilde{e}_t)^\gamma P_{t-1}^{(1-\gamma)} y_t} = F(L)k_t + D(1)b_0 + b_1\left(g_0 + g_1\left(r_t^* + E\left[\frac{\Delta\tilde{e}_t}{\tilde{e}_t}\right]\right)\right)$$

where [1-F(L)] = [1-A(L)][1-(D(L)]

$$\Rightarrow \qquad \frac{1}{F(L)k_t + D(1)b_0 + b_1(g_0 + g_1 r_t^*)}\left(d_t - b_1 g_1 E[\Delta\tilde{e}_t]\right) = \tilde{e}_t \qquad (6)$$

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)[4].

$$\tilde{e}_t = \frac{d_t}{F(L)k_t + D(1)b_0 + b_1(g_0 + g_1 r_t^*)} - \frac{b_1 g_1 \mu}{\left(F(L)k_t + D(1)b_0 + b_1(g_0 + g_1 r_t^*)\right)^2} \qquad (7)$$

Obstfeld (1986) proves that as soon as the floating exchange rate becomes higher than the fixed rate ($\tilde{e}_t \geq \overline{e}$) then the monetary authorities see their reserves reduced to $\overline{R}$ (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

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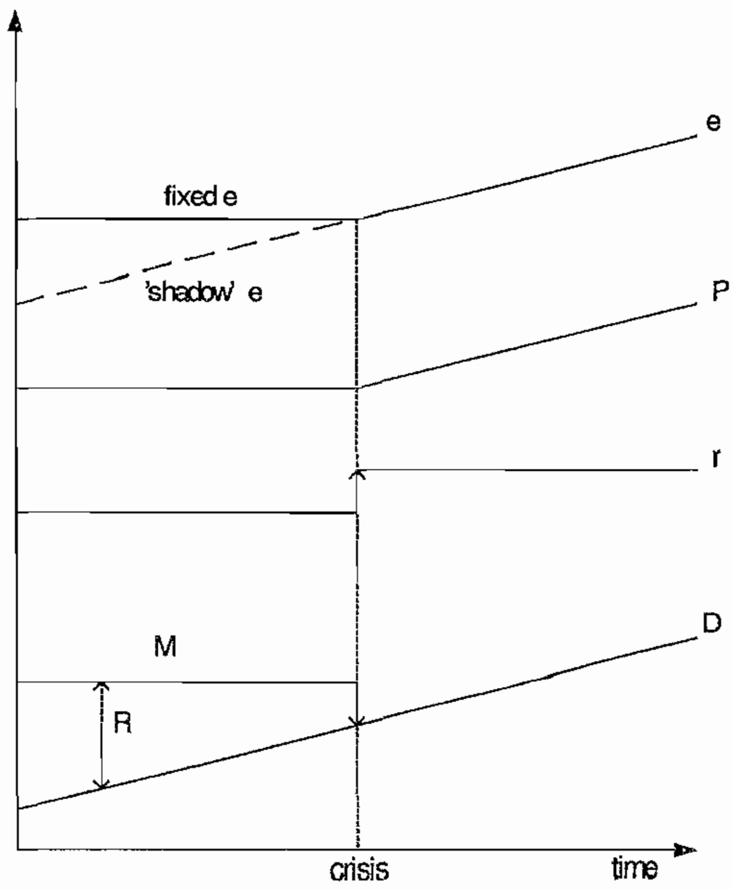
[3] Note that if lagged vales of k_t and r_t are included in the underlying equations (1) and (4) respectively, then equation (6) holds only in the first post-attack period, since in the second period M_{t-1} will be given by D_{t-1}, and so on for further post-attack periods. However, the purpose of generating the shadow exchange rate series is to identify periods when speculative attack was possible; for this purpose only the shadow exchange rate in the first potential post-attack period is relevant.

[4] 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. There is therefore an implicit assumption that the complementary function element of the difference equation is set at zero, which limits the time-path of the shadow exchange rate to its equilibrium value determined by the evolution of economic fundamentals. Note also that non-zero expected changes to the denominator, due to the presence of known lagged terms in k_t, are ignored.

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 demonstrate that a crisis must occur when the shadow floating rate becomes higher than the fixed parity requires further analysis.[5]

FIGURE 2: TIME-PATH OF A CRISIS



The time-path of key variables around the time of the crisis is given in Figure 2. 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 all lag terms are ignored. 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 a certain threshold value at which the shadow exchange rate equals the fixed level, 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.

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

The model outlined in equations (1)-(5) can be estimated either including or excluding the lag terms. If the various lagged dependent variables are excluded, the estimated parameters give the implied long run effect, whereas the dynamic model, including the lag structure on the dependent variables, gives the short run picture. Estimating both long-run and short-run forms fulfils two purposes. Firstly, it allows a comparison of the results depending upon whether or not dynamic factors are included, which gives an indication of any possible errors in the results if the lagged dependent variables are ignored. Secondly, the long run equations provide an estimation of the cointegrating vectors linking the variables should the underlying variables be I(1) non-stationary but cointegrated. The issue of stationarity and cointegration is discussed in the appendix along with an outline of the data sets used.

Finally, in order to estimate the shadow exchange rate series, a proxy for μ must be arrived at. The private sector as well as the researcher faces a problem extracting the underlying trend in domestic credit growth from the white noise component to the random walk process. As the process underlying the determination and evolution of μ is not known, the private sector is presumed to use the 12-month moving average of Δd_t as a proxy for the trend component μ.[6]

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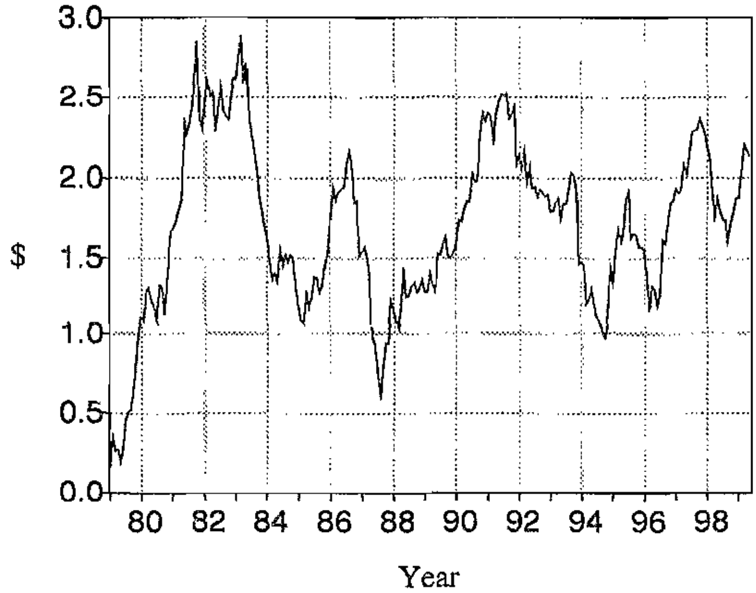
[5] See Obstfeld (1986) Theorem 1 and Proof.

[6] Note that d_t varies between the dynamic model and the long-run model in which PPP is assumed to hold. The proxy μ series for each estimated shadow exchange rate is therefore generated from the appropriate series for d_t.

Tables A1 and A2 in the appendix give the results of the estimated long-run parameters. The presence of serial correlation in the residuals (indicated by the low Durbin-Watson Statistic) suggests the coefficient estimates are likely to be biased although consistency should be maintained. The estimated shadow exchange rate derived from the long run parameters is given in Figure 3.

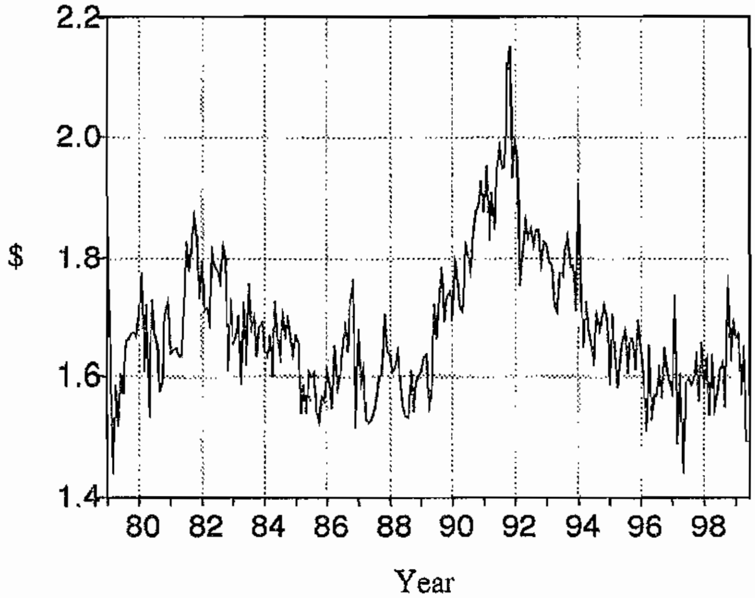
FIGURE 3: SHADOW EXCHANGE RATE (LONG-RUN MODEL)



Tables A3-A5 in the appendix give the results of estimating equations (1), (4) and (5) allowing for the hypothesised lag structures. The length of the lag structures in (1) and (4) arrived upon is based upon iterative attempts to achieve a parsimonious representation. Once again the probable presence of residual serial correlation in one of the equations undermines the unbiassedness property of least-squares estimation and consistency arguments must be invoked to support the use of the estimates arrived upon. The estimated shadow exchange rate derived from these parameters is given in Figure 4.

The results presented in Figures 3 and 4 indicate that not allowing for lagged dependent variables in the underlying behavioural equations leads to a very different outcome in terms of the derived shadow exchange rate series. In particular, the long-run model suggests that the shadow exchange rate was above 2 on several occasions and should therefore have triggered a devaluation. However, once the dynamic structure of the dependent variables is allowed for, the shadow exchange rate is seen to remain below 2 for the entire period, except for two months in 1991.

FIGURE 4: SHADOW EXCHANGE RATE (DYNAMIC MODEL)



Since no devaluation occurred either in the early 1980s or late 1980s / early 1990s, the dynamic model obviously has greater (in-sample) predictive success. If we assume the results of the dynamic model to be correct, the failure to devalue in late 1991 despite the shadow exchange rate being above 2 is easy to rationalise. Given the lags in private sector expectations and the high transactions costs of speculation engendered by prohibitive exchange controls, the comparatively short period of infringement was probably insufficient to trigger a devaluation. The currency anchor would have been additional strengthened by the IMF standby arrangement (negotiated the previous month) which indicated a strengthened commitment to the peg on the part of the government.

IV. A SECOND GENERATION MODEL

Second generation models of exchange rate crises recognise that the choice of exchange rate policy and the government's willingness to adhere to its desired stance reflect a weighing of political costs and benefits. The credibility of the currency peg is therefore determined by the private sector's belief that the government, having committed itself to a fixed parity, is willing to bear the potential political costs of doing so. As Krugman (1998) argues, there exists a two-way relationship between the costs of defending the parity and the private sector's faith in the government's resolve. As the costs of the currency peg rise, speculators increasingly doubt whether the government's commitment will hold. As the speculative pressure increases, this adds to the cost of defending the parity, as the government commits ever greater foreign currency resources fighting off the speculators and as the real economy suffers under tight monetary policy.

This discussion can be condensed into a formal, albeit qualitative, model. Let C represent the costs to the government of defending the exchange rate peg, which is an increasing function of the degree of speculative pressure, S, which the private sector subjects the currency to. At the root of this speculative pressure is the private sector's scepticism of the government's commitment to the peg in face of its costs.[7] C is also a decreasing function of the state of economic fundamentals, F. That is, when the economic environment improves (through, say, an increase in export demand), the costs of the fixed currency regime (loss of scarce reserves, high unemployment) are reduced. In steady state we therefore have:

$$\overline{C} = C\big(\underset{+}{S}, \underset{-}{F}\big) \tag{8a}$$

This steady-state relationship gives the cost consistent with S and exogenous factors. However the actual costs are slow to adjust, due to lags in economic activity. Define S′ as the level of speculative pressure consistent with C being in a steady state *at its present value*. In other words, S′ is the level of speculative pressure at which the cost of defending the exchange rate parity remains constant. When S is greater (less) than S′, costs increase (decrease):

$$\dot{C} = \phi(S - S'); \qquad \phi>0 \tag{8b}$$

[7] As Obstfeld and Rogoff (1995) point out, the idea that government must pay a cost for any lack in credibility in their exchange rate policy is similar to the lesson of rational expectations critiques of discretionary monetary policy in a closed-economy model, as set out in Kydland and Prescott (1977) and related literature.

The degree of speculation, S, is increasing in the costs of the peg, and decreasing in the general level of confidence in the future performance of the economy, defined as P. Therefore in steady state:

$$\bar{S} = S\left(\underset{+}{C}, \underset{-}{P}\right) \tag{9a}$$

The degree of speculative pressure is subject to lags, both because the underlying expectations shift adaptively due to imperfect information, and because transactions costs and delays involved in reducing holdings of Barbados currency limit the degree of immediacy with which the expectations can be acted upon. Defining C' as the level of costs consistent with S being at a steady state *at its present value*, S is revised upwards (downwards) when C is greater (less) than C':

$$\dot{S} = \varphi(C - C'); \qquad \varphi>0 \tag{9b}$$

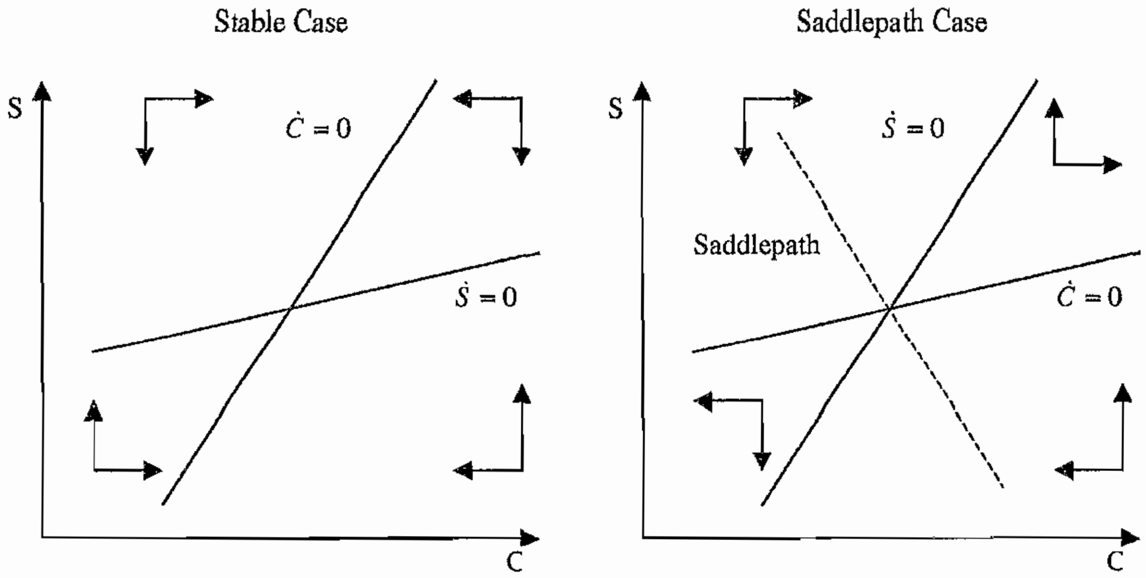
An equilibrium is defined as $E(C^*, S^*)$, where $C^*=C(S^*, F)$ and $S^*=S(C^*,P)$. It is assumed that an equilibrium exists and is unique. The overall dynamic behaviour of the system is dependent on the relative gradients of the two steady state relationships. In C, S space, if the line defined by (8a) is steeper, the system is dynamically stable, with C and S converging to their equilibrium values (C^*, S^*) irrespective of their starting values. With (9a) defining the steeper line, the system exhibits saddle-path stability, with the saddle path sloping downwards to the right. This is illustrated in Figure 5. The stable case is assumed to be the relevant benchmark in what follows.[8]

A period of crisis and adjustment can be defined by shifts in fundamentals and underlying beliefs about future economic performance, F and P. In the initial state, F and P are given as F_0 and P_0 respectively. The onset of crisis is signalled by a deterioration in fundamentals, with F shifting to $F_1<F_0$. This shift in fundamentals could be occasioned by, say, a deterioration in the external balance or an 'excessively' lax fiscal policy. With the steady-state cost function shifted to the right,

[8] The saddlepath case involves a number of unsatisfactory features. For instance, an exogenous adverse shift in either of the steady state relationships actually results in a superior outcome (lower C and S) in equilibrium. In addition, with neither state variable allowed to change discretely to allow the economy to move to the saddlepath, the economy is dynamically unstable. If discrete jumps in S are allowed for (assuming S represents expectations formed rationally rather than adaptively), the implied movements in variables are not consistent with any common-sense account of a currency crisis.

the values of C and S in the new equilibrium E_1 are strictly greater than the initial state E_0. In order to make this event an eventual trigger of a 'crisis' it is assumed that $S_1 > S_{max}$ where S_{max} is some critical value of speculative pressure at which the private sector loses all faith in the government's resolve, triggering a run on the currency and forcing devaluation. Hence with the economy moving towards E_1 the government must act before S reaches S_{max} if it is to maintain the currency peg.

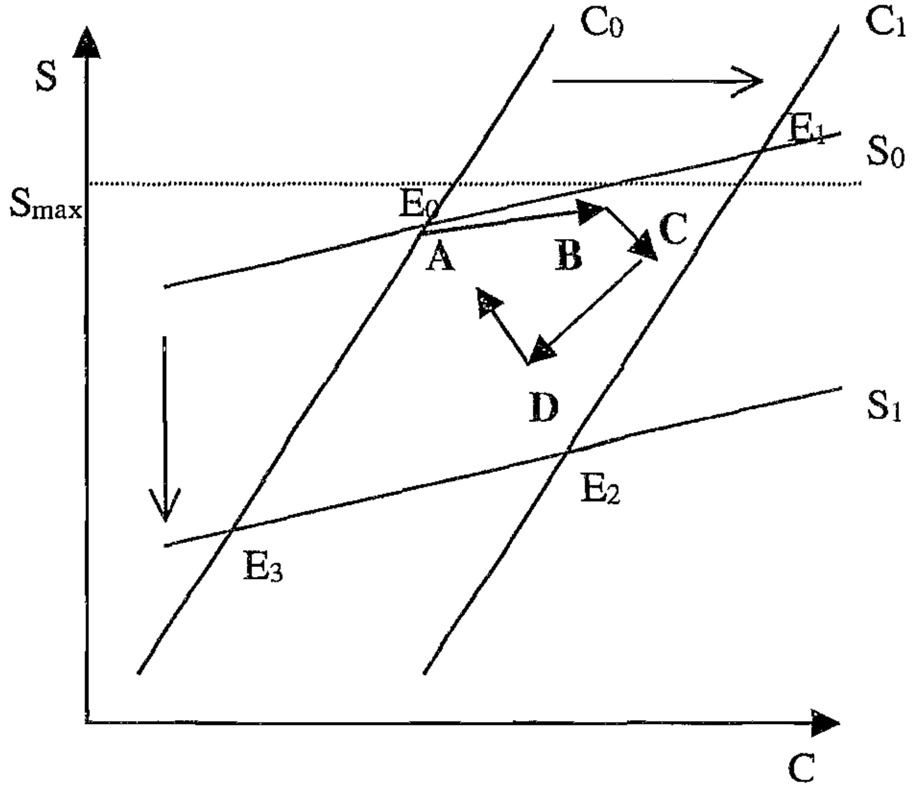
FIGURE 5: SECOND GENERATION MODEL: DYNAMIC SYSTEM



The 'rescue' is modelled as an upwards shift in the future prospects of the economy caused by a commitment by the government to pursue prudent policies over the medium term: P increases from P_0 to P_2. This commitment could be made credible by bringing in IMF assistance at the same time. Hence the new equilibrium is given as E_2, representing a shift downwards and to the left in C, S space. At a later date fundamentals shift back as, say, external conditions improve. The new equilibrium E_3 represents a further shift down and to the left. Finally, as the economy is perceived to be 'out of the woods', the government relaxes its austerity measures and the expected future prospects are scaled back to their starting point and the equilibrium returns to its initial state.

The dynamic behaviour of C and S is given in Figure 6. The model predicts a gradual increase in both C and S following the deterioration in economic fundamentals. The response to the crisis (IMF intervention) brings about a decrease in S although C continues to rise (however, it may later fall if the path of the economy crosses the C_1 line). Following the improvement in fundamentals C and S decline. Finally, with the return to more normal beliefs about the future prospects of the economy, S starts to rise and C continues its fall (although it may later increase if the path of the economy crosses the C_0 line).

FIGURE 6: EVOLUTION OF C AND S DURING PERIOD OF CRISIS AND ADJUSTMENT



Whilst the qualitative nature of the model outlined above precludes rigorous econometric analysis, some attempt to arrive at suitable proxies for C and S can be undertaken to see whether the previous discussion matches the Barbadian experience. The two periods of crisis and adjustment are identified as 1980-89 and 1989-98, respectively. Events are matched to years as given in Table 1.

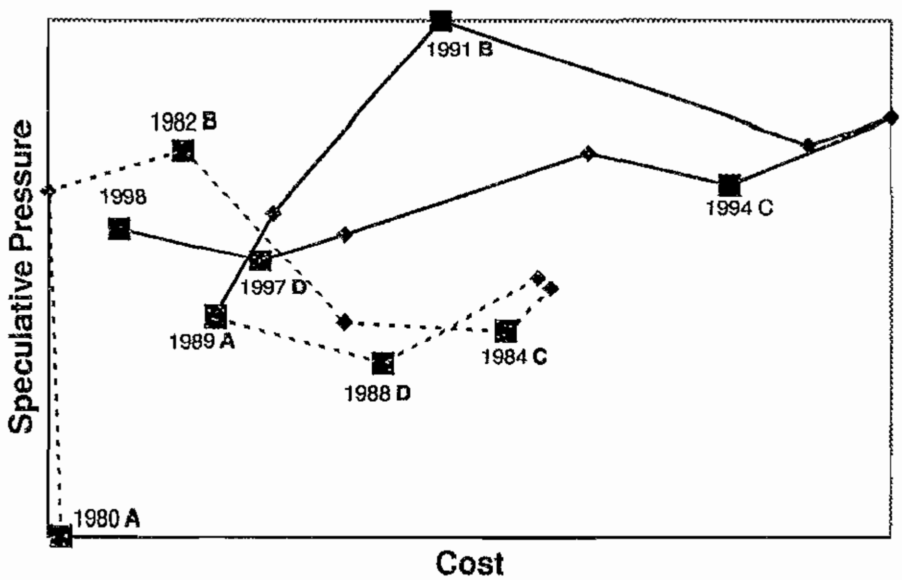
Clearly only the event labelled 'B' can be unequivocally dated, as the years in which IMF assistance programmes were introduced. Periods 'A' and 'C' are identified with reference to marked shifts in tourist arrivals, as representing changes in underlying external conditions. It is difficult to accurately pin-point Periods 'D' on an a priori basis. The penultimate year of each cycle is chosen as a reasonable estimate.

TABLE 1: Critical Years in Crisis Periods

Event	Crisis 1	Crisis 2
A: Deterioration in Fundamentals	1980	1989
B: Response to Crisis	1982	1991
C: Improvement in Fundamentals	1984	1994
D: Return to 'normal' beliefs	1988	1997

The cost of defending the exchange rate parity is proxied for by the rate of unemployment.[9] The degree of speculative pressure is proxied for by the interest rate differential (3-month treasury bill rates) between Barbados and the US, reflecting expected devaluation risk. Both variables are normalised to return values of between 0 and 1. Their movement over time is plotted in Figure 7.

FIGURE 7: EVOLUTION OF C AND S, 1980-98



[9] In their anatomy of the UK's exit from the ERM in 1992, Obstfeld and Rogoff (1995) cite high unemployment as one of the deciding factors underlying the lack of credibility behind the government's inability to defend sterling.

The similarities between the actual pattern and that predicted by the model are significant in both periods. The A-B periods are associated with increases in both S and C as the deterioration in fundamentals increases the costs of defending the parity and increases the private sector's misgivings over the government's commitment to the currency anchor. The B-C periods see a continued increase in the cost of the anchor but a fall in speculative pressure, due to the negotiation of an IMF standby agreement improving the government's credibility. During the C-D periods both costs and speculation are reduced as the improvement in fundamentals takes effect. Following period D the degree of speculative pressure starts to increase as the perceived discipline of the recovery period wears off.

One interesting result from the above analysis is the greater cost incurred by the government in defence of the parity, as well as the greater degree of private sector scepticism, during the second crisis. It may well be that either or both the underlying fundamentals (F) and the degree of exogenous optimism concerning the economy's prospects (P) shifted downwards following the first crisis. This suggests that periods of crisis have a lasting negative effect on both the fundamental strength of the economy and on the private sectors' belief in the government's policymaking ability.

V. CONCLUSIONS

The first and second generation models of exchange rate crises outlined above provide a number of results with regard to the periods of crisis and adjustment experienced by Barbados over the last two decades. Both models identify 1991, the year assistance was sought from the IMF to support a programme of macroeconomic adjustment, as the period of greatest danger to the exchange rate peg. In the case of the first generation model, this is manifested in a shadow exchange rate briefly above the fixed rate. In the second generation model, the danger is signalled by a maximum value for the speculation proxy, the interest rate differential with the US.

In addition, both models indicate that the exchange rate was under a significantly greater degree of pressure in 1991 than in 1982. The fact that a lower cost was incurred in the 1982-84 period of adjustment suggests that solving the problem when the level of confidence is still relatively high, and speculative pressure is correspondingly lower, may be wise.

Both models suggest that capital market imperfections helped dampen the impact of macroeconomic disequilibrium on the viability of the exchange rate peg. The first generation model can be simulated under conditions of perfect capital mobility and efficient financial markets. This is achieved by replacing equation (4) with a simple UIP condition, with $g_1=1$ and $g_0=0$ and lags set to zero, but otherwise using the parameters derived from the dynamic first generation model. This produces an estimated shadow exchange rate in the order of 2.1-2.2 during 1981 and 1990-91, which implies that had the expansionary credit performance of the crisis periods occurred under conditions of perfect capital mobility, the currency anchor could not have been preserved.

The second generation model implies that if the sluggishness in the adjustment of speculative pressure is reduced (that is, φ increases), then the impact of shifts in F and P will be more immediately felt. For instance, with $\varphi=\infty$, that is, with a highly geared foreign exchange market in which agents form expectations rationally and there are no impediments to speculative activity, S will immediately jump to the long-run value given in (9a). If this is greater than S_{max}, then a currency collapse will occur immediately. This implies that countries which have removed exchange controls and where speculators have access to derivatives and other financial instruments which allow massive short sales in the currency, will face greater difficulty in preventing exchange rate crises.

Although policies such as exchange controls cannot fully insulate a currency from speculative activity, they are likely to buy some time for the government to make suitable adjustments to macroeconomic policy.[10] In terms of the first generation model, exchange controls and other capital market imperfections imply a weaker relationship between domestic and world interest rates (lower g_1); in terms of the second generation model they imply a lower value for φ. Both models therefore predict that further liberalisation of the capital account would damage the ability of the monetary authorities in Barbados to maintain the currency anchor in the face of future macroeconomic disequilibria. In addition, if external disequilibrium were to be avoided in a post-liberalisation environment, monetary policy management would need to be far more tightly focussed on external conditions, implying less autonomy for dealing with imbalances in the domestic economy.

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[10] The IMF *Exchange Arrangements and Exchange Restrictions* (Various Years) details the exchange controls exercised in Barbados. Despite movement towards liberalisation, the controls implemented in Barbados are still fairly strict compared to industrialised countries and to most other economies in the region.

This paper is, therefore, supportive of the view that capital account liberalisation, exchange rate stability and an autonomous monetary policy are not simultaneously attainable. Significant relaxation of exchange controls and greater integration with world capital markets, whilst desirable in their own right, imply either the loss of the currency anchor or diminished monetary autonomy. Or possibly both.

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APPENDIX

First Generation Model Regression Results

Long Run Model

TABLE A1: Equation (1)

Dependent Variable	k
Method	2SLS (IV)
Sample	Jan-76 May-99 (281 obs)
Coefficient	Estimate (t-statistic)
b_0	0.000387 (8.25)
b_1	-0.032087 (-3.60)
Adjusted R^2	-5.99
F-Statistic	12.97
DW-Statistic	0.04

TABLE A2: Equation (4)

Dependent Variable	R
Method	OLS
Sample	Jan-76 June-99 (282 obs)
Coefficient	Estimate (t-statistic)
g_0	0.004196 (13.68)
g_1	0.188955 (3.67)
Adjusted R^2	-0.43
F-Statistic	13.48
DW-Statistic	0.04

Dynamic Model

TABLE A3: Equation (1)

Dependent Variable	k
Method	2SLS (IV)
Sample	Feb-76 May-99 (280 obs)
Coefficient	Estimate (t-statistic)
α	0.950508 (21.32)
b_0	0.0000214 (1.06)
b_1	-0.001998 (-0.96)
Adjusted R^2	0.93
F-Statistic	1855.63
DW-Statistic	0.94

TABLE A4: Equation (4)

Dependent Variable	r
Method	OLS
Sample	May-76 May-99 (278 obs)
Coefficient	Estimate (t-statistic)
δ_1	1.249359 (20.89)
δ_2	-0.125276 (-1.30)
δ_3	-0.012291 (-0.13)
δ_4	-0.151681 (-2.55)
G_0	0.000127 (1.74)
g_1	0.01524 (1.65)
Adjusted R^2	0.97
F-Statistic	1867.16
DW-Statistic	1.99

TABLE A5: Equation (5)[11]

Dependent Variable	$\Delta\ln(P)$
Method	OLS
Sample	Feb-76 June-99 (281 obs)
Coefficient	Estimate (t-statistic)
Constant (assumed to be zero in model)	0.000635 (5.63)
γ	0.04373 (5.11)
Adjusted R^2	0.09
F-Statistic	26.12
DW-Statistic	2.06

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 derived parameter estimates used in the first generation model 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.[12] The price series might be I(0) with strong serial correlation or I(1).

[11] (5) is transformed by regressing the first difference of ln(P) against ln(P*e)-ln(P)

[12] If we assume that a stable underlying demand for money function exists, then this is equivalent to assuming, like Friedman, that the velocity of circulation does not vary greatly over time. This implies that the velocity is stationary.

Stationarity in the variables is tested econometrically using the Augmented Dickey-Fuller (ADF) and Phillips-Perron Z_t tests. The results are given in Table A6 below. Critical values are provided by E-views.[13] The econometric evidence is not supportive of either k or r* being stationary, although the price variables appear to be stationary and the evidence for r is mixed.

TABLE A6: Econometric Tests for Stationarity[14]

Variable	ADF Test Statistic	Z_t Test Statistic
k	-1.54	-1.30
r	-3.55 ***	-2.61 *
r*	-0.75	-0.76
Ln P	-4.07 ***	-4.08 ***
Ln P*e	-4.98 ***	-6.28 ***

Significance level for rejecting null hypothesis of a unit root (non-stationarity I(1)): 1% ***, 5% **, 10% *

If we assume that these variables are in fact I(1), then standard statistical inference techniques remain valid if the series are cointegrated. If this is indeed the case, then the long-run relationships based on (1) and (4) give the estimated cointegrating vectors (with the first coefficient normalised to unity). This implies that, with both dependent and independent variables I(1), if the estimated coefficients describe a cointegrating relationship rather than a spurious correlation between two I(1) trending variables, the residuals from these equations should provide evidence of stationarity. Therefore a test for cointegration can be undertaken by analysing the residuals from the long run equations estimated in tables A1 and A2 above to see whether they display evidence of stationarity. The results of unit root tests on the residual series ε_1 and ε_2 are given in Table A7.

[13] All Econometric analysis is undertaken using E-Views for Windows Version 3.

[14] The truncation lag for the Z_t test statistic is 5, based on the value recommended by E-Views which is derived from Newey-West's proposed formula [truncation lag=floor $(4(T/100)^{2/9})$], where T is the sample size. The order of the ADF statistic is derived by proposing a maximum order of lags and then iteratively deleting lagged difference terms based on the acceptance of an F-test of a zero coefficient on the lag terms to be deleted. The sample period is Jan-76 to June-99.

TABLE A7: Econometric Tests for Cointegration[15]

Variable	ADF Test Statistic	Z_t Test Statistic
ε_1	-3.43 **	-2.58
ε_2	-3.44 **	-2.68

The evidence for cointegration is therefore mixed. The ADF test is supportive of stationarity in both residual series, which suggests a cointegrating relationship if we assume the dependent and independent variables to be I(1); however the Phillips-Perron Z_t statistics do not support this view. Moreover, we might distrust the econometric evidence that these variables are indeed I(1) given our a priori view that strong serial correlation is more likely. Therefore, we are not able to say categorically that the regression results underlying the derived first generation model parameters are invalid. It may be that the underlying variables are I(0) in which case standard consistency results can be invoked, or that they are I(1) but cointegrated. Alternatively, the view that some are I(0) and some I(1), or that all are I(1) but not cointegrated, cannot be rejected. The econometric evidence is mixed, but economic theory is supportive of the results.

Data Selection and Sources[16]

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.[17] 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.

[15] Lag structures are derived in same way as for Table A6. Critical values differ from those given by E-Views which are incorrect for analysing residuals from spurious cointegrating regressions. The relevant values are taken from Hamilton (1994) Table B.9 p.766.

[16] Barbados data for some years was available in electronic form from CBB. The author wishes to thank Dr Roland Craigwell for providing access to this data.

[17] 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.

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 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 interest rates used are those on 3-month Treasury Bills. Barbados TB rates are given in CBB *Economic and Financial Statistics* Table E2. The US 3 month TB 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, the long-run correlation between (long-stay) tourist arrivals and real GDP is in the order of 97% over the period investigated. It is assumed that, in deciding their money balances based on a desire to smooth consumption over the medium term, agents use information on tourism arrivals as a proxy for permanent income. The 12-month moving average of tourist arrivals (CBB *Economic and Financial Statistics* Table H9/H10) is therefore used as a proxy for the real GDP component.

The unemployment rate used in the second generation model is taken from IDB (1997) Table 2.3 and CBB (1998). The interest rate differential is calculated using the 3 month TB rates taken from CBB *Economic and Financial Statistics* Table E2.