

ESTIMATION OF SPECULATIVE ATTACK MODELS AND THE IMPLICATIONS FOR MACROECONOMIC POLICY:

Jamaica 1991-00

ABSTRACT

This paper attempts to generate an empirical model aimed at predicting the timing and magnitude of currency depreciation forced by speculative attacks on Jamaica's managed exchange rate system. The paper is grounded within a first generation approach ('fundamentals approach') to speculative attack modeling, which stresses the role played by weak economic fundamentals in inducing currency crises. While this approach has been applied exclusively to fixed and pegged exchange rate regimes, we believe that with some modification the empirical model can be applied to managed exchange rate systems. The estimation procedure generates an equilibrium exchange rate derived from a reduced form equation and the difference between the evolution of the actual exchange rate and the generated equilibrium rate is considered as the misalignment gap. The gap revealed the extent to which the market has persistently factored in an expected depreciation of the currency driven primarily by the inconsistency in fiscal and monetary policy as well as random shocks relating to the unavailability of external credit supplies and relative prices. The methodology is applied to the Jamaican dollar and the model is estimated using data from 1991 to 1999. The model generates time-series estimates of the twelve period-ahead (January to December 2000) probability of depreciation and the expected value of the new managed exchange rate.

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Table of Contents

1. INTRODUCTION.....	3
2. LITERATURE REVIEW.....	5
3. JAMAICA'S EXCHANGE RATE EXPERIENCE (1991 TO 1998).....	9
4. THE MONETARY MODEL & COLLAPSE PROBABILITY.....	13
5. DATA ANALYSIS AND ESTIMATION PROCEDURE.....	20
6. ESTIMATION RESULTS.....	24
6.1 Test for Stationarity.....	24
6.2 Money demand.....	24
6.3 Shadow Exchange Rates & Collapse Probabilities – In-Sample Results.....	25
6.3 Collapse Probabilities – Out-of-Sample Results.....	31
7. POLICY IMPLICATIONS & CONCLUSION.....	34 33
8. APPENDIX.....	36
9. REFERENCES.....	40

1. INTRODUCTION

In recent years, a number of articles on exchange rate management have emphasized the importance of implementing sustainable exchange rate policies. The effectiveness of such an exchange rate policy requires the harmonization of monetary and fiscal policies, and the maintenance of a high degree of credibility in the foreign exchange market. Since exchange rates are strongly influenced by expectations, the behaviour of monetary authorities, in particular, is of critical importance for exchange rate behaviour. If monetary policy objectives are inconsistent with fiscal policy for a prolonged period of time, an exchange rate crisis may ultimately materialize. This crisis is often characterized by continuous deficits on the current account of the balance of payments, leading to a gradual erosion of central bank's reserves, which is followed by a sharp speculative attack on the currency.

In addition to acknowledging the importance of monetary and fiscal discipline in pursuing a sustainable exchange rate regime, this paper emphasizes the contribution of other random shocks to the domestic money market, most notably shocks from external credit supplies and relative prices. It is possible that the unexpected availability of external credit supplies may avoid, at least temporarily, the depreciation of the currency and make the depletion of central bank reserves by a speculative attack more difficult to accomplish. Relative price shocks on the other hand randomizes the demand for nominal money balances and therefore may also have a strong direct influence on the probability of a currency depreciation.

Within the context of the Jamaican economy, recurrent depreciation of the currency has been one of the realities of the economy, particularly after the liberalization of the foreign exchange market in 1990. During the period 1991 to 1993, the economy experienced notable macroeconomic instability, characterized by sharp downward movements in the exchange rate, continuous deficits on the current account and unprecedented inflation rates. Consequently, the authorities had to tighten monetary

policy in an effort to stabilize the exchange rate and moderate the movements in the inflation rate. For the period 1994 to 1999, relative stability in the Jamaican economy was restored, particularly to domestic prices and, to a lesser extent, the exchange rate. However, to the extent that interest rates remained relatively high during the period, the fiscal imbalance widened due in part, to higher interest costs on domestic debt. This added further impetus for speculative pressures in the market. In response, the authorities intensified open market operations, which led to the attainment of relative economic stability, albeit at a cost to economic growth and the country's debt position.

The interest in the ability of the authorities to support the current managed exchange rate policy in light of recurring foreign exchange instability has been a source of motivation for this paper. The objective, therefore, is to generate a model aimed at predicting the timing and magnitude of a currency depreciation forced by speculative attacks on the exchange rate system, and to provide an 'early warning' of regime fragility. In this context, the paper develops a monetary model of speculative attacks under a managed exchange rate regime, which is then used to assess the probability that the exchange rate will depreciate, by a speculative attack on the currency¹. This should allow policymakers to anticipate the destabilizing impact of future currency depreciations and redirect policy targets towards the attainment of macroeconomic stability and growth.

The paper is divided into six sections. Section 2 presents a literature survey on speculative attack models. Section 3 gives an historical overview of Jamaica's exchange rate policies during the period 1991 to 2000. Section 4 develops a monetary model of the Jamaican economy as an extension of some of the models in the literature. Data analysis and estimation procedures are detailed in section 5. In section 6, the estimates of the model for the Jamaican sample are presented and section 7 summarizes the findings of the paper and draws together the major policy implications for Jamaica.

¹ Variants of speculative attack models have examined the collapse of the fixed exchange rate into a permanent float, the attack on the fixed exchange rate leading to a devalued post-attack fixed exchange rate, or the pre-attack regime may be a crawling peg rather than a pure fixed exchange rate, as in Connolly and Taylor (1984) and Goldberg (1994)

2. LITERATURE REVIEW

The literature on currency crises has not been embraced a standard definition of a currency crisis. Most of the studies on exchange rate crises have focused exclusively on devaluation episodes as a definition of 'crises'. Frankel and Rose (1996) examined large and infrequent devaluations, while others such as Collins (1995) include in their sample, small and infrequent devaluations that are not full-blown currency crises. A few studies adopt a broader definition of crises, which includes, in addition to devaluation, episodes of unsuccessful speculative attacks with a sharp increase in domestic interest rates and /or a sizable loss of international reserves. These definitions have been applied exclusively to fixed and pegged exchange rate systems. However for the purposes of a managed exchange rate system there is a conceptual issue of the definition of a currency attack. The term 'managed' is used here to describe systems where official intervention is practiced to smooth erratic fluctuations in the exchange rate that is not planned according to any pre-considered strategy or agreed in advance and whose parameters are unannounced to the market and not even known to the authorities. As such the paper utilizes Kamisky's (1998) definition of a currency attack which involves:

A situation in which an attack on the currency leads to a sharp depreciation of the exchange rate, a large decline in international reserves, or a combination of the two. The definition is also comprehensive enough to include not only currency attacks under a fixed exchange rate but also attacks under other exchange rate regimes².

The literature on currency crises is based on the fundamentals approach which has flourished following Krugman's (1979) seminal paper, which showed that under a fixed exchange rate regime, crises were caused by weak 'economic fundamentals'. Krugman explained that rapid domestic credit expansion in excess of money demand growth, leading to a persistent loss of reserves, would

ultimately force the authorities to abandon the exchange rate system. His model suggests that the period preceding a crisis would be characterized by a gradual but persistent decline in international reserves and a rapid growth of domestic credit, which increases the money supply relative to the demand for money. In addition, the Krugman model emphasizes that excessive money creation may result from the need to finance the public sector. In this regard, fiscal imbalances and credit to the public sector may serve as indicators of a looming crisis.

A number of papers have extended Krugman's basic model in various directions. For instance, using quarterly data from 1973 through 1982, Blanco and Garber (1986) adapted the model to a regime of recurring discontinuous devaluations to interpret the dynamics of the Mexican exchange rate. They emphasized that the recurrence of currency devaluation in Mexico implied that the exchange rate regime pursued by the authorities was a secondary goal, conditional on fulfillment of other primary goals, such as the government's fiscal position. They also viewed excessive domestic credit growth as a catalyst for currency crises. Blanco and Garber then estimated the value of the fixed minimum reserve level and the parameters governing the devaluation policy rule. To generate the probability of an attack, they minimized the deviations of the one-quarter ahead-expected exchange rates from observed forward exchange rates. It was found that the estimated probabilities of devaluation jumped to peaks of **20 percent** just prior to the major devaluation in 1976 and 1982 and fell to low levels immediately after devaluation.

Cumby and van Wijnbergen (1989) also applied the speculative attack model to the Argentine crawling peg of 1979 to 1981. A similar principle for determining the timing of an attack under a fixed exchange rate regime was extended to the crawling peg system i.e. when the shadow exchange rate exceeds the official rate, speculators will attack the currency³. An attack might lead to a floating exchange rate, a crawling peg with an increased rate of depreciation, or a devaluation. Cumby and van Wijnbergen

² See Graciela Kaminsky et al, (1998), Leading Indicators of Currency Crises, page 15.

found that the probability of a speculative attack was driven primarily by domestic credit creation and that it reached its highest level of about **80 percent** just prior to the attack that led to the abandonment of the Argentine policy in 1981.

Goldberg (1994) used Mexican data from 1980 through 1986 to study the influence of both fiscal and monetary shocks on speculative attacks on the peso, in both the fixed exchange rate and in the ensuing crawling peg regime. Goldberg added to the list of forces contributing to an attack by explicitly modeling real exchange rate movements and foreign credit disturbances. She found that the one step-ahead probability generally reached levels of **100 percent** in the period before a crisis and that at such times, the realized shadow exchange rate significantly exceeded the official rate. She also found that domestic credit creation, not external credit disturbances, drove the timing of speculative attacks in the Mexican situation.

The general consensus in the literature therefore indicates that speculative attacks on exchange rate systems are driven primarily by excessive domestic credit creation relative to the demand for money. This may be in response to the need to finance the public sector or the extension of credit by central banks to domestic financial institutions in difficulty, which inevitably leads to the collapse of the system. It was also recognized in some of the literature that the availability of external credit in supplementing the reserves of the central bank could make speculative attacks more difficult to accomplish and can, in practice avoid a regime collapse. Flood (1984) stressed however “... *that ultimately, if the underlying fiscal and monetary policy process are inconsistent with the exchange rate regime, there will be a need for a new exchange rate because there is a limit to borrowing reserves on the international market*”.⁴

³ The shadow exchange rate is defined as the rate that clears the money market, and the rate that prevails once an attack has taken place.

⁴ Flood (1984), Collapsing exchange rate regimes: some linear examples, page 3.

Over the past few years, attention has shifted towards studying the usefulness of several variables in signaling an impending crisis, generally known as the '*signals approach*' or '*Second Generation approach*'. This approach involves monitoring the evolution of a number of economic variables whose behaviour usually departs from 'normal' in the period preceding a currency crisis. The method compares the behavior of variables in periods preceding a crisis with the behavior of the same variables in periods of tranquility. Deviations of these variables from their normal levels beyond a certain threshold value are taken as 'warning signals' of a currency crisis within a specified period of time. Some of the indicators that provided good signals were the real effective exchange rate, a proxy for political violence, errors and omission plus short-term capital in the balance of payments, stock prices, proxy for election and multilateral development bank loans.

Most research papers that utilizes the '*signals approach*' have also acknowledged the importance of monetary and fiscal discipline, but view government fiscal policies as partial catalysts for speculative attack on a currency.

Obstfeld (1994) summarizes the focal point of the literature appropriately by recognizing "*...that typically, exchange rate crisis situations arise when the central bank does not have sufficient instruments at hand to attain both its internal and external policy goals. Devaluation forced by speculative attacks thus allows for the reconciliation of these conflicting objectives*"⁵.

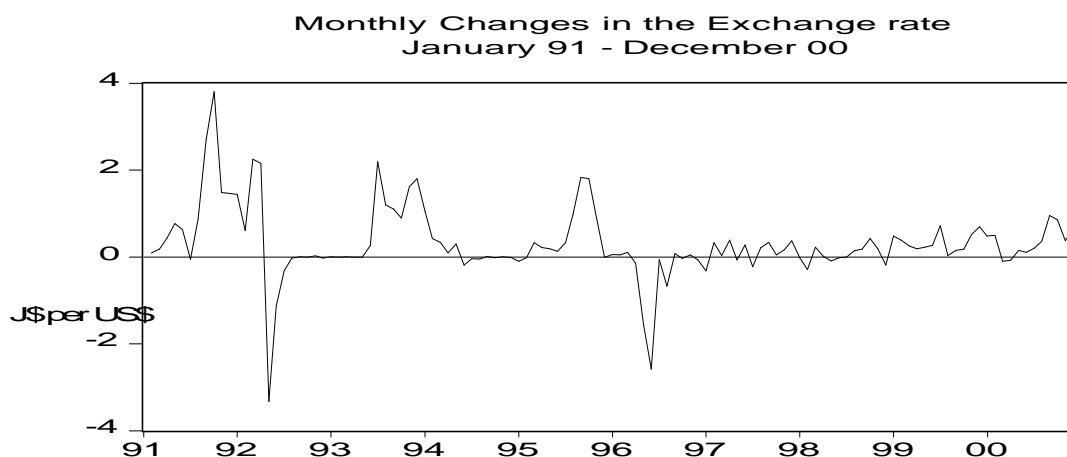
⁵ Obstfeld (1986a), Rational and Self fulfilling balance of payments crises, page 74

3. JAMAICA'S EXCHANGE RATE EXPERIENCE (1991 to 2000)

The Jamaican economy has been transformed since the 1980s by a wide range of structural reforms aimed at increasing the role of market forces in resource allocation and creating a stable macroeconomic environment for the achievement of growth and development. The liberalization of the foreign exchange market in 1990 and the freeing of the capital account in 1991 represented the continuation of such reforms. Following liberalization, the economy experienced severe macroeconomic instability, evidenced by substantial depreciation in the external value of the currency, unprecedented levels of inflation and a sharp decline in real interest rates. For the latter part of the 1990's, relative stability in the Jamaican economy was restored, particularly to domestic prices and to a lesser extent, the exchange rate. However, this stability was attained at a cost to economic growth and the country's debt position.

The paper examines distinct phases of the exchange rate process over the period 1991 to 2000, with figure 2.1 portraying movements in the exchange rate over the period.

Figure 2.1



With the removal of exchange rate controls in September 1991, the Jamaican dollar depreciated considerably from J\$13.67 per US\$ to J\$20.91 per US\$ (or 53% depreciation) by end-December 1991. This contributed significantly to inflation (point-to-point) reaching the record level of 80.2 percent for the year. With further expectations of devaluation, the demand for liquid assets increased, signaled by a 95.3 percent growth in narrow money (M1), and a 54.6 percent increase in broad money (M2). In an effort to constrain liquidity and reduce demand pressures, the monetary authorities relied heavily on open market operations. In addition, the fiscal authorities implemented measures aimed at constraining liquidity and limiting domestic borrowing, such as the reduction in expenditure on selected public entities and further price liberalization. By the end of 1991, the six-month treasury bill rate, a prime indicator of market interest rates, rose sharply to 35.1 percent, while the rate on BOJ certificates of deposit increased to 40.1 per cent. Concurrently, the net international reserves fell by US\$54.1 million between September and December 1991.

For the first half of 1992, the Jamaican dollar depreciated further before it stabilized at J\$22.20 per US\$ by mid-June 1992. This relative stability in the foreign exchange market continued through to the middle of June 1993, as the contractionary monetary and fiscal policy stance of the authorities slowed the growth in money supply considerably, reduced the level of demand pressures on the Jamaican dollar and accounted for a deceleration in the inflation rate. These factors, in combination with the private sector initiative to augment the supply of foreign exchange in the banking system in an effort to stabilize the dollar engendered a greater level of stability in the foreign exchange market.

By mid 1993, the Jamaican dollar came under pressure again and depreciated to J\$32.70 per US\$ by the end of 1993. Reduced foreign exchange inflows to the banking system by the private sector and the placement of a US\$20.0 million bearer bond issue on the market by the government fueled further expectations of devaluation. The determination by the authorities to maintain tight monetary and fiscal policies was underlined by more aggressive open market operations and the offer of government debt

instruments to the market, to reduce uncertainties and promote greater confidence in the economy. Consequently, interest rates, which had begun to decline since the latter half of 1992 (23.22 percent in December 1992), increased sharply during the second half of 1993 (39.36 in December in 1993). The rate of money growth slowed considerably and inflation rates moderated to 30.1 percent from 40.2 percent in 1992.

By early 1994, relative stability in the domestic exchange rate was achieved at approximately J\$33.5 per US\$, which helped to temper the rate of growth in domestic prices to 26.7 percent by the end of 1994. The stability in the foreign exchange market was attained by continued tight monetary policy and the intensification of open market operations, which resulted in further liquidity absorption and invariably pushed interest rates to unprecedented levels. The high interest rate regime contracted the growth in domestic credit and contributed to an expansion in the net foreign assets of the banking system, which in turn, contributed to the rapid growth in money supply (M3) from 30.2 percent in 1993 to 35.2 percent by the end of 1994. Over the period however, the growth in narrow money contracted from 40.0 percent in 1993 to 24.3 percent in 1994, induced mainly by portfolios shifts in response to the widening interest rate differential between savings deposit, time deposits, and government securities. During the latter half of 1994, the continued stability in the foreign exchange market was facilitated by increased supplies of foreign exchange arising from the broadening of the market to include merchant banks and the establishment of a network of cambio operations.

By 1995, the contractionary monetary policy stance was relaxed slightly to facilitate increased investments. Treasury bill rates declined to 20.3 percent in April 1995, while M2 grew at a rate of 38.5 percent relative to the 36.6 percent in 1994. By July 1995, the ensuing growth in consumer credit arising from rapid wage increases and lower bank lending rates accelerated inflationary and foreign exchange pressures in the market. By mid-November 1995, the currency depreciated to J\$40 per US\$. In response, monetary policy was tightened sharply and domestic treasury bill rates rose from 23

percent in July 1995 to 36 percent in October 1995. Between August and November 1995, the BOJ sold over US\$95.0 million of foreign exchange reserves to slow down the depreciation of the currency.

Following a substantial devaluation of the dollar in 1995, a loss of international reserves and an acceleration of inflation, the authorities focused more sharply on achieving a reduction in inflation. During the period 1996 to 2000, monetary policy was tightened substantially, resulting in substantial reduction in the inflation rate. However, over the same period, the fiscal sector's overall balance shifted from a surplus to a deficit, partly reflecting higher wages and interest cost on domestic debt. Within the context of high real interest rates and declining output, the liquidity crises in the financial system surfaced in 1997 and demand pressures in the foreign exchange market have resulted in more frequent open market operations at a cost to the central bank's reserves and the country's debt position.

4. THE MONETARY MODEL & PROBABILITY OF DEPRECIATION

This section of the paper applies the monetary model of exchange rate determination used by Goldberg (1994) and Flood et al (1992) to Jamaica's managed exchange rate system for the period 1991 to 1999. The monetary model relies on the money market equilibrium condition, which determines the equilibrium exchange rate under a freely flexible exchange rate system. The model is specified in logarithms in equations (1) – (9) below:

$$Md_t - Q_t = a_0 - a_1 i_t + a_2 y_t - a_3 \{E_t S_{t+1} - S_t\} \quad (1)$$

$$Q_t = a P_t + \{1 - a\} \{S_t + P_t^*\} \quad (2)$$

$$P_t = S_t + P_t^* + \Omega_t \quad (3)$$

$$\Omega_t = \rho \Omega_{t-1} + d_t \quad (4)$$

$$i_t = i_t^* + \{E_t S_{t+1} - S_t\} \quad (5)$$

$$MS_t = R_t + D_t \quad (6)$$

$$D_t = D_{t-1} + \mu_t + \lambda_t \quad (7)$$

$$\lambda_t = g_t + f_t \quad (8)$$

$$Ms_t = Md_t \quad (9)$$

Where,

Md_t	=	natural logarithm of money supply (M2),
Q_t	=	natural logarithm of the aggregate price index,
i_t	=	nominal monthly treasury bill rate,
i_t^*	=	treasury bill rate for the United States
y_t	=	monthly real interpolated GDP
S_t	=	natural logarithm of the weighted average exchange rate vis-à-vis the US\$.
P_t	=	domestic goods prices
P_t^*	=	foreign goods prices
W_t	=	the deviation from PPP which follows an AR(1) process
R_t	=	level of foreign reserves (valued in domestic currency)
D_t	=	level of domestic credit of the public and private sector
λ_t	=	domestic credit shock
γ_t	=	shocks that are induced domestically by the monetary authorities
ϕ_t	=	external credit shocks

Equation (1) shows that the demand for real money balances in Jamaica is a function of domestic interest rate, the level of income and a currency substitution motive. The paper subsumes the important role of inflation in the nominal specification of interest rates. This captures the influence of inflationary inertia and its impact on influencing portfolio shifts between real and financial assets in Jamaica. The aggregate price index in equation (2) is defined as the weighted sum of domestic goods prices (P_t) and traded goods prices ($S_t + P_t^*$). The weight α corresponds to the share of domestic goods in consumer expenditure. The model assumes that purchasing power parity as well as interest parity holds. Thus, purchasing power parity (PPP) is determined according to equation (3), where domestic

and foreign good prices differ due to medium-term systematic deviations from PPP, W_t and follows a first-order auto-regressive process in equation (4). Equation (5) is the interest parity condition, where i_t^* is the exogenously given world market interest rate and equation (6) defines the supply of money as the sum of the stock of central bank reserves R_t , and the stock of domestic credit D_t .

In accordance with the literature, this paper views domestic credit creation and domestic spending in excess of the demand for money balances as the main catalyst for reserve depletion and for an ultimate regime collapse. Following Goldberg's (1994) model specification, domestic credit is modeled in equation (7) as evolving according to a trend rate m , and a stochastic random disturbance component λ_t with the former mirroring trend fiscal deficits or expected monetary financing of government deficits. The random disturbance λ_t is then decomposed into two components. The first component γ_t relates to the need to monetize government deficit due to unanticipated expenditures for which no revenues are currently available, and ϕ_t shocks stem from the uncertain availability of external credit flows to cover domestic deficits. According to Goldberg (1994), unanticipated domestic credit creation could arise when the government had expected to finance domestic deficits by borrowing on the international market. If external credit does not materialize, a greater share of basic government deficit will be monetized. In equation (9), the money market equilibrium condition is specified.

This money market equilibrium condition will be used to determine the path of a freely floating exchange rate regime, which is compared to rates that exist under a managed exchange rate regime. The difference between the evolution of the actual managed rate and the evolution of the generated rate derived from the fundamental approach is considered as the misalignment gap, which may be temporary or permanent in nature. If the gap between actual and generated exchange rates diverge with no evidence of mean-reversion, then it suggests that the monetary authorities 'managed' official

exchange rate is severely misaligned relative to the market's perception of what it should be. This situation can arise, for example when there are changes in fundamentals that trigger a change in the equilibrium exchange rate, but that are not reflected in changes in the actual rate.⁶ In such situations, the rate is likely to be subjected to speculative attacks as rational agents may doubt the ability of the central bank to continue to support the managed exchange rates. Economic agents who correctly foresee the realignment of the currency because the requirement to stabilize the exchange rate drives reserves to a critical level, will exploit the opportunity and initiate a speculative attack on the reserves.

The timing of such an attack depends on the policies agents expect the central bank to adopt in response to a run on its reserves. Most of the papers on exchange rate crises have assumed that the central bank will simply withdraw from the market when reserves are driven to a critical level. Melick (1996) assumed that the authorities would sterilize the loss of reserves at the time of the collapse, leading to a discrete jump in the money supply. For simplicity, this paper assumes that the central bank will withdraw from defending the currency once the attack has driven foreign reserves to a critical level. This is followed by a depreciation of the exchange rate.

The principle behind the literature on speculative attacks is that an attack will occur when economic agents expect the exchange rate that would be realized in the event of an attack to be above the current managed rate. Speculators will then profit from purchasing a significant portion of the central bank's reserve stock and experience an instantaneous capital gain. The post-attack permanently floating exchange rate that prevails once an attack has taken place is known as the 'shadow floating exchange rate' S_t^* , which is defined as the rate that clears the money market. The shadow floating rate which reflects market fundamentals is the exchange rate that would prevail in period t , if reserves R_t are driven to their critical level R_c such that,

⁶ From a theoretical approach, the concept of misalignment requires assuming that there exist institutional or other type of rigidities that prevent the actual rate from adjusting rapidly towards its medium to long run equilibrium level.

$$R_t = R_c$$

and the exchange rate was allowed to float freely. Alternatively, the shadow rate can be interpreted as the minimum bound for the rate that would prevail if speculators attacked central bank reserves and depleted reserves to a critical level.

Using the money market clearing condition, the shadow exchange rate in period t is determined by substituting equation (2) – (8) into (1) and solving for the shadow rate⁷, S_t^* :

$$S_t^* = \frac{1}{(1 + a_1 + a_3)} \sum_{j=0}^{\infty} \left[\frac{a_1 + a_3}{1 + a_1 + a_3} \right]^j E_t H_{t+j} \quad (10)$$

$$H_{t+1} = D_t - P_{t+1}^* + m_{t+1} + g_{t+1} - f_{t+1} - ar\Omega_t - ad_{t+1} - a_0 - a i_{t+1}^* - a_2 y_{t+1} + R_c$$

Equation (10) has two important characteristics. First, the current exchange rate depends on the future path of the H_{t+1} variables, which are known as the ‘fundamentals’. Second, while all expected future variables included in H_{t+1} , influences the equilibrium exchange rate, the quantitative importance of each period’s influence varies directly with how close it is to the present. That is, the influence of say, period $t+j$ ’s expected relative outcome on the fundamentals is discounted by the factor

$$\frac{(a_1 + a_3)^j}{(1 + a_1 + a_3)^{j+1}} \text{ which since } a_1 > 0 \text{ approaches zero as } j \text{ approaches infinity.}^8$$

While the work of Blanco and Garber (1986), focused on assessing the probability of devaluation in the context of a pegged exchanged rate system, applying models of collapse probabilities to managed

⁸ Where a_1 is the coefficient on domestic interest rates, that captures the sensitivity of interest rates to money demand holdings

regimes require minor modifications to their construct.. In a pegged exchange rate system, the central bank's optimisation strategy involves setting a rate that is equal to or greater than S_t^i such that

$$S_t^i = S_t^* + n_t$$

where n_t has a normal density function $g(n_t)$ ⁹, and S_t^i is the pegged exchange rate.

In the case of managed exchange rate systems and, in particular, the system in operation in Jamaica, the central banks' aim is to achieve "relative stability" in the foreign exchange market. Whilst this strategy does not suggest an explicit intervention rule, it seems clear that the central bank is averse to large swings in the exchange rate in the face of significant changes in foreign exchange flows. A plausible strategy would then be that the bank will want to maintain a rate in the market S_t^i such that

$$S_t^i = S_{t-1} + n_t \quad (11)$$

where S_{t-1} is the rate realized in the market in the previous period, with or without the explicit intervention of the central bank, and $n_t \geq 0$. Different degrees of tolerance for exchange rate slippages can be incorporated by adjusting the magnitude of n_t . If an attack on the currency is initiated, the central bank will intervene in the market to prevent its rapid slide. When the requirement to reduce large fluctuations in the currency drives reserves to their critical level, the central bank will withdraw from the foreign exchange market. The rate that would prevail in a post-attack period will then become the shadow exchange rate S_t^* , and the subsequent intervention rule will then seek to "stabilise" the movements in this new exchange rate level.

⁹ With zero mean and standard deviation σ

Using this framework, the probability that a speculative attack on the Jamaican dollar will occur at the beginning of period $t+1$ is the probability that the shadow rate will exceed the managed exchange rate. Therefore, the probability of depreciation at time $t+1$ based on information available at time t is defined as β_t , where:

$$\mathbf{b}_t = \Pr \left[S_{t+1}^* - S_{t+1}^i > 0 \mid \mathbf{e}_t \right] \quad (12)$$

S_{t+1}^i is the managed exchange rate in period $t+1$ and \mathbf{e}_t is all the information available in period t . Based on equation (12), the solution procedure entails minimizing the deviation of the shadow exchange rate from the observed managed exchange rate, and computing the probability density function over the range of the deviation. The probability of depreciation is expected to peak prior to or at the period when a depreciation occurs and fall to low levels immediately after the currency depreciation. Estimating the probability using this approach attempts to capture the systematic relationship between the realized depreciation, economic fundamentals and the contribution of important shocks, and to evaluate whether speculative pressures on the exchange rate can be accounted for by these factors.

5. DATA ANALYSIS AND ESTIMATION PROCEDURE

The implementation of a speculative attack model requires as a fundamental prerequisite, the absence of exchange rate controls. In this context, monthly analysis of the exchange rate regime spans the period October 1991 – December 1999. Out-of-sample forecasts are generated for the period January to December 2000.

A description of the data set used in the paper is provided in Table 1 in the appendix. The identification of the appropriate time series that closely represents the theoretical constructs of the model was not entirely straightforward, particularly so for the GDP data (y_t). In the context where real GDP data is not available on a monthly or quarterly basis, a quarterly series was interpolated using the weighted quarterly variation in major exports of goods and services¹⁰ and major imports. The imputed GDP series was seasonally adjusted and smoothed using a four-period moving average representation to generate the quarterly series, and subsequently a three-period moving average to derive the monthly GDP data series.

With regard to the procedure used to estimate the model, the focal point was to derive the probability of a speculative attack on Jamaica's managed exchange rate system. To make this approach operational, a working definition of speculative attack was required. For the purpose of this paper, a speculative attack is defined for periods in which the change in the level of reserves falls by more than 10 percent relative to the previous month and/or the domestic interest rate rises by more than 5 percent, which precipitates or responds to a currency depreciation of over 1 per cent during any given month¹¹. This definition is based on the notion that the monetary authorities can successfully prevent an attack on the currency, up to a point, by drawing down on their reserves, or by simply raising

¹⁰ These include the major traditional exports and tourism arrivals.

¹¹ Sensitivity analysis was employed for reserve changes that were higher and lower than the 10% specified. For values higher than 10%, there were some reductions in the number of crisis periods, but very little change in the overall results. A 10% fall in the value of reserves is deemed to be significantly high over a given month.

interest rates. It is also important that the fall in the level of reserves or the increase in the interest rate be significantly large to rule out routine changes.

The next step was to derive the probabilities of a speculative attack on the currency. In order to estimate the probability of a speculative attack, the shadow exchange rate in period $t+1$ was computed. These required estimates of the money demand function (eqn. 1), the stochastic process governing domestic credit creation (eqn. 7 & 8), deviations from PPP (eqn. 3 & 4) and an assumption about the critical reserve floor. Also, forecasts were required to update the expectations of the non-stochastic variables in H_{t+1} (the fundamentals) that is, foreign interest rate (i^*_{t+1}), US wholesale prices (P^*_{t+1}), GDP (y_{t+1}) and the calculated weights in the aggregate price index (α_{t+1}).

The series on domestic credit was regressed on domestic credit lagged once and a trend component m_t . The trend component was calculated by using a four-period moving average of the seasonally adjusted domestic credit. The residual λ_t was collected, which defined the domestic credit shock and then decomposed into its source components γ_t , which captures the domestic induced shock and ϕ_t which relates to external shocks. The method of decomposition to obtain external credit shocks was to regress external supply credit $F(t)$ on the residual from the domestic credit equation¹². The residual from this regression gives an estimate of the component of domestic credit shocks linked in any way to the supply of net external credit to Jamaica, consistent with Goldberg (1994). The shocks that are domestically induced by the monetary authorities γ_t , were derived by subtracting λ_t from ϕ_t .

To generate forecasts for the shocks to domestic credit, γ_{t+1} and ϕ_{t+1} , an ARIMA process was fitted over 18 months rolling sample, beginning at period t and going back 17 additional months¹³. The standard deviation was computed and fitted over the sample range 1991:10 to 2000:12. Forecast of expected

¹² $F(t)$ is net foreign assets of monetary authorities and deposit banks. $F(t)$ was used in levels and difference twice because negative values were recorded for earlier periods. $F(t)$ was then regressed on domestic credit residuals such that, $\phi_t = -F(t)$

systematic departures from PPP were also generated using the same procedure above. The relative PPP shock Ω_t was then decomposed into its medium term systematic departures from PPP, Ω_{t-1} and its random shocks d_t by the following regression, $W_t = rW_{t-1} + d_t$

For the specification of the critical reserve floor, we note that Blanco and Garber (1986) modeled the reserve floor as a constant multiplied by an index of US import prices. Melick (1996) and Grilli (1990) adopted the simplifying assumption that the authorities will defend the regime until reserves are completely exhausted. Goldberg (1994) used an ad hoc approach and estimated the complete model for a range of reserve floors. The specification of the critical reserve level used in this paper is consistent with Goldberg's approach, with the exception that a constant reserve floor was not maintained for the entire sample. The model was estimated using a range of reserve floors beginning at US\$400.00mn, (the mean of the NIR from 1993 to 1998)¹⁴, and gradually adjusting downwards according to the following rule: Over the period 1991 to 1993, when the NIR was negative, the critical reserve floor was taken to be US\$0.50mn; for the period 1994 to 1995, when reserves were positive and below US\$200mn, the reserve floor was specified as US\$10.0mn, for the period 1996 to 1998, the reserve floor used was US\$50mn and US\$80mn for 1999 to 2000.¹⁵ To obtain a well-defined series, the specified reserve floor was smoothed using the Hodrick-Prescott filter. This approach is justifiable given the sensitivity of the model to reserve floor changes, and the fact that it allows for an adequate representation of growth in the NIR and the concurrent changes, we believe, in the authorities view of R_c .

For the other variables for which forecasts were required, the autocorrelation and partial correlation functions were examined, to determine the structure of the ARIMA process. A unique ARIMA process was then selected based on the Akaike Information Criteria, and fitted to the variables to be forecasted

¹³ The data set for domestic credit goes back to March 1990.

¹⁴ The NIR was negative for the period 1991 to November 1993.

¹⁵ The reserve level was converted to domestic currency using the end of period average weighted exchange rate

over the entire sample period, inclusive of period t^{16} . Forecast for period $t+12$ was then estimated over rolling sub-samples of 18 months of data.¹⁷ The forecasted values for period $t+12$ were collected and tested for model adequacy¹⁸ and where appropriate, the standard deviation of the forecast residuals were calculated.

Finally, the estimation procedure applied to the set of structural equations takes the form of an iterative process that estimates the money demand function in equation (15):

$$Md_t - Q_t = a_0 - a_1 i_t + a_2 y_t - a_3 \{S_{t+1} - S_t\} \quad (15)$$

The parameters from this money demand model were used to generate start up values to compute the shadow exchange rate in equation (11) and to provide first pass estimates of probabilities of depreciation in equations (12) and (13). The probabilities obtained from these estimates were then used in the estimation of equation (16) below, where the currency substitution term is now weighted by the probability of depreciation.

$$Md_t - Q_t = a_0 - a_1 i_t + a_2 y_t - a_3 \left\{ -\mathbf{b}_t \{S_{t+1} - S_t\} + \mathbf{b}_t \{S_{t+1}^* - S_t\} \right\} \quad (16)$$

Equation (16) is then re-estimated to obtain the long run demand for money weighted by agents' notion of the probability of a depreciation of the currency.

¹⁶ Table 3a in the appendix shows the results of the ARIMA processes, including the r-squared, D-W and AKAIKE results for the variables for which forecast is required.

¹⁷ The sample was broken up in 18 equal periods and forecast were generated using an 18-month rolling samples with an interval of 6 months.

¹⁸ Tests were carried out for stationarity, serial correlation and heteroskedasticity.

6. ESTIMATION RESULTS

This section of the paper details the results generated from applying the monetary model to derive the shadow exchange rate and the probability of a speculative attack on the currency. In the analysis that follows, the predicted probability is used in determining the consistency of the model by seeing how well it compares with known events during the sample period. A similar procedure is adopted for the out-of-sample forecasts. In this instance, the last year (January - December 2000) is used in determining the probability of the occurrence of speculative attack on the Jamaican dollar.

6.1 Test for Stationarity

The first step in estimating the components of the monetary model was to examine the stylized properties of the macroeconomic data series used in the model specified in section 3 above. Table 2a in the appendix shows the results of the unit root test and displays the 1.0% to 10.0% McKinnon critical values and the order of difference stationary processes. The variables, domestic interest rate, real money supply, income (GDP), currency substitution/expected depreciation, domestic prices were integrated of order (1). The other variables, such as the domestic credit and inflation were integrated of order (0). As shown, all the variables in the money demand equation are $I(1)$ and hence potentially cointegrated.

6.2 Money demand

The paper utilizes the multivariate Johansen test (1991) to test for the existence of a stable long-run money demand and cointegrating relationship. The null hypothesis under the Johansen test is no cointegration against the alternative of cointegration. As shown in table 3a in the appendix, there exists one cointegrating vector for the set of variables, real money supply, domestic interest rates, expected depreciation and income. The results from the first pass estimates show that in the long run, the decision to hold broad money appear to be driven by movements in domestic interest rate, the level of income and the expected depreciation of the currency. The currency substitution variable/expected

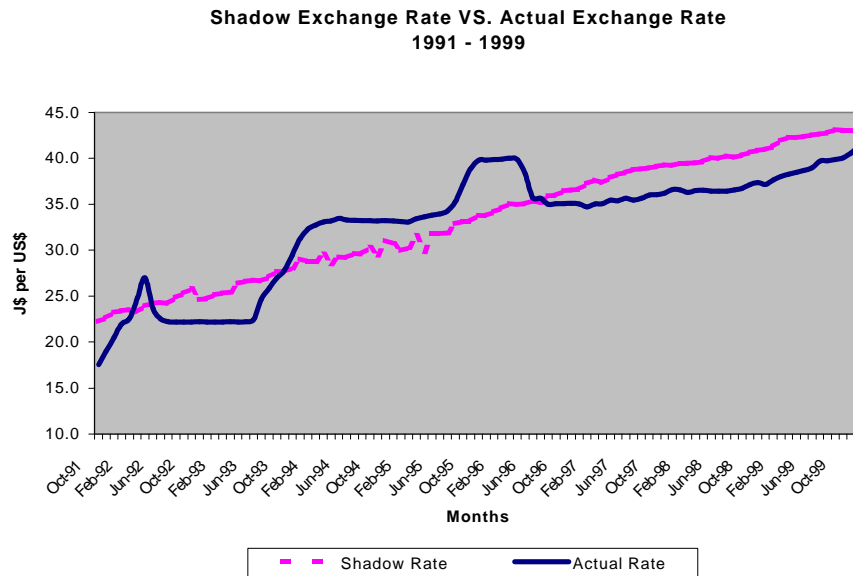
depreciation reflects the notion that devaluation expectations result in a substitution out of broad money holdings to foreign currency. As such, instruments such as foreign assets and treasury bills are used to hedge against the impact of high inflation and expected devaluation on money holdings. Since, to a large extent treasury bills are outside of the deposit money banks, this may imply that the non-bank public may have expected that nominal interest rates on deposits have not been adjusting quickly enough to compensate for higher inflation and devaluation expectations. Table 4a shows the second-pass estimates of the long run money demand function with the currency substitution variable now weighted by the probability of depreciation. All things considered, the money demand function with the inclusion of monthly seasonal dummies showed evidence of parameter stability.

6.3 Shadow Exchange Rates & Collapse Probabilities – In-Sample Results

The shadow exchange rate is defined as the rate that would prevail if speculators attacked the central bank reserves and forced the collapse of the currency. Thus the computed shadow rate is consistent with the contemporaneous state of monetary and fiscal conditions in the economy. Chart 1 gives a comparative view of the shadow exchange rates computed from the second iterative process and the observed managed exchange rates.

The degree of misalignment is computed as the difference, at any moment in time, between the equilibrium and the actual exchange rate. If the shadow equilibrium rate is greater than the actual rate, the model would suggest that the currency is overvalued, conversely if the shadow rate is less than the actual rate, the model would indicate that the domestic currency is undervalued. For the entire period 1991 to 1999, it would appear that the Jamaican dollar was overvalued during the periods **October 1991 – February 1992; May 1992 – September 1993 and August 1996 – December 1999.**

Chart 1



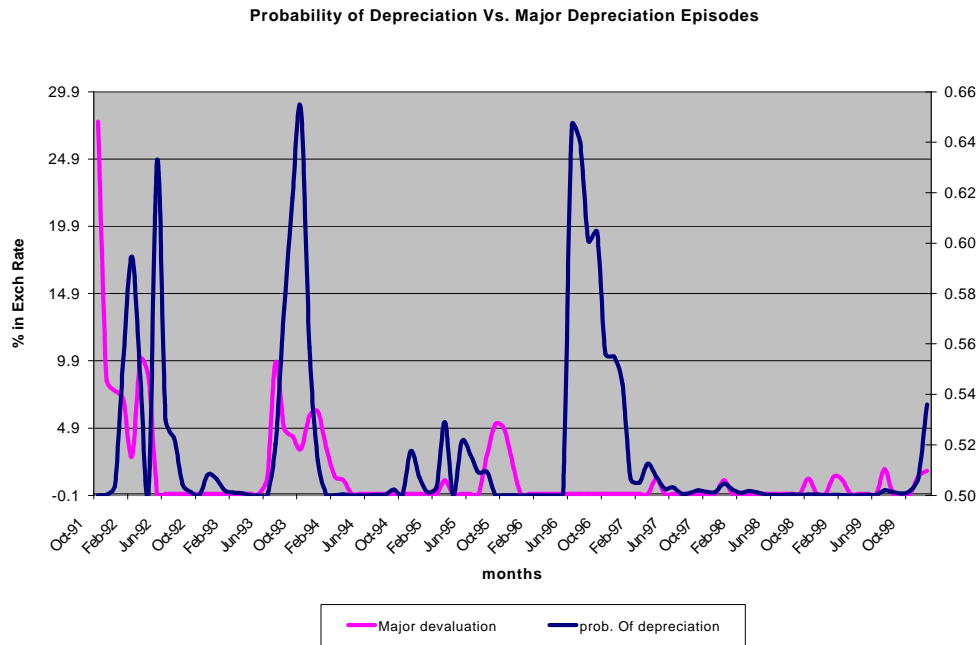
The probabilities of depreciation are indicative of the profitable arbitrage that could be gained by speculative activities in the foreign exchange market. These probabilities are expected to peak prior to or during an episode of currency attack. For the purposes of this paper, a probability value greater than 0.5, which represents the mean of the data is used to determine the occurrence of a speculative attack. Obviously, the higher the probability value, the more severe the incidence of an attack on the currency. However, it is quite interesting to note that the probability of depreciation may be high during a particular period but the severity of the actual depreciation itself may be compressed by central bank intervention in the market. If this is found to be the case, then the explanation for such occurrences may in fact suggest the need to use intervention data and to investigate other institutional factors.

It is worthy of note that other articles have used probability values that are close to 1.0 to determine the occurrence of a crisis, while some have estimated probability values of 0.5 and less. For instance Blanco and Garber (1986) in applying the speculative attack model to Mexico found that the estimated

probabilities jumped to peaks of 20 percent just prior to a major devaluation, while Goldberg (1994) found that collapse probabilities reached a 100 percent level prior to the exchange rate crises.

Chart 2 gives a graphical representation of the probabilities of depreciation measured against major depreciation episodes for the in-sample period while Table 2 gives the selected probabilities of depreciation for Jamaica measured against the percentage change in the currency, the treasury bills and the net international reserves of the Bank. A major depreciation episode is identified as one that is symptomatic of a depreciation of over 1.0 percent during a given month.

Chart 2.



Overall, the collapse probabilities were able to accurately predict the major attack episodes particularly after the liberalization of the foreign exchange market in 1991, and the depreciation of the currency during July 93 to January 94 and September and October 95. In the periods identified, the exchange rate depreciated by over 3.0 percent in any given month. During the months following the

liberalization of the currency in September 1991, the exchange rate depreciated by over 27 percent in October 91 (see table 2), this depreciation continued with the second largest fall in the value of the currency noted in March 92. Although the probabilities were at 0.5 percent for October 91, the probabilities began to rise in November 91 and remained high during the period, attaining a value of 0.59 percent, which was a month prior to the sharp depreciation in March 92. During these months, Jamaica experienced significant devaluations, which manifested itself in an unprecedented rise in the inflation rate, and without the cushion of reserves to halt the slide of the currency, the monetary authorities were forced to increase interest rates sharply.

Table 2:

Selected Collapse probabilities measured against the percentage change in the currency, the Treasury bills and the Net International Reserves of the Bank of Jamaica

	<u>Prob. Of depreciation</u>	<u>NIR</u>	<u>Percentage Changes</u>	
			<u>Exchange Rate</u>	<u>Treasury-Bills (6-Mths)</u>
Oct-91	0.500003		-27.67	
Nov-91	0.500266		-8.45	13.27
Dec-91	0.503673		-7.67	13.13
Jan-92	0.553423		-7.04	13.03
Feb-92	0.594629		-2.77	3.43
Mar-92	0.547289		-10.00	8.15
Apr-92	0.501664		-8.69	-7.78
Jun-93	0.500014		-1.19	-0.41
Jul-93	0.520296		-9.78	7.32
Aug-93	0.574052		-4.87	43.33
Sep-93	0.618092		-4.28	14.24
Oct-93	0.653136		-3.33	-3.77
Nov-93	0.558633		-5.81	6.81
Dec-93	0.513789	139.94	-6.12	-0.35
Jan-94	0.500265	-32.13	-3.37	1.50
Feb-94	0.500053	48.17	-1.30	3.80
Mar-94	0.500340	345.55	-1.03	-3.64
Aug-95	0.509170	-6.61	-2.92	-1.03
Sep-95	0.500062	13.82	-5.19	16.14
Oct-95	0.500000	-11.03	-4.85	22.17
Nov-95	0.500000	-10.37	-2.31	1.17
Apr-97	0.507386	-1.75	-1.11	-9.45
Dec-97	0.504650	-4.03	-1.02	1.23
Oct-98	0.500314	-2.28	-1.14	4.62
Jan-99	0.500227	-0.54	-1.29	-4.60
Feb-99	0.500076	-0.05	-1.04	-3.10
Jul-99	0.501988	-17.91	-1.85	-0.60
Nov-99	0.506941	2.99	-1.30	5.14
Dec-99	0.535873	-11.20	-1.73	1.47

Criteria: 10% fall in Reserves, 5% rise in interest rates and a 1% depreciation of the currency.

For the second period, July 93 to January 1994, the currency depreciated by 9.78 percent in July with the rate of depreciation gradually falling to 6.1 percent in December and 3.4 percent in January 1994. From table 2, we note that the probabilities started to rise in June of 1993 and gave a strong indication of the imminent sharp depreciation of the currency in July and subsequently after. It is interesting to note however that the probabilities were relative low when compared to the sharp depreciation that occurred in July. Also in October, when the rate of depreciation was at its lowest, the probability of an attack reached its peak of 0.65 percent. This explanation may lie in the fact that the money supply (M2) growth of 4.0 percent in October 1993 was in excess of the monthly growth rates recorded in 1993, implying an increased probability of depreciation. From table 2, it is obvious that the monetary authorities had to increase interest rates subsequently to reduce demand pressures in the market.

During the months of September and October 1995, the exchange rate depreciated by 5.2 percent and 4.9 percent respectively. The probabilities peaked prior to this attack episode, remained high and then declined precipitously to its base value of 0.5 percent. From table 2, one can observe that the monetary authorities were forced to intervene in the market, with reserves falling by 11 percent on average and interest rates rising by 16 percent and 22 percent in the respective months. This policy response helped to reduce demand pressures in the foreign exchange market.

From May to December 1996, the model generated high probabilities of an attack, when the exchange rate had achieved relative stability. The high probabilities can in fact be interpreted as a reflection of the inconsistency between fiscal and exchange rate policies. Connolly (1986) highlighted that to avoid a speculative attack, the exchange rate needed to be devalued by an amount no less than the rate of growth of domestic credit, and an attack is risked when domestic credit growth exceeds the rate of currency depreciation. Within the model, the monthly average rate of domestic credit growth was 5.1 percent higher than the rate of currency depreciation during the period May to December 1996. Indeed, the collapse probabilities signaled the opportunity for profitable arbitrage during these two

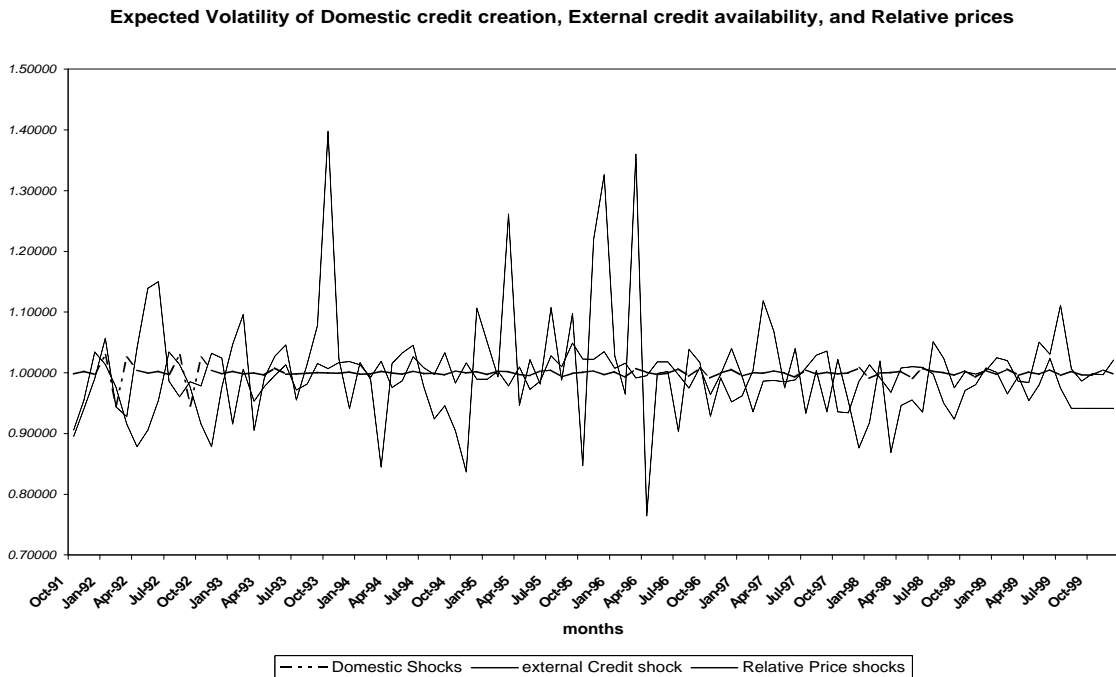
periods, due to the expansionary credit growth relative to the movements in the exchange rate. However, the market rate was affected by substantial sales of foreign exchange to the market, which resulted in a substantial loss of approximately US\$168.0 million in international reserves. Concurrently, the authorities also had access to significant external credit to cushion the fall in the reserves level. Therefore the availability of external credit in the context of intervention sales to the market allowed the Central Bank to compress the size/extent of speculative demand pressures in the foreign exchange market.

For the period January to December 1999, the probabilities hovered around their mean value of 0.5 percent. However, the probabilities began to rise in October 1999 and attained a value of 0.54 percent in December 1999. In table 3, the shadow exchange rate, which reflects underlying economic conditions, suggested that the currency was overvaluation, yet the probabilities did not adequately track the build-up in demand pressures experienced in 1999. Although pressures in the market emanated from the difficulties the country experienced in raising external credit to cover the fiscal deficit, the role of news concerning governments operation in the domestic and capital markets, the market rate was again affected by substantial sales of foreign exchange by the central bank. Given the high level of net international reserves during the period and the subsequent receipt of external credit during the latter part of 1999, the central bank was able to compress the rate of currency depreciation, substantially.

Chart 3 examines the role of external credit shocks and relative prices and domestic credit shocks in influencing the probabilities of an attack on the currency. The uncertainty surrounding the ability of the government to obtain external credit was more pronounced in earlier periods relative to the period 1997 and 1998, while in July 1999, the variability surrounding external credit shocks increased marginally. It is likely that the impact of governments unsuccessful bond offer during the period of

June to July 1999 could have influenced this outcome. However, this paper finds that the variability of these shocks do not significantly alter the direction of the collapse probabilities.

Chart 3.



6.4 Collapse Probabilities – Out-of-Sample Results

For the out-of-sample period January to December 2000, the probabilities showed that there would have been a successful attack on the currency even though the misalignment gap indicated that the exchange rate was overvalued and undervalued at some points during the sample period. These results are rather interesting and somewhat puzzling, as during the period the authorities had access significant foreign inflows ¹⁹, which helped to boost the NIR and enable the restoration of some level of confidence in the foreign exchange market. During the latter part of 2000, however, there were significant demand pressures on the exchange rate, stemming from the relative attractiveness of a Eurobond offer that was floated on the international market, which forced the central bank to intervene

heavily to ward of pressures on the exchange rate. To the extent that the country benefited from significant external credit, the level of intervention in the market by the central bank was not reflected in the change in the NIR. Table 4 shows the actual exchange rate compared with the computed shadow rates for 2000, while table 5 gives selected collapse probabilities for the period.

Table 4

Actual Exchange Rate VS Shadow Exchange Rate Out-of-Sample Results January - December 2000			
Months	Actual rate	Shadow rate	Deviation
Jan	41.75	41.6778	-0.0722
Feb	42.25	41.8557	-0.3943
Mar	42.15	41.9319	-0.2181
Apr	42.07	42.2906	0.2206
May	42.22	42.4064	0.1864
Jun	42.33	42.4389	0.1089
Jul	42.53	42.5709	0.0409
Aug	42.89	42.6841	-0.2059
Sep	43.85	42.6812	-1.1688
Oct	44.71	43.0897	-1.6203
Nov	45.08	43.2119	-1.8681
Dec	45.75	43.3110	-2.4390

¹⁹ Foreign exchange flows from the receipt of cellular license, proceeds of Eurobond flows and IADB/World Bank flows

Table 5.

Selected Collapse probabilities measured against the percentage change in the currency, the Treasury bills and the Net International Reserves of the Bank of Jamaica

	Prob. Of Depreciation	NIR	Percentage Changes	
			Exchange Rate	Treasury Bill
Jan-00	0.654649	0.92	-1.16	-0.27
Feb-00	0.643974	30.62	-1.20	0.43
Mar-00	0.651571	19.12	0.24	-11.92
Apr-00	0.651492	6.06	0.19	-1.94
May-00	0.652498	4.26	-0.36	0.31
Jun-00	0.654162	-2.70	-0.26	-0.93
Jul-00	0.654909	4.26	-0.47	-0.68
Aug-00	0.651945	18.52	-0.85	-1.57
Sep-00	0.579843	0.06	-2.24	0.51
Oct-00	0.542744	-9.77	-1.96	0.00
Nov-00	0.527778	-9.87	-0.83	0.82
Dec-00	0.508128	27.86	-1.49	15.15

7. POLICY IMPLICATIONS & CONCLUSION

So far, the attempt by this paper to predict depreciation pressures in the market has been relatively successful. The in-sample results based on probability estimates predicted the depreciation of the currency following the liberalization period, and prior to and during other major depreciation episodes. The paper finds that the most important influence on the probabilities was the pattern of domestic credit creation and monetary financing of governments deficit. The paper highlights that in order to achieve stability in the foreign exchange market, government borrowing needs must be covered by non-monetary financing methods, such as taxation, foreign borrowing and grants.

The out-of-sample results are disappointing. However, these results are qualitatively robust to the choice of reserve floor specification, with higher values of reserve floor associated with higher predictions of the likelihood of a successful attack on the reserves.

This kind of research is useful in the following respects: Firstly, the computed shadow exchange rate based on economic fundamentals and the probabilities are capable of generating an early warning system of regime fragility. If the model predicts a high probability of depreciation, then the monetary authorities can be proactive in their policy approach in reducing future demand pressures. The policy options at their disposal may either lead to higher intervention sales to the market, contractionary monetary and fiscal policy, or a combination of both.

One of the limitations of using this model to calculate the probabilities is that to derive the forecast of these probabilities, a forward exchange rate market must exist. To the extent that Jamaica does not have a forward market, this may pose some difficulties. However, an alternative option may be to utilize the financial program generated by the Bank, which assumes relative fixity in the exchange rate over the forecast horizon.

Overall, the paper finds that the credibility and sustainability of the managed exchange rate system can be achieved by influencing the pattern of credit creation in financing governments operation. The fiscal imbalance must be addressed if monetary policy is to be effective in curtailing demand pressures over the medium term. The point must therefore be emphasized that exchange rate stability can only be achieved by stabilizing exchange rate expectations, and the policy instruments to be used are fundamental fiscal adjustments. As such, fiscal adjustments in conjunction with the stance of monetary policy, can restore credibility in the market, maintain low inflation, provide an avenue for declining interest rates, increased investment and ultimately growth.

Interesting areas for further research work could examine the 'signals approach' to speculative attack in the foreign exchange market by examining the evolution of macroeconomic variables that may have influenced speculative activities. This model requires the construction of an exchange rate crisis index as an indicator of a looming crisis. This line of research should be potentially useful to the central bank. Another area of interesting research work could also examine the role of central bank intervention and the impact of their operation in stabilizing the foreign exchange market.

1. APPENDIX

Table 1a

Data Sources and Definition

$F(t)$	<i>Net foreign asset of monetary authorities and commercial banks, obtained from various issues of the BOJ statistical digest</i>
P^*	<i>United states wholesale prices, obtained from various issues of the International Financial Statistics</i>
$S(t)$	<i>End of period monthly weighted average exchange rate, obtained from the Statistical Digest</i>
$a(t)$	<i>Jamaica exports plus imports of goods converted to local currency using the monthly weighted average exchange rate and expressed as a ratio of real GDP interpolated</i>
$\tilde{S}(t)$	<i>The author's calculation of the shadow exchange rate</i>
$I(t)$	<i>Domestic nominal six-month treasury bills, obtained by using the treasury bill rate provided in various issues of Statistical Digest and adjusted to obtain monthly series</i>
$I^*(t)$	<i>US treasury bills, from various issues of the IFS</i>
$P(t)$	<i>The consumer price index, from the Statistical Digest</i>
$Y(t)$	<i>Interpolated monthly real GDP, using an index of exports, imports and</i>

	<i>Tourism</i>
<i>D(t)</i>	<i>Credit to the public sector, the private sector and to other financial institutions on a net basis. Obtained from the Statistical Digest, various issues</i>
<i>R(t)</i>	<i>Net Foreign assets of the Bank of Jamaica.</i>

Table 2a. Unit Root Tests

<u>Variable</u>	ADF Test Results			
	Lags	Levels	1st Difference	Significance
<i>Nominal Domestic interest rates</i>	4		-4.247	1%
<i>Real Money supply (M2)</i>	8		-3.463	5%
<i>Domestic prices</i>	3		-3.445	10%
<i>Domestic credit</i>	6	-2.500		
<i>Inflation</i>	4	-3.035		
<i>GDP</i>	3		-6.522	5%
<i>Currency Substitution</i>	3		-8.286	1%

Figure 1a. Time-Series of the Data

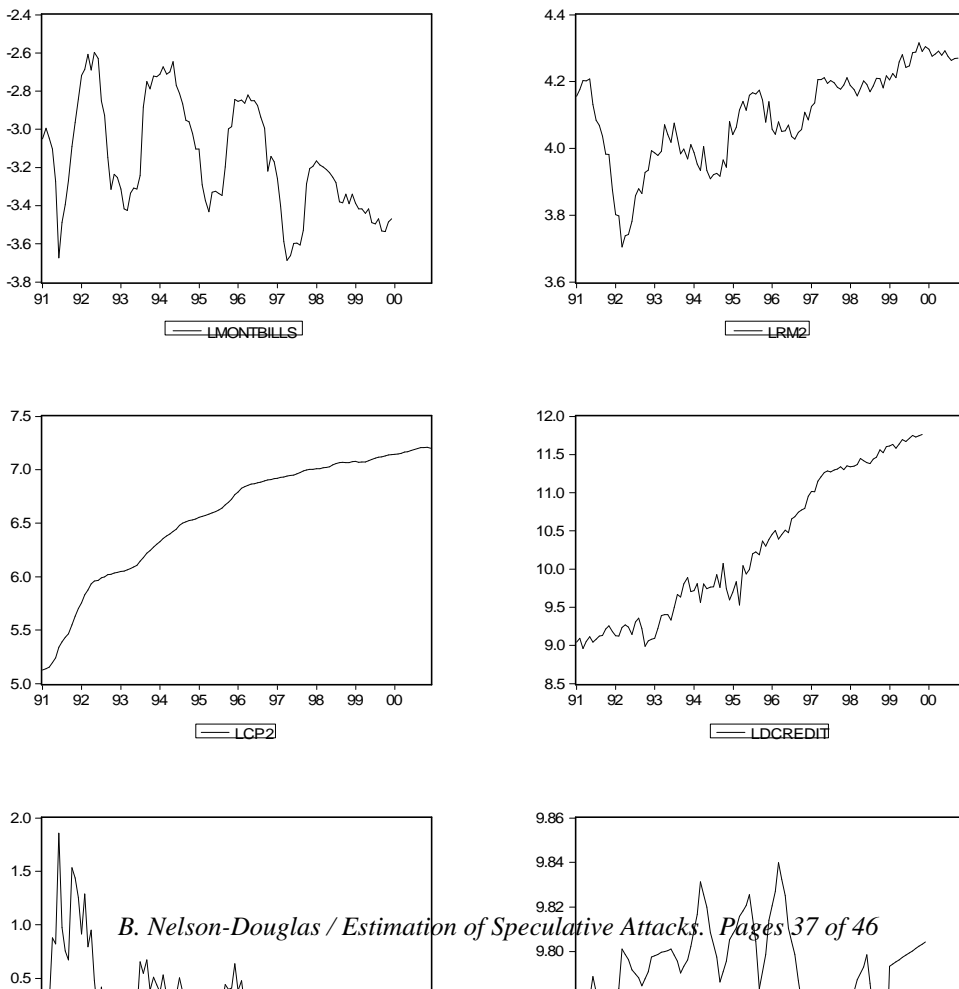


Table 3a.

JOHANSEN COINTEGRATION TEST

Sample: 1991:01 2000:12
 Included observations: 105
 Test assumption: No
 Deterministic trend in the data
 Series: LRM2 CURRSUB LMONTBILLS LGDPINTER
 Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.441885	80.26950	39.89	45.58	None **
0.143373	19.03458	24.31	29.75	At most 1
0.025019	2.785577	12.53	16.31	At most 2
0.001191	0.125172	3.84	6.51	At most 3

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LRM2	CURRSUB	LMONTBILLS	LGDPINTER
-0.287609	-2.785860	-0.121805	0.085243

0.701608	-0.306427	0.512912	-0.126214
-0.849760	0.164138	-0.083171	0.326994
0.007136	0.064146	-0.013156	0.002667

Normalized Cointegrating Coefficients: 1
Cointegrating Equation(s)

LRM2	CURRSUB	LMONTBILLS	LGDPINTER
1.000000	9.686291 (4.19339)	0.423511 (0.13395)	-0.296386 (0.04238)

Log likelihood	882.5736
----------------	----------

Table 4a

JOHANSEN COINTEGRATION TEST

Sample: 1991:01 2000:12
Included observations: 97
Test assumption: No
deterministic trend in the data
Series: LRM2 LMONTBILLS PIE LGDPINTER
Exogenous series: DUMMY1 DUMMY11 DUMMY12
Warning: Critical values were derived assuming no exogenous series
Lags interval: 1 to 1

Eigenvalue	Likelihood Ratio	5 Percent Critical Value	1 Percent Critical Value	Hypothesized No. of CE(s)
0.496947	83.66705	39.89	45.58	None **
0.120576	17.02232	24.31	29.75	At most 1
0.044626	4.558918	12.53	16.31	At most 2
0.001345	0.130591	3.84	6.51	At most 3

*(**) denotes rejection of the hypothesis at 5%(1%) significance level

L.R. test indicates 1 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

LRM2	LMONTBILLS	PIE	LGDPINTER
-0.290084	-0.116379	-8.159606	0.504678
-0.711619	-0.559575	0.699464	0.081477
0.787823	0.109956	-0.465178	-0.274214
0.614375	0.134911	0.220692	-0.215015

Normalized Cointegrating
Coefficients: 1 Cointegrating
Equation(s)

LRM2	LMONTBILLS	PIE	LGDPINTER
1.000000	0.401191 (0.12700)	28.12846 (12.3616)	-1.739766 (0.63671)
Log likelihood	944.3426		

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