BANK OF BOTSWANA'S REACTION FUNCTION: MODELLING BOTSWANA'S MONETARY POLICY STRATEGY

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THIS PAPER EXAMINES how monetary policy was actually conducted in Botswana, by specifying and estimating a monetary reaction function for the Bank of Botswana (BoB). Basically, a monetary reaction function (MRF) for a central bank is an equation that is intended to establish the goals that have actually been influencing the actions of the central bank. A MRF would exist if the monetary authorities (or BoB in particular) have been purposeful and reasonably consistent in the policy-making process. Thus, a study of a MRF provides a test on whether the monetary policy-making process has been characterised by systematic (if it exists) or random (if it does not exist) changes in the policy instrument(s).

Knowledge of the monetary policy of Botswana may be of great value to other African countries or developing countries in general. This is particularly so in view of the economic circumstances that prevailed in Botswana during the period under study. For about a decade in the 1980s, the economy experienced an unparalleled boom. But in spite of this, policymakers managed to avoid chronic inflation. Botswana's annual CPI inflation has never exceeded 20 per cent since the inception of the BoB in 1976. Cowan (1998) finds that in the period 1976-95, Botswana has had the most stable average CPI inflation, compared to the rest of the

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SACU countries. Botswana's experience contrasts with that of other developing countries that also enjoyed a commodity boom, or natural resource boom. For example, in Zambia, economic mismanagement of the mineral-led boom the country experienced led to an inflation problem (Nankani, 1979) and a serious economic crisis (see MacWilliam, 1996). In general, Nankani (1979) observes that mineral-exporting countries are characterised by high demand-pull type of inflation rates. Unless accompanied by nominal depreciation of the exchange rate, high inflation rates lead to real currency appreciation and the Dutch disease, both of which Botswana has managed to avoid.

Monetary reaction functions have been estimated in both developed and underdeveloped countries – see Wood (1967), Fair (1984), Clarida, Gali and Gertler (1998), and Shen, Hakes and Brown (1999) for the former; and Porzecanski (1979), Joyce (1991), and Bleaney and Lisenda (2001) for the latter. It is important to note that in general, in developed countries, several MRF studies have been conducted for each country. The reason was to establish a robust reaction function. For Botswana, only two MRF studies have been conducted – the study by Bleaney and Lisenda (2001) estimates a reaction function for the period 1990-99,[2] and the other by Setlhare (2002) estimates a reaction function for the period 1977-95. Thus, it is crucial that a reliable Bank of Botswana MRF equation be established. This study will make contributions to this end *(i)* by offering a modified MRF specification and *(ii)* by estimating the MRF equation on different samples of data.

The paper is organised as follows. In section 1 we provide a brief review of the macroeconomic history of the economy of Botswana over the period of study. After specifying the Bank's MRF equation in section 2, section 3 investigates the stochastic properties of the variables of the model. The estimation results are presented in section 4 and then analysed in section 5. Section 6 then offers conclusions and suggestions for future research.

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[2] Bleaney and Lisenda also estimated their MRF equation over the sub-sample 1992-99.

1. MACROECONOMIC HISTORY OF BOTSWANA

For much of the 25 years after independence in 1966, Botswana was the fastest growing economy in the world with real GDP growing at an average of 12 per cent per annum; and thereby attaining the status of an upper middle income country by 1993.

Diamond exports have resulted in a rapid increase in foreign exchange reserves. When combined with exchange controls on the capital account (that restricted capital outflows)[3] and limited absorption capacity, the rapid increase in foreign exchange reserves led to a situation of excess liquidity in the banking system.

Two major regimes could be identified in the monetary history of Botswana. The first period (1976-88) is characterised by financial repression, and the second period (1989 to present) is characterised by financial liberalisation.

Prior to 1989, the monetary authorities followed the forced saving approach, characterised by financial repression. This approach maintains that since investment, not saving, is the constraint on growth, a low or even negative real interest rate is a prerequisite for economic growth. Thus, the monetary authorities can autonomously increase investment without prior savings through monetary expansion; such an investment will then generate its own savings (for details, see Hossain and Chowdhury, 1996). Other aspects of the financial repression included the imposition of floors on deposit rates, refusal to license additional commercial banks and exchange controls.

By 1989 the failure of the financial repressive policy (to promote productive investment) had become apparent. The problem of excess liquidity remained unabated. The market for loanable funds remained thin;[4] since the low real interest rates discouraged private saving, while the Bank's protective policy

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[3] While exchange controls on non-residents were very liberal, they were less so towards domestic residents.

[4] A thin market is one in which there are relatively few buyers and sellers.

essentially perpetuated a duopoly comprising two commercial banks, and thus the range of instruments from which borrowers could choose to save or lend was limited. When the market is thin, the transmission of monetary policy is hindered and hence monetary policy becomes less effective.

On account of these problems, the monetary authorities started with the process of financial liberalisation in 1989. This entailed removal of controls on interest rates, an increase in bank competition (by allowing entry by new commercial banks) and progressive liberalisation of exchange controls. In the case of interest rates, the BoB began issuing its own paper, the Bank of Botswana Certificates (BoBCs), in May 1991. The reasons for using BoBCs were to mop up excess liquidity, to achieve positive real interest rates (comparable to those prevailing in major international capital markets) and to introduce a monetary framework in which monetary control was effected through indirect instruments. And in respect of the liberalisation of exchange controls, the process entailed the complete removal of controls on current account transactions and a substantial reduction of controls on the capital account. All remaining capital account controls were eliminated in 1999 (Masalila, 2001).

The exchange rate policy also underwent a major shift.[5] Before 1989, the Rand/Pula exchange rate was managed so as to control imported inflation from South Africa and on the other hand, to ensure the competitiveness of exports other than minerals in the South African market. But since 1989, the exchange rate policy is only used to promote competitiveness of exports by maintaining a stable real exchange rate.

The next section specifies an equation that models the behaviour of the BoB.

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[5] Botswana operates a fixed exchange rate system; where the Pula (Botswana's currency) is pegged to a basket of currencies that comprise 50 per cent Special Drawing Right and 50 per cent South Africa's currency, the Rand.

2. MONETARY REACTION FUNCTION SPECIFICATION

MRF equations are specified such that the variable that serves as the indicator of the stance of monetary policy (*i.e.* the instrument of policy) is the dependent variable and the variables that serve as policy target variables are explanatory variables (these are variables that reflect the state of the economy). Explanatory variables also include intermediate variables – the importance of these variables emanates from their ability to affect or predict policy target variables.

Using the three categories of variables just described, most of the empirical studies on the MRF have specified an equation of the form:

$$x_t = a + \alpha x_{t-1} + \sum w_i y_{it} + e_t \qquad (1)$$

where, x_t represents an indicator of monetary policy, y_{it} represents "target variables" which usually also include intermediate variables, e_t is a classical error term and a, α, w_i are parameters to be estimated. This study will follow suit by specifying and estimating a version of (1).

(a) Specification of the Bank of Botswana MRF Equation

To formulate a MRF equation for BoB we adapt equation (1) to the context of monetary policy in Botswana.

We must first choose a variable to use as a plausible instrument of policy. BoB has always treated the Bank rate as its policy instrument. However, the fact is that the Bank rate gained pre-eminence in signalling the desired direction and level of interest rates after 1991. Before then, the Bank's call loan rate had a greater influence on interest rates – commercial banks did not borrow much from the BoB on account of excess liquidity.[6] This

[6] In 1976 the Bank introduced a call account facility for commercial banks (which was an ordinary interest-earning account for the banks) to permit them to earn some interest on the excess liquidity in the banking system (see Bell, 1987). The call account facility was discontinued in 1991.

situation seems to suggest using a spliced series of the Bank's call rate and the Bank rate. Unfortunately, the data on the Bank's call rate are not published, and hence unavailable to us. Consequently, we use the Bank rate as the policy instrument for the whole period, which is somewhat justifiable since interest rates in Botswana have tended to move together (see Setlhare, 2002).

In respect of goal variables, one plausible variable is inflation. Inflation is a plausible goal of monetary policy on the basis of the consensus that has emerged among many economists and practitioners that the primary goal of monetary policy should be to attain and maintain price stability (see Kadioglu, Ozdemir and Yilmaz, 2000). In fact, in Botswana, both the government and the Bank have repeatedly stated that the main objective of monetary policy is price stability.

Another variable is the real exchange rate, which became a policy variable in 1989. This variable essentially captures the response of monetary policy to inflation differentials between Botswana and its trading partners, particularly South Africa (see section 4 for explanation).

The third policy variable we consider is output, which could be seen as a theoretically and historically plausible goal of monetary policy in Botswana. On theoretical grounds, we can argue that keeping track of income is useful even when inflation is the main objective of monetary policy since the level and/or growth of real income relative to capacity has implications for inflation. On historical grounds, we observe that the government has stated that monetary and fiscal policies will be used to foster economic growth (National Development Plan, 1985-91).

In respect of intermediate variables, we use M1, M2, and domestic private credit and total revenue from diamond sales. Financial aggregates will be included in the BoB's MRF because the BoB has been using them (particularly domestic credit) as information variables. An information variable is an intermediate variable that is used as an early indicator of the effect of monetary policy on economic activity – aggregate output or inflation in our

case.

As for the revenue from diamond sales, it seems reasonable to view it as an intermediate variable given that diamond exports are the main source of foreign exchange and government revenues. Our conjecture is that the BoB may have been concerned with upward changes in the diamond sales revenue since an increase in diamond revenues, by increasing liquidity in the economy, is inflationary. Thus, the Bank could have engaged in a pre-emptive countercyclical monetary policy strategy in response to the growth of diamond sales.

And lastly, we have a variable that does not fall into any of the three categories, the South African Treasury bill rate. It seems plausible that in formulating policy, the monetary authorities in Botswana may take into account the effect of the (foreign) interest rates of South Africa. The South African interest rates may have an influence on monetary policy in Botswana since in the studies of Anyangah (1995) and Setlhare (2002), the Treasury bill rate of South Africa was found to determine the demand for money in Botswana. This effect could be anticipated even for the pre-liberalisation period because Botswana's capital controls were liberal towards non-citizens. So interest differentials could affect capital flows. In fact, the Bank's own accounts show that it has been concerned about the interest rate differentials between Botswana and South Africa (see BoB Annual Report, 1982).

We now turn to the actual specification of the MRF equation for the BoB. We specify two MRF equations. One equation will assume that the Bank followed an integral rule in reacting to inflation; so inflation enters in level form. The other equation will assume that the Bank followed a proportional rule in reacting to inflation; hence, inflation enters in growth form. Either of these two feedback rules seems equally likely concerning the BoB's response to inflation, in the period we are modelling.

Under the integral rule, the policy instrument is changed until the goal variable (inflation) is back on target. This rule is plausible when the goal is inflation stabilisation and monetary authorities

have adopted an anti-inflation stance, as has been the case with BoB, which made repeated statements about its concern with inflation. Although the BoB did not declare a target value for inflation until just recently, it is plausible to think that the central bank could have tried to maintain tight control over inflation.

Under the proportional rule, the policy instrument is changed only once, in response to a deviation of the goal variable from target. This rule is not consistent with a tight control over inflation. The one-time change in the instrument may not be enough to remove the deviation (see Cameron, 2001). This rule also seems plausible since other tools (such as the exchange rate and incomes policy) have also been used to fight inflation.

Supposing that BoB focuses on the growth of real GDP as a measure of aggregate demand, our first MRF equation is specified as follows:

$$DBr_t = a + \sum_{i=1}^{5} \alpha_i Inf_{t-i} + \sum_{i=2}^{3} \phi_i Drgdp_{t-i} + \sum_{i=1}^{2} \theta_i DrFA^*_{t-i} + bDdvl_t + cDTbSA_{t-i} + e_t \quad (2)$$

where DBr_t, is growth in the Bank rate; Inf_t is the level of inflation; $Drgdp_t$ is growth of real GDP; $DrFA^*_t$ is the growth of a real financial aggregate, purged of the effect of South African interest rates – financial aggregates are real M1, real M2 and real private domestic credit; $Ddvl_t$ is the growth of revenue from diamond sales and $DTbSA_t$ is the growth of the South African Treasury bill rate.[7] When policy is assumed to have followed a proportional rule towards inflation, we replace the level of inflation term in (2) with a first-difference (of inflation) term.

The reader will note the following about equation (2). First, the maximum lag length for the output variable has been made shorter than that for the inflation variable since GDP is a leading

[7] To purge a financial variable of the effect of DTbSA, we estimate an ADL equation for the financial variable with DTbSA as one of the determinants. The equation is then subjected to a simplification search.

indicator of inflation. Thus beyond three quarters, the Bank would likely pay more attention to the trend of inflation than the trend of real GDP. That is, they will likely act quicker on changes in real GDP, so they react sooner, even though growth in real GDP is revealed only slowly. Similarly, the lag length for the financial aggregates is shorter than that for goal variables.

Second, the income variable enters with the shortest lag set to two quarters. This is intended to make the MRF equation consistent with the fact that BoB does not have access to GDP data until in the second quarter.

Third, when the proportional rule is assumed, the MRF will include a one period lagged term for the growth of the Bank rate as an explanatory variable. This is based on the idea that in general central banks avoid sharp and sudden changes in setting short-term interest rates (Svensson, 1999). Interest-rate smoothing is compatible with the proportional rule – where the policy instrument is not changed vigorously, in response to deviations of the goal variable. The idea is incompatible with the integral rule.

And fourth, our assumption about the final target values of the rate of inflation and output is that they remain constant over the sample period under study and therefore can be captured in the intercept. This is an expedient simplifying assumption in view of our lack of knowledge of the target values of these variables. For most of the period, neither the government nor the BoB spelled out in public their target values.

The next section examines the time series properties of the model variables.

3. TIME SERIES PROPERTIES AND ESTIMATION RESULTS

In order to determine whether or not estimating the MRF equation will be subject to spurious correlation problems, we must examine the time series behaviour of the variables included in the equation. In this regard, we conduct a unit root test, using the Phillips-Perron test. The results (not reported, but available from the author upon request) are such that only inflation is stationary in

levels, I(0); the rest of the variables become stationary after being differenced once, I(1).

These results imply that all the variables in equation (2) are stationary. Thus, the use of the integral feedback rule will not lead to spurious results. In the next section, we estimate the MRF equation.

Estimation Results

Results will be presented as follows. For each financial aggregate, we shall estimate two versions of the MRF equation, each including one of the three financial aggregates. One version assumes a proportional feedback rule for inflation; and the other assumes an integral feedback rule (see section 2 for explanation).

Another consideration that our MRF estimation takes into account is the major policy regime shift that occurred in 1989. This entails re-estimating the equation over the post-financial liberalisation period. However, given that the more powerful market-based policy instruments were only introduced in 1991, we re-estimate the equation over the 1991-2000 period. Bleaney and Lisenda (2001) also argue that although the BoB gained some autonomy over its monetary policy in the late 1980s, the Bank really gained operational control over monetary policy in 1991. We start by estimating the MRF equation over the whole period: 1977-2000.

(a) MRF Estimation over the 1977-2000 Period

Given the large amount of output, we only present the 'best' results in the text; the rest of the output is placed in Appendix 2. The best results occur when we assume that the Bank focused on real M1 as the most important information variable

(i) Results When Growth of real M1 is the Key Information Variable

The results from the estimating (2) as is, are presented in panel A of Table 1. To obtain the final parsimonious equation in panel A, we applied the testing-down procedure of the general-to-specific modelling technique. The reduction process was evaluated using the F-test for omission of a variable.

The results show that the central bank changed the growth of the Bank rate in response to changes in the one period lag of the level of inflation. The positive sign of the coefficient of the variable suggests that the bank followed a countercyclical policy with respect to inflation.

The last piece of information in this section of the table shows the temporal stability tests due to Hansen (1992). There is no evidence of individual coefficient instability since none of the statistics for parameter instability tests (shown in the last column entitled "Instab") is significant at the 5 per cent level.[8] The model also passes the variance instability test, indicated by σ^2.

Table 1. MRF with Growth of real M1 as Information Variable and Target Variables as the Level of Inflation or Growth of Inflation and Growth in Real Income

Modelling DBr by OLS - Sample is: 1978(2) - 2000(3)

PANEL A				PANEL B			
Variable	Coeff	t-value	Instab	Variable	Coeff	t-value	Instab
Const	-0.55	-1.88*	0.12	Const	0.07	0.97	0.09
Inf_1	0.06	2.18*	0.07	Dinf_4	0.09	1.75*	0.07
R^2 = 0.05; F(1, 88) = 4.75 [0.03];				R^2 = 0.03; F(1, 88) = 3.05 [0.08];			
σ = 0.70; Instability $(\sigma^2 = 0.12)$				σ = 0.71; Instability $(\sigma^2 = 0.14)$			
Misspecification Tests				**Misspecification Tests**			
AR 1- 5 F(5, 83) = 1.32[0.26]				AR 1- 5 F(5, 83) = 1.51[0.20]			
ARCH 4 F(4, 80) = 1.04[0.39]				ARCH 4 F(4, 80) = 1.32[0.27]			
Normality Chi^2(2)= 29.3[0.00]**				Normality Chi^2(2)= 29.4[0.00]**			
Xi^2 F(2, 85) = 0.80[0.45]				Xi^2 F(2, 85) = 0.64[0.53]			
Xi*Xj F(2, 85) = 0.80[0.45]				Xi*Xj F(2, 85) = 0.64[0.53]			
RESET F(1, 87) = 1.54[0.25]				RESET F(1, 87) = 0.00[0.99]			

Notes: 1.*and **denote the 5 and 1 per cent level of significance respectively

Under misspecification tests, we present two types of tests to check the specification of the equation: the residual tests (testing the properties of the equation's residuals) and the specification test (testing the correctness of the equation).[9] Except for the

[8] These are within-sample parameter constancy tests.

[9] The properties of the residuals are tested using five tests: *(i)* Lagrange Multiplier (LM) test for autocorrelated residuals (denoted as AR 1-5); *(ii)* LM test for autocorrelated squared residuals – this is the autoregressive conditional heteroscedasticity (denoted ARCH) test; *(iii)* the normality test, for testing whether the skewness and kurtosis of the residuals correspond to that of a

normality test, none of the misspecification tests indicates problems. The normality test result suggests possible misspecification of the functional form; a suggestion that is heavily discounted by the finding that the RESET test suggests no such problem. So we ignore the rejection by the normality test.

In the second version of the reaction function equation, we use all the variables entered in (2), but now the rate of inflation is entered in growth form.

The results are presented in panel B of Table 1. They suggest that the Bank's monetary policy decisions were influenced by the four period lag of growth of inflation. As in the case of the integral rule, policy reacted in a countercyclical fashion to the rate of inflation.

An important point to note is that for both versions of the MRP equation, the real M1 aggregate has dropped out of the equation during the reduction process, suggesting absence of its role as an information variable.

The estimation results, when the growth of real M2 is taken as the key information variable, are presented in Table A2.1 in Appendix 2. The results still suggest that inflation has had an important influence on monetary policy. However, in the case of the integral rule, the adjustment in policy to changes in inflation seems to have been temporary, and not permanent – since the sum of the coefficients of the inflation terms is zero. The proportional rule-based equation still finds a countercyclical response to inflation. Both of these equations do not fit the data so well, particularly the integral rule equation which fails not just the heteroscedasticity test, but also the RESET test.

When the credit aggregate is taken as the key information variable, the resultant estimation results (not shown) are exactly the same as those in Table 1. That is, the parameter values, tests

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normal distribution; *(iv)* the test for heteroscedasticity using squares of the regressors (denoted Xi^2); and *(v)* White's test for heteroscedasticity (denoted XiXj). Ramsey's specification test (denoted RESET), tests to see if the original functional form is incorrect

statistics, summary statistics, *etc,* are exactly the same.

In the following sub-section, we estimate the MRF over the 1991-2000 period.

(b) MRF Estimation over the 1991-2000 Period

The MRF specification of this sub-section will differ in one important respect from that estimated for the whole period. The equation for the 1991-2002 period will include the growth of the rand-pula real exchange rate as one of explanatory variables. The reader will recall that with effect from 1989, the authorities terminated the use of the (rand-pula) exchange rate as policy instrument. The objective of the policymakers has since been to maintain a stable real exchange rate (see Monetary Policy Statement, 1999).

This implies that since 1989, the exchange rate ceased from being a policy instrument and became a policy variable.
Thus, the MRF equation is modified to become:

$$DBr_t = a + \sum_{i=1}^{5} \alpha_i Inf_{t-i} + \sum_{i=2}^{3} \phi_i Drgdp_{t-i} + \sum_{i=1}^{2} \theta_i DrFA_{t-i} + bDdvl_t + cDTb_{t-1} + dDrxr_{t-1} + e_t \quad (3)$$

where Drxr is growth of the real rand-pula exchange rate.[10]

The sign of the coefficient of the exchange rate variable is specified as follows. On the basis of the relative purchasing power parity (PPP) hypothesis, and if the exchange rate is flexible, we expect the rate of domestic currency depreciation or appreciation to be equal to the inflation differential between two countries in order to leave the real exchange rate constant. This implies that for Botswana, where the exchange rate is pegged, policy makers could maintain the PPP between the domestic and foreign currency by changing the peg to mirror the differential between Botswana's inflation rate and that of trading partners. However, the BoB has made it clear that it wants "to avoid having to devalue

[10] If adjusted for Tbill rate, *DrFA* becomes *DrFA**.

the nominal exchange rate in order to maintain a stable real exchange rate" (Monetary Policy Statement, 1999). So, since international competitiveness is important to the monetary authorities in Botswana,[11] we expect BoB to maintain a stable real exchange rate by using its policy instrument to react to domestic inflationary pressures that differ from those in the country's trading partners. That is, in terms of (3), the Bank would increase the growth of the Bank rate in response to an appreciation of the real exchange rate (indicated by an increase in DrXr) resulting from a domestic inflation shock. This suggests a positive relationship between DrXr and DBr.

We first estimate (3) assuming that real M1 is the key information variable.

(i) Results When Growth of Real M1 is the Key Information Variable

The results for the integral rule version of the equation are presented in panel A, while the results for the proportional rule version are presented in panel B of Table 2.

As can be seen, both versions of the MRF show that in the 1991-2000 period, the monetary authorities were mainly concerned with the stability of the rand-pula real exchange rate. This implies that the authorities have been concerned with the differentials between the domestic inflation rate and that of South Africa (and other trading partners). This is consistent with statements made by the BoB in its recent Monetary Policy Statements; where the Bank indicated that its policy would target an inflation rate comparable to the average inflation rate of Botswana's major trading partners. Given that Botswana's non-traditional trade is dominated by South Africa, we expect Botswana's monetary policy to be mainly influenced by the inflation differential with South Africa, more than with any other trading partner.

[11] The level and stability of the real exchange rate plays a major role in the competitiveness of Botswana's non-traditional exports (IMF, 1998).

Table 2. RF with growth of real M1 as Information Variable and Target Variables as the Level of Inflation or Growth of Inflation and Growth in real Income

Modelling DBr by OLS - Sample is: 1992(2) - 2000(3)

PANEL A				PANEL B			
Variable	Coeff	t-value	Instab	Variable	Coeff	t-value	Instab
Const	-0.02	-0.32	0.15	Const	-0.02	-0.32	0.15
Dmr_1	4.84	2.18*	0.07	Dmr_1	4.84	1.76*	0.04
R^2 = 0.09; F(1, 32) = 3.09 [0.09];				R^2 = 0.09; F(1, 32) = 3.08 [0.09];			
σ = 0.33; Instability $(\sigma^2 = 0.07)$				σ = 0.33; Instability $(\sigma^2 = 0.07)$			
Misspecification Tests				**Misspecification Tests**			
AR 1- 3 F(3, 29) = 1.57[0.22]				AR 1- 3 F(3, 29) = 1.57[0.22]			
ARCH 3 F(3, 26) = 0.56[0.64]				ARCH 3 F(3, 26) = 0.56[0.64]			
Normality Chi^2(2)= 2.60[0.27]				Normality Chi^2(2)= 2.60[0.27]			
Xi^2 F(2, 29) = 0.02[0.98]				Xi^2 F(2, 29) = 0.02[0.98]			
Xi*Xj F(2, 29) = 0.02[0.98]				Xi*Xj F(2, 29) = 0.02[0.98]			
RESET F(1, 31) = 3.93[0.06]				RESET F(1, 31) = 3.93[0.06]			

Notes:.*denotes the 5 per cent level of significance

The results, when real M2 and real domestic credit are taken (alternatively) as the key information variables, are presented in Table A2.2 and Table A2.3 respectively in Appendix 2. In the case of M2, the significance of the M2 term suggests that the central bank followed a countercyclical policy with respect to policy goals (especially inflation) – a "reaction to an information variable" actually means a reaction to the expected movement of the policy goal variable(s). As in the case of M1 (see Table 2), the significance of the real exchange rate term suggests that the Bank tried to use policy to avoid substantial differentials between domestic and South African inflation.

Turning to the MRF using credit as the key information variable, we find that in both versions of the MRF equation, changes in the growth of the Bank rate are explained only by the one period lag of the growth of real credit. This implies that the Bank reacted to what it considered impending changes in the policy goal(s) solely on the basis of information presented by changes in the growth of private credit.

4. ANALYSIS OF RESULTS

In this section, we look at the results more closely with three

objectives in mind: *(i)* to highlight the main variable(s) that have influenced monetary policy decisions over the period of study, *(ii)* to see whether policy was mainly countercyclical or accommodative, and *(iii)* to see which feedback rule outperforms the other.

In respect of the first objective, it is apparent that the monetary authorities were mainly concerned with inflation. The inflation variable turns out to be statistically significant at standard levels in all the versions of MRF in the whole sample regressions. This is true irrespective of the financial variable used as an information variable. Similarly, when we focus on the 1991-2000 period, empirical results seem to still point to the dominating influence of inflation on monetary policy. The statistical significance of the real exchange rate variable, given the Bank's decision not to change the nominal exchange rate to maintain a stable real exchange rate, could also be associated with policy reacting to inflation – in terms of inflation differentials with South Africa. These results suggest that the monetary authorities were not much concerned with reacting to changes in the growth of real output – the variable is statistically insignificant in all the equations. This means that the monetary authorities were more concerned with the stabilisation of inflation, and not much concerned with stabilising output.

These findings (*i.e.* inflation, whether explicitly or via the real exchange rate, having a predominant influence on policy) are consistent with the monetary policy history of Botswana. As already indicated, the Bank has stated, in both its annual reports and Monetary Policy Statements that its ultimate variable of policy interest is inflation. Therefore, we could argue that in general, the postulated empirical reaction function is able to explain the past history of the conduct of monetary policy in Botswana.

An interesting empirical evidence that needs highlighting is the predominance of the private domestic credit variable in influencing monetary policy decisions in the 1990s. When real private credit is taken as the key information variable, the final

parsimonious MRF equation shows that the policy decisions of the Bank concerning the growth of the Bank rate are influenced solely by the growth of the credit variable. This probably reflects the fact that in the current monetary policy framework the BoB treats the growth of real private credit not just as an information variable but as its "key intermediate target variable" (see Monetary Policy Statement, 2001). In theory, an intermediate target variable is taken as a proxy for an ultimate target variable; so that the policymakers react to the intermediate target and not to the ultimate target variable(s).

Although the literature suggests that the monetary authorities have been concerned with interest rate differentials *vis-à-vis* South Africa, particularly in the pre-liberalisation period, empirical evidence for this is rather weak. Only one regression equation detects influence from South African interest rates.

Turning to the issue of policy stance, we observe that the monetary authorities followed a policy of 'leaning against the wind' (*viz.* countercyclical policy) in respect of inflation. That is, when the inflation rate rose relative to the desired level, in the case of the integral rule, the BoB responded by increasing the growth of the Bank rate to dampen inflationary pressures. Similarly, in the case of proportional rule, the results suggest that the BoB responded to increases in the growth of inflation relative to the desired growth rate by increasing the growth of the Bank rate.

Lastly we compare the performance of the two feedback rules to determine which, if any, outperforms the other. Such a comparison is only possible in the case of regressions for the whole sample,[12] where we observe the following pattern. The integral rule tends to suggest that policy reacted to immediate past inflation – specifically, policy reacted to inflation of the previous quarter. In contrast, the proportional rule suggests that monetary policy reacted to the growth of inflation by up to four quarters in

[12] For the 1991-2000 period, none of the explicit inflation terms (whether in the integral rule or proportional rule equations) is significant. Hence, the final parsimonious equations do not permit comparison of the rules.

the past. It is not apparent why monetary policy would tend to react to inflation during long periods in the past. Hence, we are inclined to conclude that the integral rule-based MRF performs better than the proportional rule-based MRF in the whole-sample results. However, in the sub-sample results (1991-2000), both versions of MRF equation perform equally well. This makes it difficult to rule one way or the other. Perhaps this outcome suggests that there has been regime-switching. If this is the case, both rules are valid characterisations of the historical pattern of monetary policy. That is, it is possible that on some occasions, monetary policy followed an integral feedback rule, while on other occasions, policy followed a proportional feedback rule.

5. CONCLUSION AND SUGGESTIONS FOR FURTHER WORK

This paper intended to study how monetary policy was conducted in Botswana. We accomplished this task by specifying and estimating an empirical monetary policy reaction function for the Bank of Botswana (BoB) over the period of study, 1977-2000 and also over the post- liberalisation period, 1991-2000. In both periods, we have identified a predominantly countercyclical policy reaction function. The reaction function suggests that inflation (directly and indirectly via the real exchange rate) is the ultimate variable of policy interest.

Our results are broadly similar to those found in Bleaney and Lisenda (2001). The authors find a countercyclical response of the BoB's Bank rate to both real private sector credit and inflation. A contrast in results arise in that whereas Bleaney and Lisenda find that the monetary authorities' decisions are not influenced by changes in international competitiveness (*via* the real exchange rate) and South African interest rates, we do find some influence from both these variables.

The existence of the reaction function suggests that the monetary authorities have been systematic in conducting policy. That is, as stated in Bleaney and Lisenda (2001), the existence of the MRF implies that Botswana has had a stable policy regime.

This probably explains why Botswana, a country that has enjoyed a very high economic growth rate for much of the 25 years after independence, has not experienced chronic inflation. Of course, monetary policy should be seen as a complementary policy within the broad package of macroeconomic policies. In fact, the success story of Botswana, both in terms of achieving impressive growth rates and macroeconomic stability has been attributed partly to sound macroeconomic policies by both domestic researchers (*c.f.* Harvey and Lewis, 1990) and international observers (*c.f.* IMF, 2002)

Although the empirical reaction function in this paper generates results that are consistent with what the monetary authorities claim to be doing, we have assumed a homogenous type of response by the central bank to target variables. That is, by using a fixed-parameter-model to represent the Bank's MRF, we have implicitly assumed that the Bank responds to, say, inflation "with the same vigour regardless of whether the level of inflation is unusually high or low" (Shen, Hakes and Brown, 1999). This may not be the case, as confirmed in Shen *et al.* (1999) for the Fed Reserve Bank of U.S. and Shen (2000) for the central bank of China. Thus, future work may consider testing this hypothesis in the case of the BoB.

APPENDIX 1: DATA DESCRIPTION

m1 denotes log of nominal M1.[13] M1 is Narrow money = currency outside banks plus current (*i.e.*, demand) deposits at the commercial banks (in millions of Pula), labelled "money" in the IMF's International Financial Statistics (IFS) publications. These are end- of-quarter values for quarterly data.

m2 denotes log of nominal M2. M2 is Broad money = M1 plus Quasi-money values (reported in the IFS publications); these are end-of-quarter values like M1. Quasi – money consists of call, savings and time deposits at commercial banks.

cr denotes log of nominal domestic credit (in millions of pula) from commercial banks to the non-financial private sector. These are end-of-quarter values, labelled "Claims on Private Sector" in IMF's IFS publications.
rm1 denotes real m1; where real m1 is in constant (1991) pula.

[13] All logs refer to natural logarithms.

rm2 denotes real m2; where real m2 is in constant (1991) pula.

rcr denotes real credit; where real cr is in constant (1991) pula.

Br denotes the Bank rate. The values are in per cent per annum. These are end-of-quarter data, as reported in the IFS publications.

rgdp denotes log of real GDP. The quarterly values were interpolated by the author from annual values (using Friedman's method, the procedure is described in chapter 3 of the author's dissertation).

Xr is Botswana's Rand/ Pula nominal exchange rate. These are averages of the end-of- month values. The monthly values were obtained from the Bank of Botswana's computer.

rxr is the log of rand-pula real exchange rate; calculated using the CPI of Botswana and CPI of South Africa. Real exchange rate (rXr) was calculated as follows:

rXr=(rand/ pula) (BOTprice / SAprice)* where BOTprice denotes Botswana prices and SAprice denotes South Africa prices (with base in 1991: 4).

dvl denotes the log of the value of diamond exports (in millions of Pula).The data are averages of end-of-month values obtainable from CSO bulletins in Table 3.3A which is entitled "EXTERNAL TRADE – EXPORTS B PRINCIPAL COMMODITIES" (*c.f.* CSO bulletin for September 1992 or March 1996).

Tb denotes South Africa's Treasury bill rate in per cent per annum (as noted in the IFS publications). This is the 91-day rate. Monthly data are averages of each Friday of the month.

Inflation (inf) was calculated from the CPI using the formula:
$((CPI_t / CPI_{t-4})-1)*100$.

Notes:

1. All variables (except the Consumer Price Index, inflation, the Bank rate, the exchange rate, and South Africa's Treasury bill rate) are measured in millions of Pula.
2. Pula is the name of Botswana's currency.
3. The monetary aggregates and credit values (from Botswana Financial Statistics and IFS bulletins) were expressed in units of 1 million pula in order to make them comparable in size to the GDP values.
4. All variables are seasonally unadjusted.

APPENDIX 2: ESTIMATION RESULTS

Table A2.1 MRF with Growth of Real M2 as Information Variable and Target Variables as the Level of Inflation or Growth of Inflation and Growth in Real Income

Modelling DBr by OLS; Sample is:1978(2)-2000(3)

PANEL A				PANEL B			
Variable	Coeff	t-value	Instab	Variable	Coeff	t-value	Instab
Const	0.300	0.742	0.06	Const	0.168	2.216*	0.06
Inf_1	0.052	1.878*	0.06	DInf_2	0.083	1.696*	0.02
Inf_5	-0.064	-2.050*	0.06	DInf_4	0.092	1.890*	0.06
Dm2_1	-2.410	-2.480**	0.15	Dm2_1	-2.172	-2.405**	0.18
Dm2_2	-2.461	-2.532**	0.11	Dm2_2	-2.154	-2.384**	0.11
DTb_1	0.088	1.669*	0.30				
R^2 = 0.17; F(5,84)= 3.52[0.01];				R^2 = 0.16; F(4,85) = 4.10[0.00];			
σ = 0.67; Instability $(\sigma^2 = 0.11)$				σ = 0.67; Instability $(\sigma^2 = 0.11)$			
Misspecification Tests				**Misspecification Tests**			
AR 1- 5 F(5, 79) = 1.09[0.37]				AR 1- 5 F(5, 80) = 1.03[0.40]			
ARCH 4 F(4, 76) = 1.81[0.14]				ARCH 4 F(4, 77) = 1.80[0.14]			
Normality Chi^2(2)= 18.1[0.00]**				Normality Chi^2(2)= 20.2[0.00]**			
Xi^2 F(10, 73) = 1.93[0.06]				Xi^2 F(8, 76) = 3.02[0.01]**			
Xi*Xj F(20, 63) = 2.84[0.00]**				Xi*Xj F(14, 70) = 5.53[0.00]**			
RESET F(1, 83) = 9.77[0.00]**				RESET F(1, 84) = 3.45[0.07]			

Notes: 1. * and ** denote the 5 and 1 per cent level of significance respectively.

Table A2.2 MRF with Growth of Real M2 as Information Variable and Target Variables as the Level of Inflation or Growth of Inflation and Growth in Real Income

Modelling DBr by OLS; Sample is:1992(3)-2000(3)

PANEL A				PANEL B			
Variable	Coeff	t-value	Instab	Variable	Coeff	t-value	Instab
Const	-0.050	-0.880	0.12	Const	-0.048	-0.846	0.07
Dm2_1	1.629	2.067*	0.09	DBr_1	0.223	1.768*	0.26
Dexr_1	4.541	1.757*	0.05	Dm2_1	1.668	2.135*	0.13
				Dexr_1	4.597	1.797*	0.07
R^2 = 0.20; F(2,30) = 3.72[0.04]				R^2 = 0.26; F(3,30) = 3.58[0.03]			
σ = 0.31; Instability $(\sigma^2 = 0.13)$				σ = 0.31; Instability $(\sigma^2 = 0.17)$			
Misspecification Tests				**Misspecification Tests**			
AR 1- 3 F(3, 27) = 2.16[0.12]				AR 1- 3 F(3, 27) = 0.99[0.41]			
ARCH 3 F(3, 24) = 0.26[0.85]				ARCH 3 F(3, 24) = 0.37[0.78]			
Normality Chi^2(2)= 5.60[0.06]				Normality Chi^2(2)= 6.20[0.05]*			
Xi^2 F(4, 25) = 0.23[0.92]				Xi^2 F(6, 23) = 0.36[0.89]			
Xi*Xj F(5, 24) = 0.29[0.91]				Xi*Xj F(9, 20) = 0.29[0.97]			
RESET F(1, 29) = 0.00[0.99]				RESET F(1, 29) = 0.04[0.84]			

Notes: 1. * and ** denote the 5 and 1 per cent level of significance respectively.

Table A2.3 MRF with Growth of Real Private Credit as Information Variable and Target Variables as the Level of Inflation or Growth of Inflation and Growth in Real Income

Modelling DBr by OLS; Sample is:1992(3)-2000(3)	
PANEL A	**PANEL B**
Variable Coeff t-value Instab	Variable Coeff t-value Instab
Const -0.050 -0.837 0.05	Const -0.037 -0.607 0.05
Dscr_1 2.580 2.089* 0.22	Dscr_1 2.633 2.094* 0.15
R^2 = 0.12; F(1,31) = 4.37[0.05]	R^2 = 0.12; F(1,32) = 4.38[0.04];
σ = 0.32; Instability $(\sigma^2 = 0.06)$	σ = 0.33; Instability $(\sigma^2 = 0.33)$
Misspecification Tests	**Misspecification Tests**
AR 1- 3 F(3, 28) = 1.11[0.36]	AR 1- 3 F(3, 29) = 0.90[0.45]
ARCH 3 F(3, 25) = 1.44[0.25]	ARCH 3 F(3, 26) = 1.32[0.29]
Normality Chi^2(2)= 2.15[0.34]	Normality Chi^2(2)= 1.29[0.53]
Xi^2 F(2, 28) = 0.07[0.94]	Xi^2 F(2, 29) = 0.10[0.91]
Xi*Xj F(2, 28) = 0.07[0.94]	Xi*Xj F(2, 29) = 0.10[0.91]
RESET F(1, 30) = 0.53[0.47]	RESET F(1, 31) = 0.20[0.66]

Notes. * denotes the 5 per cent level of significance.

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