Working Paper

Monetary Policy Rules and the Transmission Mechanism in Jamaica

Courtney Allen and Wayne Robinson [1]
Research and Economic Programming Division
Bank of Jamaica

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Abstract

This paper uses an aggregated small-scale macroeconomic model to study the monetary transmission mechanism in Jamaica. It also simulates the behaviour of the economy under different monetary policy rules. There is a direct transmission from interest rates to exchange rates through portfolio substitution, which is reflected in and reinforced by changes in domestic liquidity conditions. Monetary policy has the greatest impact on inflation in the second quarter after the innovation. Inflation stabilization is achieved mainly through the exchange rate, which itself reflects the combined effect of policy on asset portfolios and aggregate demand. The output gap plays a minor role in terms of a direct impact on inflation and is affected by monetary policy through the credit channel and the real exchange rate. While the monetary authority should continue with the intermediate regime of inflation targeting *lite*, the paper recommends the adoption of a more forecast based policy rule. Given the monetary transmission process, the change in the exchange rate is the most appropriate intermediate target. Irrespective of the policy rule, there are gains to be had from greater interest rate smoothing in the pursuit of price stability.

Keywords: SUR, monetary transmission, monetary policy rule
JEL Classification: C51,C52

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Corresponding author: Wayne Robinson, email: wayner@boj.org.jm

1.0 Introduction

The conceptual framework that underpinned the conduct of monetary policy since the latter half of the 1990s was based on a robust link between money supply and inflation. Thus by regulating the supply of money and credit, through its control over the monetary base, the central bank influences agents' portfolio decisions, aggregate demand and consequently inflation. This approach has led to a significant reduction in inflation, with the period being characterized by moderate monetary expansion and six consecutive years of single digit inflation.

However, it is likely that nature of the process through which monetary policy affects the economy- the monetary transmission mechanism, has evolved[2] over the years. This is in a context where the 1990s was characterized by a significant transformation of the financial sector and a progressive opening of the economy to international trade and capital flows, which accelerated in the latter half of the decade. This evolution poses significant implications for the design and implementation of monetary policy.

Against this background, this paper uses a simple aggregated model, similar to Allen, Hall and Robinson (2003), to study the current monetary transmission process in Jamaica. The analysis is conducted over the post liberalization period[3]. The effect of a monetary shock on the economy is simulated under different policy rules.

The next section outlines the model and the estimation results, which is followed by an analysis of the transmission process, using stochastic simulations, in section 3. In section 4 we evaluate the efficacy of alternative policy frameworks, while the final section presents some conclusions and possible extensions.

[2] See Robinson & Robinson (1997) for an earlier analysis of the transmission process in the Jamaican context.

2.0 The Model

Given the data limitations, the model is highly aggregated, consisting of IS and LM curves, Phillips curve, exchange rate equation and a monetary policy rule. Economic agents are forward-looking and form expectations rationally, using information up to time t-1 and are aware of the policy rule.

The model differs from Allen, Hall and Robinson (2003) in its treatment of potential output. As is frequently done, potential output was estimated using the Hodrick-Prescott filter. This is purely statistical treatment of a real dis-equilibrium, the major shortcomings of which are documented in Harvey and Jaeger (1993). These include the possibility of spurious cyclicality, excessive smoothing and the large end sample bias. Against this background, in this paper, potential output was estimated using an unobserved components method, which utilizes the information contained in observed variables (see **Appendix A1**). That is, it exploits the relation between potential output and observable variables such as unemployment or wages and inflation.

The model presented also extends the treatment of the Phillips curve in Allen, Hall and Robinson (2003) to account for forward-looking expectations. This forward-looking model provides richer dynamics compared to the backward looking ISLM type model of Allen, Hall and Robinson (2003) and is more consistent with models based on intertemporal optimization.

The equations were estimated as a system using the seemingly unrelated regression estimator (SUR)[4]. Each equation was first estimated using general to specific modeling to obtain a parsimonious error correction form, which was then used in the system. The model was estimated using quarterly seasonally adjusted data for the period 1990 to 2002 and all variables are expressed in logs, except for interest rates.

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[3] Limited sample size precludes an analysis of the post 1995 period specifically.

[4] While the right hand side variables, particularly in the money demand equation, are generally weakly exogenous (see Allen, Hall and Robinson (2003)), it may be unrealistic to expect that the equation errors are truly uncorrelated (contemporaneously). The likelihood ratio for contemporaneous correlation was 67.23. With ten degrees of freedom we cannot reject the null. FIML estimation was also done, but the performance of the SUR estimates was superior (it is known that the log likelihood for both estimators are identical).

2.1 Consumer Price

The relatively high consumer price inflation[5] in Jamaica in the early 1990s was to a large extent influenced by monetary conditions. Further the openness of the economy has given more prominence, certainly in the short run, to exchange rate fluctuations (Robinson 2000). However, although the exchange rate pass through is still significant, with macroeconomic stabilization and increased competition, supply shocks have recently emerged as a major determinant of inflation. Against this background consumer price inflation is modeled along the lines of a forward-looking[6] open economy Phillips curve. i.e.

$$p_t = a_0 \mathrm{E}_t p_{t+1} + (1 - a_0) p_{t-1} + a_1(L)(y_t - y_t^*) + a_2(L)(\Delta s_t + \Delta p_t^*) \qquad (1)$$

where p_t is the inflation rate, $E_t p_{t+1}$ represents expected inflation, y_t denotes output, y* potential output, s_t is the exchange rate, p* represents foreign inflation and L the lag operator. Equation (1) conveys that inflation dynamics are influenced by inflation expectations, some measure of excess demand and imported inflation. Excess demand is proxied by an output gap[7] measured by the deviation of output from a measure of potential output. The inclusion of a backward looking component in this 'hybrid' model captures the importance of lagged inflation to expected future inflation under rational expectations[8].

We estimated equation (1) by a two-step procedure similar to Galí (2000). In the first stage estimates for a_0 were obtained using GMM, with p_{t+1} serving as a proxy for $E_t p_{t+1}$ and current and lagged values of the output gap and first differences of the exchange rate

[5] Although core inflation is more relevant to policy, the model uses headline inflation measured by the consumer price index as this is what the public uses to gauge inflation. In this context, for credibility the headline inflation is the ultimate target for the central bank, which is communicated to the public.

[6] This is consistent with the New Keynesian Phillips curve which assumes wage setting behaviour according to the rational expectations staggered contract models of Taylor (1980) and Calvo (1983). See Roberts (1995) Gali and Gertler (1999), Fuhrer (1997) and Rudd and Whelan (2001).

[7] In the New Keynesian approach, the Phillips curve embodies a relation between price and marginal cost (see Galí and Gertler (1999). The use of an output gap as a measure of real activity therefore assumes that there is a proportional relation with marginal cost.

[8] See Galí and Gertler (1999).

as the instruments[9]. This estimate is then imposed in the SUR system to obtain the coefficients of the output gap and imported inflation[10]. The results are shown in Table 1.

Table 1: Inflation

Variables	Coefficients	S. Error	t-stat	P-value
a_0	**0.368334**	**0.082533**	**4.462843**	**0.0001**
$y_{t-1} - \bar{y}_{t-1}$	0.276600	0.132935	2.080713	0.0388
$\Delta s_t + \Delta p_t^*$	0.353274	0.042397	8.332472	0.0000
$\Delta s_{t-1} + \Delta p_{t-1}^*$	-0.144828	0.053462	-2.70896	0.0074
$\Delta s_{t-2} + \Delta p_{t-2}^*$	0.274808	0.043340	6.340694	0.0000

S.E. of regression: 0.022265 Sum squared resid: 0.017845
B-G: Prob $\chi^2(1)$=0.065 B-G: Prob $\chi^2(4)$=0.049
White: Prob $\chi^2(1)$=0.065 Jarque-Bera: Prob. = 0.609

The first row of Table 1 contains the result of the GMM estimate of a_0, and the other coefficients correspond to the SUR estimates with the restriction a_0=0.368334[11]. The size of a_0, however, suggests that past inflation is of greater importance to current inflation relative to future inflation. Imported inflation, with a lag of up to two periods, was the most important factor in explaining current inflation. The structure and characteristics of the economy supports this finding given its small size and openness, and the heavy reliance on imported items for production and consumption. Further, any excess domestic demand in the economy tends to be quickly satisfied by imports. The results show that it is the output gap in the previous period that is important for current inflation. This could be due to a staggered price setting mechanism possibly reflecting the impact of competition. Or a narrowing of the output gap in time t-1 generates wage and demand pressures, which translate into price pressures in time t.

[9] Galí (2000) posits that this technique avoid biased results.
[10] The inclusion of an error correction term was not significant and did not yield sensible results.
[11] Wald test for the null that the coefficients of p_{t-1} and p_{t+1} sum to one could not be rejected.

2.2 Aggregate Demand

Consistent with the traditional open economy IS curve, aggregate demand was specified as a function of interest rates and the real exchange rate. As in Allen, Hall and Robinson (2002) a credit channel is also incorporated in the model through the inclusion of banking system reserves, similar to Bernanke and Blinder (1988). The availability of credit facilitates consumption smoothing and investment, thereby influencing aggregate demand. Robinson and Robinson (1998) find that the credit channel is one of the monetary policy transmission channels in Jamaica. The credit channel amplifies the effect of monetary policy through the response of the external finance premium and the availability of reserves (see Dale and Haldane (1993) and Bernanke and Gertler (1995)). Aggregate demand was estimated using the following error correction form

$$\Delta y_t = -b_0[y_{t-1} - 0.17 res_{t-1} + 0.16 r_{t-1} - 0.07 rer_{t-1} - 6.65] + b_1(L)\Delta r_t + b_2(L)\Delta y_t \qquad (2)$$

where r_t is the real interest rate, rer_t is the real exchange rate and res_t is real reserves.

Table 2: Aggregate Demand

Variables	Coefficients	S. Error	t-stat	P-value
c	0.002987	0.002247	1.329196	0.1854
ec_{t-1}	-0.285010	0.076694	3.716179	0.0003
Dr_{t-3}	0.062859	0.029601	2.123560	0.0350
Dy_{t-1}	0.213221	0.104232	2.045633	0.0422
Dy_{t-2}	-0.569449	0.097980	5.811883	0.0000

S.E. of regression: 0.01556 | Sum squared resid: 0.008444
B-G: Prob $\chi^2(1)$=0.065 | B-G: Prob $\chi^2(4)$=0.577
White: Prob $\chi^2(1)$=0.097 | Jarque-Bera: Prob. = 0.934

The changes in the real exchange rate did not emerge as being important in the parsimonious dynamic specification. The error correction term was significant, however, the size suggest relatively slow quarterly adjustment of output to deviations from equilibrium. The short-run dynamics are driven mainly by lagged changes in output or the momentum in the economy.

2.3 Money Demand

The demand for real money balances[12] (M2) was estimated within an error correction framework which included the rate of depreciation, income, and an opportunity cost measure, *h*, defined as $(M^o/M2)*r$. This captures the fact that all the components of money, except for high-powered money earn interest at the outside interest rate[13]. The change in the exchange rate was included to account for currency substitution.

$$\Delta m_t = -g_0[m_{t-1} - 1.11 y_{t-1} + 2.21 h_{t-1} + 3.19 \Delta s_{t-1} - 4.89] + g_1(L) y_t + g_2(L) r_t + g_3(L) \Delta\Delta s_t \qquad (3)$$

The long run coefficients indicate that the elasticity with respect to exchange rate depreciation is greater than that for interest rate, indicating the significance of the public's perception of devaluation on their portfolio choice. Similar to the results in Craigwell (1991), the income elasticity was marginally larger than one, although not statistically different from unity. The results for the short run dynamics are shown in table 3.

Table 3: Money Demand

Variables	Coefficients	S. Error	t-stat	P-value
ec_{t-1}	-0.161042	0.018942	8.501718	0.0000
DDs_t	-0.542844	0.065022	8.348619	0.0000
Dh_t	-0.391987	0.123082	3.184769	0.0017

S.E. of regression: 0.037013 Sum squared resid: 0.052057
B-G: Prob $\chi^2(1)$=0.065 B-G: Prob $\chi^2(4)$=0.356
White: Prob $\chi^2(1)$=0.277 Jarque-Bera: Prob. = 0.434

The error correction term was negative and significant, which indicates that there is a countervailing adjustment in the demand for real money balances in the subsequent quarter in response to a dis-equilibrium. The speed of adjustment, however, is low, especially when compared to Craigwell (1991) and Henry and Kent (1996). Cuthbertson

[12] The central bank's policy is currently framed around M3, however, a stable and theoretically consistent demand function using this measure was not obtained over the sample period. The appeal of M3 has been questioned in light of the developments in the banking system and the structure of the banks' demand liabilities.
[13] See Ericsson et al (1997)

and Taylor (1990) argue that a slow speed of adjustment is likely if the current portfolio choice of agents is significantly influenced by expected future income and return. Allen, Hall and Robinson (2002) attribute this result to the increasing financial sophistication of the Jamaican investor, particularly since liberalization. Similar to Allen, Hall and Robinson (2002), although important in the long run, changes in real GDP do not affect the short run demand. Interest rate and the rate of exchange rate depreciation are significant, with the rate at which the exchange rate depreciates having the most significant and immediate effect. While the largest component of M2, savings deposits are relatively interest insensitive, there has been a growing tendency of agents to shift into other instruments including foreign currency when the trajectory of exchange rates changes.

2.4 Banking System Reserves

Reserves are determined by the real interest rate and the liquid asset ratio[14]. To the extent that short-term (risk free) securities are held as liquid assets or excess reserves, a rise in interest rates is expected to directly positively influence the stock and indirectly through any rise in interest bearing deposits. The latter would serve to increase the pool of funds available for credit.

$$\Delta res_t = -d_0[res_{t-1} - 10.02 - 1.47 * r_{t-1} - 1.58 * LAR_t] + d_1(L)\Delta r_t + d_2(L)\Delta LAR_t + d_3(L)\Delta res_{t-1} \quad (4)$$

The short-run dynamics depends on the previous positions (see Table 4). The size of the error correction term suggests a quick response to deviations from the desired or equilibrium position. Changes in the LAR were not important to the short run dynamics. This is not surprising since banks generally hold reserves in excess of the requirement and as such the LAR is not a binding constraint. Further, the impact of changes in the LAR depends on the component that is adjusted. Changes in the cash reserve component only, may not affect overall reserves as the banks may convert excess liquid assets into cash. This, however, is costly to banks since these reserves are non-interest earning.

[14] This is comprised of a statutory cash reserve ratio and (non-cash) liquid asset ratio.

Table 4: Reserves

Variables	Coefficients	S. Error	t-stat	P-value
ec_{t-1}	-0.740464	0.203506	3.638537	0.0004
$Dres_{t-1}$	0.743800	0.167760	4.433717	0.0000
$Dres_{t-3}$	-0.430545	0.110400	3.899861	0.0001

S.E. of regression: 0.084652 Sum squared resid: 0.25798
B-G: Prob $\chi^2(1)=0.139$ B-G: Prob $\chi^2(4)=0.139$
White: Prob $\chi^2(1)=0.001$ Jarque-Bera: Prob. = 0.369

2.5 Exchange Rate

The exchange rate is modeled along the lines of the standard monetary model with rational expectations, where the reduced form changes in the rate is driven by expected fundamentals. Consistent with the model presented, the forcing variables are the interest differential with the US, inflation differential and the demand for domestic money balances. To account for the market microstructure we include a measure of exchange rate volatility, the change in the rate of depreciation. In thin markets, like Jamaica's, accelerations in the rate of depreciation tend to get amplified. A general dynamic form in first differences was used.[15] The results, shown in table 5 meet a priori expectations.

$$\Delta s_t = j\,(L)_0 * (i_t - i_t^*) + j\,(L)_1 * (p_t - p_t^*) + j\,(L)_2 * \Delta m_t + j\,(L)_3 * \Delta\Delta s_t \qquad (5)$$

Table 5: Exchange Rate

Variables	Coefficients	S. Error	t-stat	P-value
i_{t-1}-i_{t-1}*	-0.046537	0.023277	-1.99929	0.0470
p_t-p_t*	1.660261	0.091113	18.22196	0.0000
Dm_t	-0.465547	0.065703	7.085652	0.0000
DDs_{t-1}	0.258833	0.055399	4.672174	0.0000

S.E. of regression: 0.0370 Sum squared resid: 0.05206
B-G: Prob $\chi^2(1)=0.065$ B-G: Prob $\chi^2(4)=0.833$
White: Prob $\chi^2(1)=0.131$ Jarque-Bera: Prob. = 0.511

[15] Test for a long run relation based on PPP did not yield satisfactory results.

2.6 Model Prediction

The in sample[16] predictive power of the model is assessed using the standard mean square error (MSE), root mean square error (RMSE) and the Theil U statistics, over the sample period. A Theil U greater than one is undesirable and the closer the statistic is to zero the more robust the predictive accuracy. Table 6 gives the results, for the main macroeconomic variables. The performance of the model can also be seen in the actual and fitted values shown in **Appendix A2**.

The statistics indicate that the model replicates the behaviour of the Jamaican economy fairly well. The predications for reserves are relatively weaker, albeit the accuracy is reasonably acceptable. The graphs indicate that the model picks up the major turning points in the series reasonably well.

Table 6: Model Prediction (1990:1 – 2000:4)

	MSE	RMSE	Theil U
GDP	0.00039	0.01981	0.00281
Inflation	0.00018	0.01335	0.02381
Reserves	0.01435	0.11978	0.55929
M2	0.00310	0.05572	0.01151
Ex. Rate change	0.00128	0.03578	0.07441

3.0 Monetary Policy Simulation

In this section define more precisely the monetary transmission mechanism in Jamaica. The transmission of monetary policy occurs through different channels, which are identified by simulating the dynamic response of the economy to an *unanticipated* monetary policy shock. In this exercise, we consider the response of the system to a 100 basis points increase in interest rates per annum, which lasts for one quarter. Bank of Jamaica's open market rates have a pervasive and strong influence on a wide spectrum of

[16] These small-scale models are designed for monetary policy simulations and not necessarily for forecasting.

market rates. Hence, purely for convenience we assume that changes in the policy rate translates one-for-one into changes in market rates. Given that the model includes forward-looking variables, the Fair-Taylor solution algorithm for rational expectations models is used.

Following on Allen, Hall and Robinson (2002), the simulations use a baseline policy rule, which accounts for the fact that changes in the exchange rate have featured more prominently in monetary policy operations in Jamaica relative to the movements in the monetary base. This is against the background that the exchange rate is an important nominal anchor, particularly for expectations in the Jamaican economy, given its openness. Hence this price has emerged over the years, under various policy regimes, as the key intermediate target.

The importance of the exchange rate to monetary policy operations even within the rubric of base money targeting is also derived from the fact that movements in the monetary base in itself may not convey sufficient information about current monetary conditions given the lagged information on (and endogeneity of) the money multiplier[17]. Fluctuations in the exchange rate therefore give a better indication of current conditions. Monetary policy in Jamaica therefore can in effect be described as a form of inflation-targeting *Lite*[18].

It must be noted, however, that the focus of monetary policy in Jamaica is not on the level of the exchange rate, but the rate of adjustment in the market. We attempt to capture this idea in the following policy rule

$$i_t = qi_{t-1} + (1-q)r^* + l_0(E_t \Delta s_{t+h} - \Delta \bar{s}) + l_1(E_t y_{t+j} - \bar{y}) \qquad (6)$$

The policy choice is therefore encapsulated by the quintuplet $\{q, \lambda_0, \lambda_1, h, j\}$, where q is the smoothing parameter, r^* the equilibrium real interest rate and λ_0, λ_1 the feedback

[17] There was also the issue of the stability of the demand for M3.
[18] There is a broad inflation objective, however, this is pursued with a stable foreign exchange (financial) market being the *foremost* policy objective (see Stone (2003)). The issues of low credibility and lack of transparency raised by Stone (2003), however, are not necessarily applicable to Jamaica.

policy parameters. In the simulations r* is suppressed as the central bank, though cognizant, does not consider the equilibrium real rate as an operational target. We set q=0.4, λ_0=0.6, λ_1=0.4, h = 0 and j = 0. These feedback parameters were found to best replicate monetary policy actions (Allen, Hall and Robinson (2002)) and as such monetary policy can be said to conform to an *outcome-based*[19] rule. The value of θ captures the secondary role that interest rate smoothing plays, as although the Bank is concerned about financial stability, it puts more weight on current market conditions. The parameters h and j indicate that the monetary authority does not employ a forecast based rule, as is the case in a number of countries with inflation targeting.

3.1 The Monetary Transmission Process

The impulse responses to the monetary policy shock are shown in figure 1. The pattern of response is similar to that found in Allen, Hall and Robinson (2002), with the magnitude being relatively small. The more perceptible impact of the interest rate adjustment on inflation lasts for approximately three to four years[20], after which the economy returns to equilibrium with inflation adjusting to the target. The influence of this policy change on inflation reflects the response of the exchange rate. On account of the policy action, the exchange rate appreciated over the ensuing four quarters with the greatest impact of 0.10% in the second quarter after the shock. In its transition back to equilibrium, however, the exchange rate exhibits some overshooting, which lasted for approximately five quarters.

The noticeable initial appreciation in the currency elicits a rise in the demand for real money balances, as it completely offsets the negative impact of the rise in real interest rates. The propensity for real money balances to rise persisted for about four quarters after which the rising inflationary tendencies subsequently resulted in a decline, which lasted for the next five to six quarters. The rise in interest rate also led to a decline in the output gap with a lag of one quarter.

[19] A rule that is based on a small set of current and lagged variables

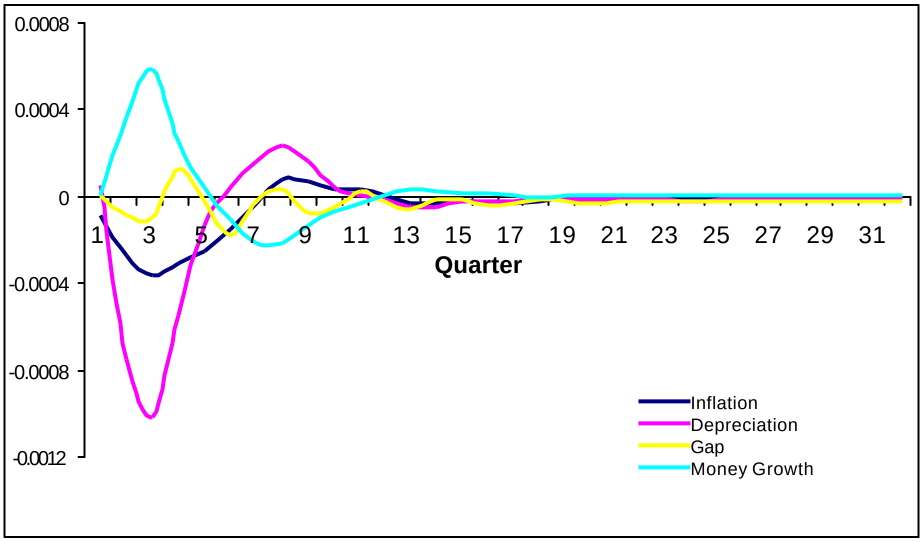


Figure 1: **Response to interest rate impulse**

The decline in the output gap also has a negative effect on inflation, albeit small. The response of the gap is not monotonic but is characterized by dampened oscillations around the equilibrium over time. This is due to the fluctuations in the real exchange rate. For example, the real appreciation in the first three quarters elicits a rise in aggregate demand in the subsequent two quarters through an increase in consumption[21] demand by the fourth quarter. The subsequent real depreciation exerts a dampening effect on aggregate demand.

In summary, the exchange rate responds most quickly, within the first quarter, to a monetary policy innovation. Monetary aggregates and output respond with a lag. An unanticipated tightening of monetary policy, by altering the relative returns on domestic assets vis-à-vis foreign assets, induces portfolio adjustments, which results in an appreciation in the exchange rate. This is reinforced by the subsequent rise in the demand for real domestic currency money balances. The adjustment in the exchange rate affects inflation directly, given the cost structure of domestic output and the ratio of tradeables to non-tradeables in domestic consumption. This is complemented by the dampening effect of the constraint on aggregate demand, arising from the higher interest rates. However, in

[20] Robinson and Robinson (1998) using monthly data for the first half of the 1990s found that the economy returned to equilibrium within two to three years.

the initial stages, this may be temporarily offset by a real appreciation, which encourages consumption.

Similar to previous studies, two main channels of monetary policy that have been identified are the exchange rate channel and the credit channel. In this setting changes in the short term interest rates, affects current inflation via its impact on the exchange rate and future inflation through real interest rates, credit availability (credit channel) and hence aggregate demand. Figures 2 and 3 shows the relative importance of both the exchange rate and credit channels in the transmission process[22].

During the first two quarters after the shock the exchange rate channel constitutes the dominant conduit through which monetary policy influences inflation. Over longer horizons, beginning in the third quarter, the fall in the output gap, resulting from the credit channel, produces a subsequent slow down in inflation. The graphs demonstrate that the exchange rate channel dominates the credit channel. In the fourth quarter, for example, the fall in inflation amounting to 0.1% can be split into 0.078% reflecting the exchange rate channel and 0.022% reflecting the influence of the credit channel.

The results highlight the dominance of the exchange rate channel. Inflation, particularly since the 1990s, has been driven primarily by shocks to the exchange rate relative to demand-pull factors associated with the credit channel. The moderation in inflation over the past five years has coincided with a more stable foreign exchange market, although credit expansion, particularly during the rehabilitation period following the financial crisis was not significant.

[21] The increase in consumption outweighs the decline in net external demand given its contribution to GDP.
[22] See Allen, Hall and Robinson (2002) for a description of the methodology.

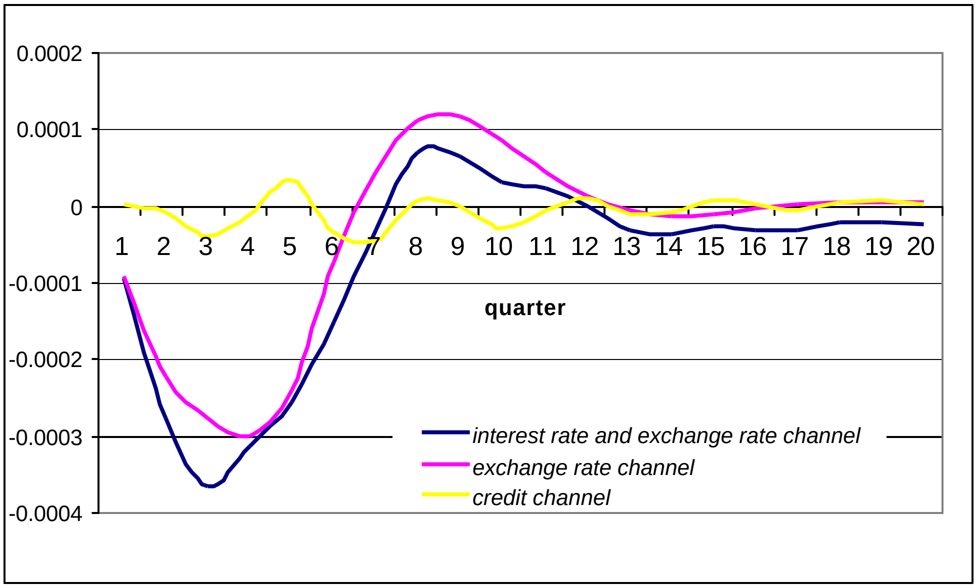


Figure 2: **Transmission channels of monetary policy**

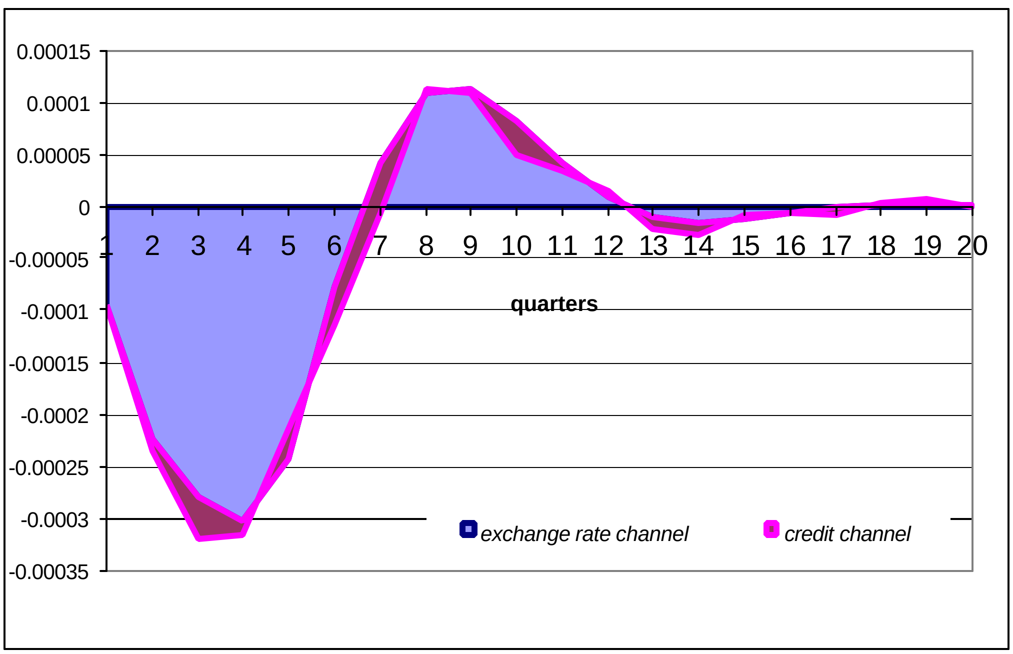


Figure 3: **Relative importance of different channels of monetary transmission on inflation**

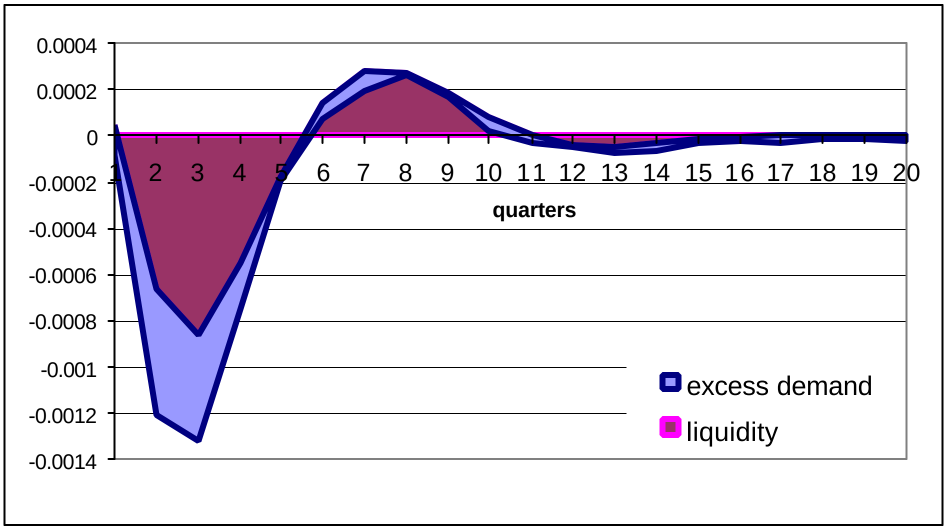


Figure 4: **Relative Importance of different channels on exchange rate**

The movement in the exchange rate reflects both the portfolio decisions of investors – capital account transactions and excess domestic demand –current account transactions. In the model the former is reflected in changes in domestic currency liquidity measured by either money or reserves. The latter would be reflected in fluctuations in the output gap. Figure 4 shows the relative importance of both factors. As to be expected liquidity effects, which in this simulation is captured by changes in M2, exerts more influence on the fluctuations in the exchange rate[23]. There is, however, a feedback relation arising from the demand for money.

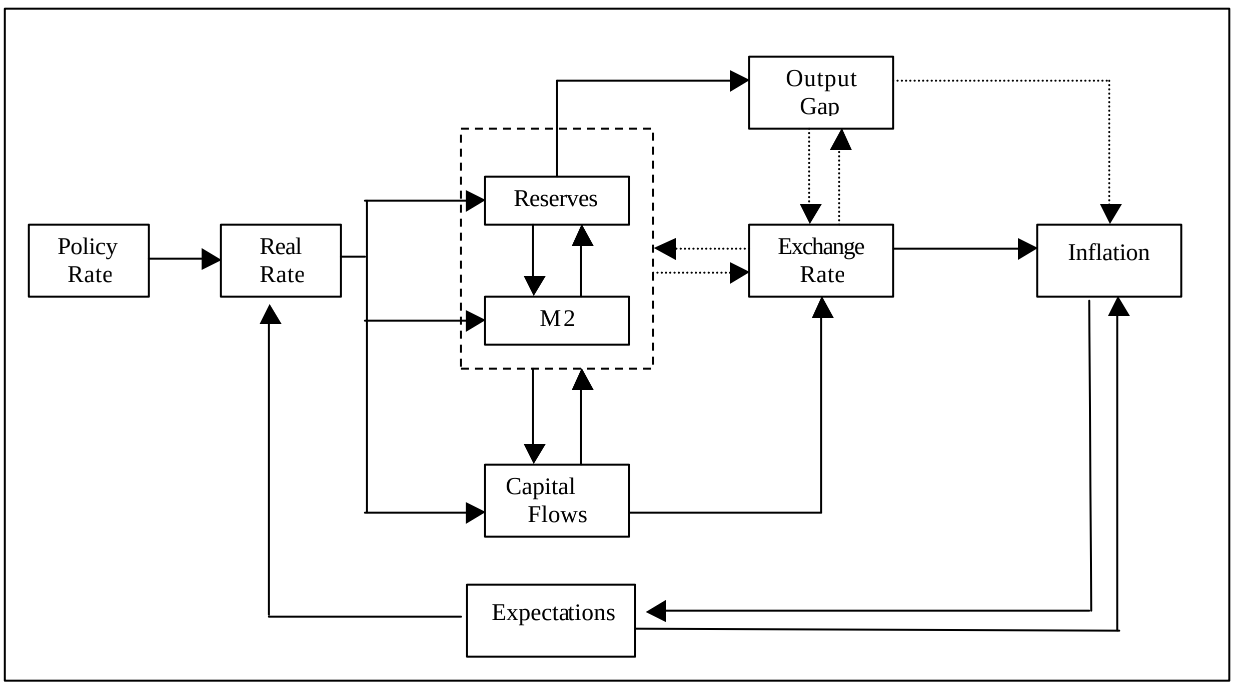
Thus the impact of domestic currency liquidity on inflation is intermediated through the exchange rate and indirectly through the output gap via changes in credit conditions, reflected in changes in reserves. The former conduit reflects a portfolio or wealth effect as changes in the interest differential induce portfolio shifts between domestic and foreign currency assets. Importantly, there is also a buffer stock effect, which operating through the credit channel links the two conduits noted above. Changes in interest rates influences the level of credit and consequently money through the deposit creation

[23] Given that agents are forward looking and form expectations rationally in this model, changes in money or liquidity conditions would influence inflation expectations. Money could also be acting as a proxy for other assets.

process. This creates a disjuncture between the supply of and demand for money, which through portfolio adjustments is reflected in changes in the exchange rate and spending[24].

In summary, monetary policy has its greatest impact on inflation in the second quarter following an innovation. The simulated responses point to the fact that, particularly within the short-run, inflation stabilization is achieved mainly through the inducement of portfolio adjustment between foreign and domestic assets, which via the impact on the exchange rate, lowers the imported component of inflation. However, although relatively small, the persistent dampening effect on aggregate demand, operating through the credit channel, does constrain price movements over the longer horizon. The responses do reflect some amount of exchange rate overshooting. The schema of the transmission process arising from the simulations is shown in Figure 5, with the dotted lines depicting the indirect channels.

Figure 5: **Transmission Mechanism**



[24] Although not simulated, the buffer stock effect can also arise through a shock to the demand for money or supply (arising from fiscal policy for example), which creates dis-equilibrium. The effect of this shows up in both interest and exchange rate changes.

The analysis points to the potency of the use of the exchange rate as an intermediate target and short-term interest rates as the operating target. Although important to aggregate demand, liquidity conditions are more suited as an indicator for foreign exchange market developments as against a leading indicator of headline inflation directly. In this regard, although the credit channel is relatively weak, the behaviour of bank reserves or credit, as well as monetary aggregates is important. This points to the use of a monetary conditions index (MCI).

4.0 Alternate Policy Scenarios

Monetary policy can have disparate effects on the economy depending on the stance and the policy horizon adopted by the central bank. This section simulates the response of the economy under the following policy rules, which are forecast based or forward looking rules.

$$i_t = qi_{t-1} + l_0(E_t \Delta m_{t+1} - \Delta \bar{s}) + l_1(E_t y_t - \bar{y})$$

$$i_t = qi_{t-1} + l_0(E_t \Delta s_{t+1} - \Delta \bar{s}) + l_1(E_t y_t - \bar{y})$$

$$i_t = qi_{t-1} + l_0(E_t p_{t+1} - \bar{p}) + l_1(E_t y_t - \bar{y})$$

The first two are forward looking money and exchange rate rules, respectively, while the third is a forecast based inflation targeting rule. We evaluate these rules by conducting stochastic policy simulations and calculating the unconditional moments of the endogenous variables, namely inflation and output. The simulations are done with the constant removed, such that the standard deviation can be interpreted as the root mean square deviation of the variables from their targets, which is set to zero for the simulation. For comparative purposes, the values for θ and λ remain the same. The results are shown in Table 7. The table also shows the degree of exchange rate overshooting measured by the cumulative size of the deviation above the steady state divided by the number of quarters above the steady state. The smaller the average, the lower the degree of overshooting.

Table 7

	Inflation %	Output %
Baseline Rule		
Minimum	-0.03698	-0.01873
Standard Deviation	0.0104	0.005
Sacrifice ratio		-0.00059
Overshooting	0.0001	
Forward Money Rule		
Minimum	-0.04182	-0.01809
Standard Deviation	0.0099	0.005
Sacrifice ratio		-0.00068
Overshooting	0.00007	
Inflation Target		
Minimum	-0.04076	-0.01934
Standard Deviation	0.0102	0.004
Sacrifice ratio		-0.00058
Overshooting	0.00004	
Forward Exchange Rate Rule		
Minimum	-0.03778	-0.01675
Standard Deviation	0.0093	0.004
Sacrifice ratio		-0.00055
Overshooting	0.00005	

The forward exchange rate rule is the most superior in terms of output and inflation stabilization. The sacrifice ratio or the cumulative loss in output is the lowest. In other words with this rule the central bank can achieve its target with the least impact on output. Both the forward exchange rate and inflation targeting rules result in the most stable output, with the degree of exchange rate overshooting being the lowest under inflation targeting.

4.1 Target Horizon

Generally, the forward-looking rules are superior to the baseline rule. Forward-looking rules have been viewed, at least conceptually, as more advantageous as they explicitly account for the lags in the monetary transmission. The question for policy makers, however, is how *far forward is the looking*, that is what horizon should we consider. In what follows we attempt to answer this by varying the forecast horizon, h, for the forward exchange rate rule. Following, Taylor (1993) we then calculate where each value puts the economy on the output-inflation variability frontier. The results are shown in figure 6. The points in the southwest quadrant give the best inflation performance while

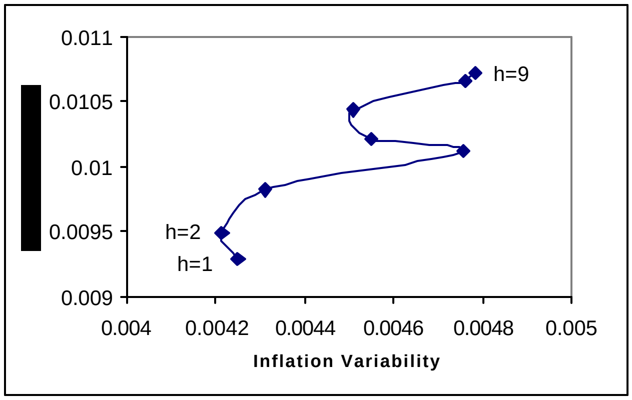


Figure 6: **Optimal Forecast Horizon**

simultaneously yielding the lowest output variability. From the figure it is clear that the optimal forecast horizon is positive and lies between one and two quarters ahead. During this period monetary policy has its largest marginal impact in that the degree of interest rate and exchange rate changes required to achieve the target are minimized at these horizons. Beyond (and below) this horizon the changes in monetary policy required are much greater, which results in a destabilization of output[25].

This result follows from the lags in the monetary transmission process and as such forecast based rules are described as *lag encompassing*. In **section 3.1** we saw where monetary policy had its greatest impact in the second quarter. Extending the forecast horizon beyond the transmission lag can lead to instabilities.[26]

In summary, the analysis indicates that a forward-looking policy is to be preferred for Jamaica. A forecast horizon of one to two quarters delivers the best combination of inflation and output stabilization. This horizon yields the best inflation performance while simultaneously providing the lowest output volatility. This result arises out of the transmission mechanism of monetary policy.

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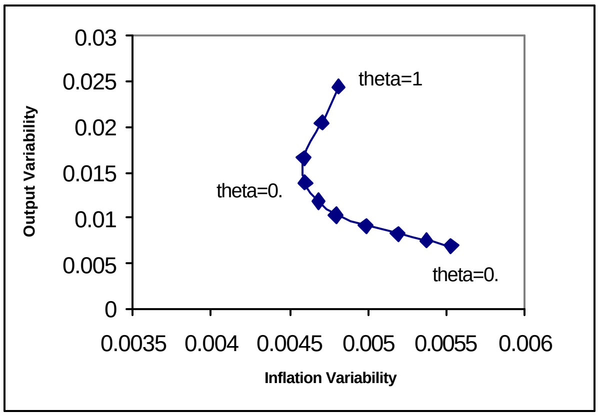
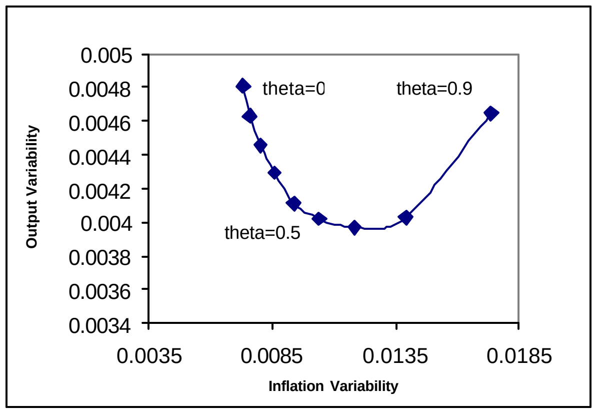
[25] Varying *j* did not alter the conclusion.
[26] See Bernanke and Woodford (1997).

4.2 Smoothing

The results and by extension the effectiveness of monetary policy depends on the degree of interest rate smoothing adopted by the central bank. The output-inflation variability frontiers with varying values of theta for both the base simulation and the forward exchange rule are shown in figure 7. With the baseline rule, a lower level of inflation variability can be obtained, with some increase in the degree of smoothing, without significantly impairing output stability. From the figure the optimal degree is 0.6.



Base Simulation



Forward Exchange Rate

Figure 7: **Interest Rate Smoothing**

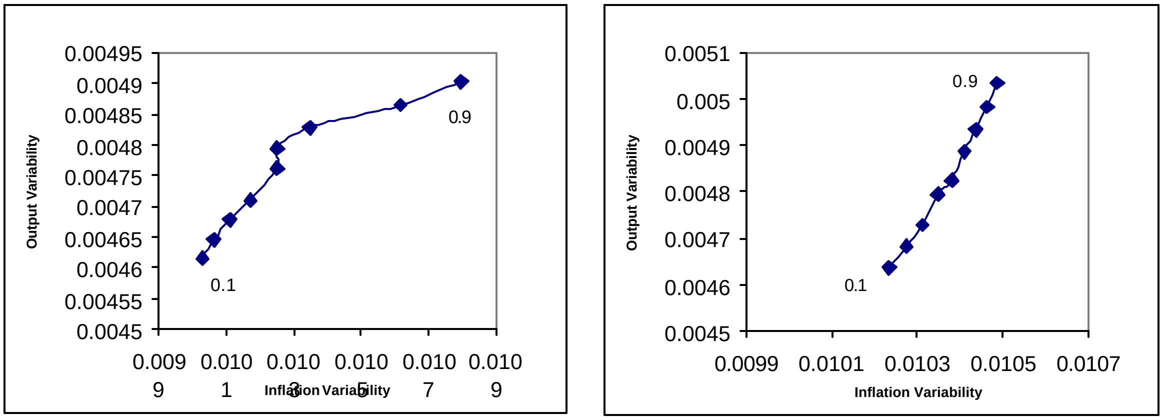
Importantly, a lower level of smoothing will lead to more stable output but at the expense of price stability, under the current backward looking monetary policy rule. Generally, a higher degree of smoothing results in a more persistent interest rate response, which tends to have a larger impact on the exchange rate and hence inflation[27]. However, it comes at some cost to output, which from the graph can be significant. The optimal degree of smoothing under a forward exchange rate rule is not significantly different at 0.5. However, the pattern of response in the variability of output and inflation is reversed under the forward exchange rate rule. A greater degree of smoothing leads to lower inflation control but leads to greater output stability below a threshold.

4.3 Feedback Response

The effectiveness of smoothing depends on the aggressiveness of policy. The welfare effects of smoothing are lower the more aggressive is policy. We therefore simulate the response of the economy with varying values of the lambdas. The higher the value, the more aggressive is policy to deviations from target. The variability frontiers are shown in figure 8 and figure 9 for the base simulation and forward-looking exchange rate rule, respectively.

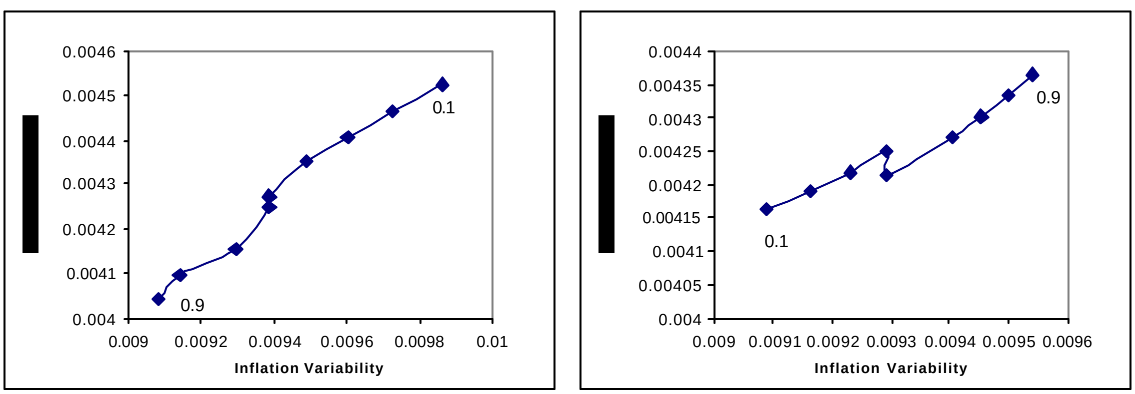
Under the base rule the less aggressive is interest rate policy towards exchange rate stabilization the more stable is inflation and output. The rationale is that while aggressive monetary policy will stabilize the exchange rate, it leads to greater overshooting in the exchange rate and hence more fluctuation in prices and output in the medium term. More importantly, being more aggressive on output deviations does not lead to more stable output. Thus placing a higher weight on inflation relative to output tends to be more welfare improving. A similar result on the relative importance of output stabilization is obtained under the forward exchange rate rule. In contrast with the base rule, however, more aggressive inflation stabilization does not lead to greater output fluctuation but both lower inflation and output variability. Thus, by adopting a forward looking rule the monetary authority can pursue price stability without destabilizing the economy. In fact under this rule greater price and output stability is possible. Batini and Haldane (1999) derive similar results and conclude that with forward looking rules there are gains to be had from placing a higher weight on inflation than output. This result arises from the fact that being forward looking, agents factor in a forward looking central bank's aggressiveness or anti-inflation stance, in setting wages and prices. Against this background a forward-looking rule for Jamaica would satisfy the *output encompassing* (smoothing) property of monetary policy.

[27] See Ball (1988).



Exchange Rate Deviation (l_0) *Output Deviation* (l_1)

Figure 8: **Policy Response –Base Simulation**



Exchange Rate Deviation (l_0) *Output Deviation* (l_1)

Figure 9: **Policy Response –Forward Exchange Rate**

4.4 Optimal Policy

The previous sections evaluated various policy options based on the combination(s) that minimized the variations in output and inflation. These rules can be described as being "*efficient*"[28]. However, the optimal policy is defined as the one that minimizes the weighted sum of output and inflation variances[29]. This is the rule that minimizes the loss function of the policy maker. As such, in this section we compare the welfare loss of the above efficient rules to that of the *optimal state contingent rule*.

By setting the policy maker's discount factor to one we can interpret the inter-temporal loss function as the weighted sum of the unconditional goal variables i.e.

$$E[L] = qVar(i_t - i_{t-1}) + l_0 Var(\hat{p}_t) + l_1 Var(\hat{y}_t)$$

where the hats denote the deviation of the variables from target (see **Appendix A3** for details). Table 8 compares the stochastic welfare loss from the optimal rule with the other

Table 8

	σ_π	σ_y	Loss	Rank
Optimal	0.0008	0.0007	0.0046	0
Baseline Rule	0.0104	0.005	1.1215	10
Forward Money Rule	0.0099	0.005	0.7059	9
Inflation Target				
(h=1, j=0)	0.0102	0.004	0.7021	7
(h=1, j=1)	0.0104	0.004	0.7129	8
(h=2, j=0)	0.0099	0.005	0.6881	6
(h=2, j=1)	0.0098	0.004	0.6402	5
Forward Exchange Rate Rule				
(h=1, j=0)	0.0093	0.00425	0.5905	1
(h=1, j=1)	0.0097	0.00408	0.6321	3
(h=2, j=0)	0.0095	0.00421	0.6119	2
(h=2, j=1)	0.0098	0.00394	0.6371	4

[28] See Ball (1997)
[29] See Taylor (1994)

policy rules. The welfare loss of the optimal rule is significantly lower than all the alternatives, however, what is important for the analysis is the comparative differences. The current baseline policy rule clearly does the worst in comparison to the optimal rule, followed by the forward money rule. Both the inflation targeting and forward exchange rate rule do better than the baseline and forward money rules. However, the difference in the welfare losses with that of the optimal state contingent rule is smallest with the forward looking exchange rate rule based on the one-quarter ahead horizon.

In general the forward-looking exchange rate rule takes us closer to the bliss point. This arises because such rules are conditioned on all the state variables that affect the future dynamics of inflation just as the optimal rule does.

5.0 Concluding Remarks

In this paper we developed a small-scale macroeconomic model for the Jamaican economy. We used this model to simulate the impact of different shocks on the path of key variables in the model, namely inflation and output. In spite of its simplicity, the model captures the essential dynamics of the economy and hence the transmission mechanisms of monetary policy.

The analysis concentrates on the efficacy of different 'policy rules'. In practice there is no precise rule for all times, as to every rule there is an exception. What is important to the policy maker from this analysis is the emphases for policy that such mathematical rules embody in terms of the target variable, aggressiveness and horizon.

In this context, a number of conclusions on the future direction of policy emerge from these results:

(i) In general, the welfare assessment indicate that monetary policy, at least in the near term, should continue with the current inflation targeting *lite* regime, with the change in the exchange rate being the intermediate target and interest rates the operating instrument. This is notwithstanding the fact that there is no significant difference in the welfare gains between this regime and a full-fledged inflation targeting regime. The central bank may have to continue with the current regime for some time as exchange rate movements are critical in the formation of inflation expectations and hence, for credibility, exchange rate changes should continue to serve as an important anchor for monetary policy. As the exchange rate pass-through wanes and the central bank's credibility[30] becomes entrenched, the monetary authority could move to a full-fledged inflation targeting regime.

(ii) The central bank should, however, adopt a more forward-looking perspective to monetary policy. That is, it should incorporate more explicitly and apply a greater weight to the forecasts of macroeconomic variables when deciding the timing and degree of adjustment of interest rates, than on past information. Specifically, because monetary policy has the greatest impact up to two quarters, the forecast of the intermediate variable over this horizon should carry more weight in the decisions on interest rates. This will require the use of forecasting models, as well as market intelligence.

(iii) Although the monetary targets are replaced by the changes in the exchange rate as the primary intermediate target, they still convey important information on the stance of monetary policy and signals for potential changes in market conditions. In this vein the paper recommends:

(a) The range of indicators, such as excess reserves, credit market conditions or an MCI should feature more prominently in the analysis of liquidity conditions.

(b) The regular monitoring of base money indicators should be over a two-quarter horizon, in the minimum. More importantly the forecasts thereof should be complemented with projections for the multiplier. This would permit a comparison between the projection for money supply and money demand.

[30] This would require institutional and fiscal policy reforms, which would insulate the central bank from fiscal dominance.

This juxtaposition can yield important insights as to the likely behaviour of asset markets.

(iv) The central bank should continue its preference for price stability viz a viz output stability. However, there are gains to be had from minimizing sharp movements in rates i.e. greater interest rate smoothing.

In terms of future work, there is a need to revisit a number of issues related to the design and implementation of monetary policy. These include the definition of money or liquidity and the determination of the market yield curve.

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APPENDICES

A1: Estimating Potential Output

Potential output was estimated using the unobservable components method. This was modeled using state space form, which is a general way of representing dynamic systems such that the observed variables are specified as a function of the unobserved state variables in the measurement equation, with a separate transition equation specifying the autoregressive process for the state variables. The relationships are written in state space form and the unobservable state vector is estimated using the Kalman filter.

The estimation was attempted with both a univariate and a bivariate form of the unobservable components method. The univariate unobservable components method decomposes the series y_t into two independent components:

$$y_t = y_{1t} + y_{2t}$$

y_{1t}, the stochastic trend component is given as:

$$y_{1t} = a + y_{1,t-1} + e_{1t}$$

and y_{2t} the cyclical component is given as:

$$y_{2t} = d_1 y_{2,t-1} + d_2 y_{2,t-2} + e_{2t}$$

where e_{it} ~ i.i.d. $N(0,s_i^2)$, i=1,2 $E[e_{1t}\ e_{2t}] = 0$ for all t

If we take both y_{1t} and y_{2t} as unobserved state variables then the above could be represented in state-space form and solve using Kalman filter.

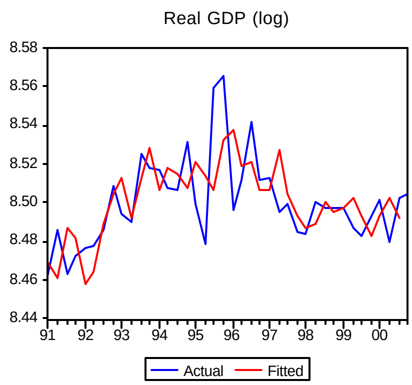
With the bivariate form definitions of potential output, the NAIRU and the inflation rate can be explicitly incorporated in the decomposition and simultaneously estimated. Similar to Clarke (1989), the cyclical movement in output is measured using a bivariate unobserved components model where output and inflation have their own trend components, but the cyclical component is common to the two series. Assume that output y_t, contains a stochastic trend n_t, and a stationary cyclical component x_t. The inflation z_t, has a trend component, L_t and a stationary, C_t. The model is:

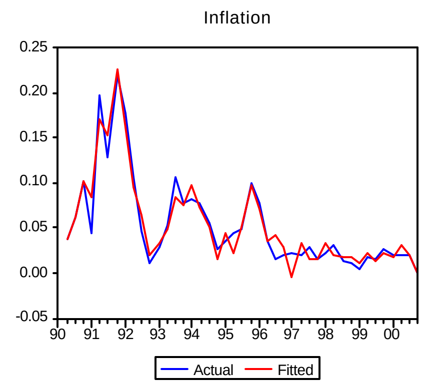
$$y_t = n_t + x_t$$

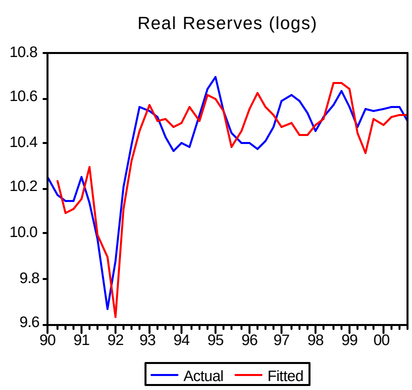
$$
\begin{aligned}
n_t &= d + n_{t-1} + v_t \\
x_t &= j_1 x_{t-1} + j_2 x_{t-2} + e_t \\
z_t &= L_t + C_t \\
L_t &= L_{t-1} + v_{lt} \\
C_t &= a_0 x_t + a_1 x_{t-1} + a_2 x_{t-2} + e_{ct}
\end{aligned}
$$

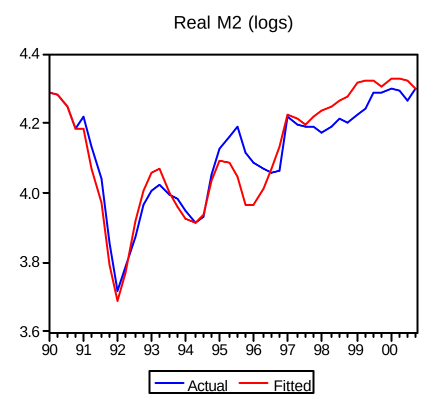
where v_t, v_{lt} e_t e_{ct} ~ i.i.d. N(0,s^2). Again, the above is estimated using Kalman filter

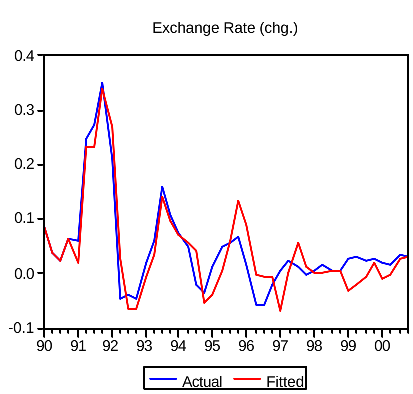
A2: Model Performance











A3: Optimal Policy Rule

The model can be re-written in the following state-space form

$$X_{t+1} = AX_t + Br_t + CZ_t + v_{t+1} \qquad \text{A3.1}$$

where

$$X_t = [p_t, p_t, s_t, \Delta s_t, \Delta s_{t-1}, \Delta s_{t-2}, \Delta\Delta s_t, \Delta\Delta s_{t-1}, y_t, y_{t-1}, \Delta y_{t-1}, \Delta y_{t-2}, r_t, r_{t-1}, \Delta r_{t-3}, ..., \Delta res_{t-3},]'$$

$$Z_t = [\Delta p*_t, \Delta p*_{t-1}, \Delta p*_{t-2}]'$$

$$B = [\ 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0]'$$

A is a 20 x 20 matrix and C is a 3 x 3 coefficient matrix constructed from the results of the estimation in **section 2**[31]. v is 20 x 1 disturbance vector and Z is a vector of exogenously given variables. The 3 x 1 vector of goal variables is given by

$$Y_t = D_x X_t + D_r r_t \qquad \text{A3.2}$$

where $Y_t = [\hat{p}_t, \hat{y}_t, (r_t - r_{t-1})]'$, $D_x = [e_1, e_9, -e_{14}]'$, $D_r = [0,0,1]'$, where e_j for j=0,1,…..20, is a 1 x 20 row vector for j=0 with all elements equal zero and for j=1, …20, with element j equal to one and all other elements equal to zero.

The inter-temporal loss function for the policy maker is given by

$$E_t \sum_{t=0}^{\infty} d^t [(p_{t+t} - \bar{p})^2 + l_0 (y_{t+t} - \bar{y})^2 + l_1 (r_{t+t} - r_{t+t-1}) \qquad \text{A3.3}$$

Minimizing equation A3.3 with respect to r_t, subject to A3.1 yields the following class of linear feedback rule

$$r_t = fX_t$$

In the limit the unconditional loss function is

$$E[L_t] = E[Y_t' K Y_t] = trace[K \Sigma_{yy}]$$

where we set $K = \begin{pmatrix} 0.6 & 0 & 0 \\ 0 & 0.4 & 0 \\ 0 & 0 & 0.6 \end{pmatrix}$ and the optimal instrument rule is

$$f = -(D_r' K D_r + B'VB)^{-1} (D_x' K D_r' + B'VA)$$

where V is the Riccati equation

[31] These are available from the authors upon request.

$$V = D_x' K D_x + D_x' K D_i f + f' D_x' K D_i' + f' D_i' K D_i f + M' V M$$

$$M = A + Bf$$