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MONETARY DYNAMICS IN BARBADOS: THE EVIDENCE FROM COINTEGRATION ANALYSIS AND ERROR-CORRECTION MODELING

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By

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1. Introduction

Theoretical work on money in the Barbadian economy (a small open economy with a fixed exchange-rate regime) suggests that there is a one-way causal relationship between money and the arguments of the money demand function (see McClean (1994)). Prices are hypothesized to be determined predominantly by the price of imports, taxation and other supply-side factors such as pricing practices in the distributive sector. The money market is considered to be demand centred, in the sense that the process of money market adjustment reflects an over-riding tendency for the supply of money to adjust to the demand for money. In the short-run, the rate of interest is regarded as the only argument of the money demand function with significant potential to be proximately responsive to money market disequilibrium However, during the last two decades, Central Bank control of interest rates would have attenuated the responsiveness of interest rates to money-market disequilibrium and other economic conditions. Hence, the rate of interest in Barbados has been policy determined rather than market determined.

These propositions have not previously been subjected to adequate econometric testing. Earlier empirical studies on money in Barbados focussed on the specification of the money demand function. Howard (1981) provided inconclusive evidence regarding the existence of a well defined functional relation for the demand for money in Barbados. McClean (1982) estimated long-run models using annual data and reported results that were indicative of the existence of a transactions money-demand function. Coppin (1991), using both annual and quarterly data, reported results that confirmed McClean's central finding.[1] However, these studies were not designed to investigate monetary dynamics.

In this study, we use cointegration analysis and error correction modeling to test the hypotheses stated above and to further explicate short-run monetary dynamics in Barbados. The paper is organised as follows: In section 2, we present an aggregative, fixed-exchange-rate, labour-surplus model of a small open economy, that is expressive of the propositions stated above. The econometric analysis is presented in section 3. This is followed, in section 4, by some concluding remarks.

2. The Model

The Barbadian economy has been characterised by a fixed exchange-rate regime, chronic unemployment, an integrated labour market, institutionalized bargaining arrangements for the fixing of wages, largely unrestricted access to foreign goods and foreign exchange, and levels of factor mobility and product substitutability that validates an aggregative approach to modeling the economy. The following fixed-exchange-rate, short-run, labour-surplus small-open-economy model, with two goods and an overlay of distributive services, is proposed as an adequate representation of the Barbadian economy:

$$P_a = [1 + \phi(r, \bar{t}_c, \bar{t}_e)][\alpha(1 + \bar{t}_d)\bar{E}\bar{P}_d^* + (1 - \alpha)(1 + \bar{t}_m)\bar{E}\bar{P}_m^*]; \quad \phi_r, \phi_{t_c}, \phi_{t_e} > 0; \; 0 < \alpha < 1 \tag{1}$$

$$y = \frac{(1 + t_d)\bar{E}\bar{P}_d^*}{p_a} q \tag{2}$$

$$W_G = (1 + \bar{t}_e)W \tag{3}$$

$$q = F(N, \bar{K}); \quad F_N, F_K > 0 \tag{4}$$

$$W = W(\overline{EP}_d^*, P_a, r, \bar{t}_e, \bar{t}_w); \quad W_{P_d}, W_{P_a}, W_{t_W} > 0; \; W_r, W_{t_e} < 0 \qquad \textbf{(5)}$$

$$\frac{W_G}{\bar{E}\bar{P}_d^*} = F_N(N, \bar{K}); \quad F_{NN} < 0;\ F_{NK} > 0 \tag{6}$$

$$y - s\,[y(1-\bar{\tau}), \frac{\epsilon}{P_a}, i - \dot{P}_a^e] - \bar{g} + \frac{1}{P_a}\eta\,[i, \bar{i}_f, \epsilon, \dot{E}^e] = \frac{dNFA}{P_a} \tag{7}$$
$$s_y, \eta_\epsilon, \eta_i > 0; \quad s_\epsilon, s_i, \eta_{\dot{E}^e} \eta_{i_f} < 0$$

$$mH - l(P_a, y, i) = \epsilon; \quad l_P, l_y > 0;\ l_i < 0;\ m > 1 \tag{8}$$

$$dH = d\bar{NLA} + dNFA \tag{9}$$

Where E is the nominal domestic/foreign exchange rate;

$\dot{E}^e$ is the expected change in the nominal exchange rate;

H is the nominal stock of high-powered money;

g is real government expenditure;

I is the nominal rate of interest;

i_f is the nominal foreign interest rate;

K is the stock of capital;

m is a portfolio-balance coefficient, linking demand/supply of money to demand/supply of high-powered money;

N is the level of employment;

NLA is the local assets of the Central Bank, net of local liabilities other than high-powered money;

NFA is the net foreign assets of the Central Bank;

P_a is the absorption price level measured at market prices and denominated in domestic currency;

P_d^* is the foreign-currency price of the domestic good, measured at factor cost;

P_m^* is the foreign-currency price of the foreign good;

$\dot{P}_a^e$ is the expected rate of inflation of the absorption price level, assumed to be exogenously determined;

t_c is the corporation tax rate;

t_e and t_w are payroll tax rates imposed on the employer and the worker, respectively;[2]

t_d and t_m are the "ad valorem" indirect tax rates on the domestic and the foreign good, respectively;

W is the nominal contractual wage rate;

W_G is the nominal gross wage rate paid by the employer, inclusive of payroll taxes;

α is the proportion of the domestic good in the absorption mix;

ϵ is excess money supply as defined by equation 8;

$\tau$is a vector of direct tax rates, including payroll taxes rebased to relate to income;

s( ) is the private expenditure function;

η( ) is the net nominal capital inflow function;

ϕ( ) is the distributors' mark-up function;

($\bar{}$) denotes an exogenous variable.

Equation 1 depicts the absorption price level as determined by international market forces, indirect taxation and and a set of factors that influence distributors' markup.[3] Equation 2 models the oft ignored relationship between real income and real output. It highlights the fact that these two variables can experience significantly different rates of change.

The notion of the short-run to which our model relates, is a period sufficiently short to preclude current investment expenditure from changing the capital stock, but sufficiently long to allow the capital stock to be influenced by prior-period investment expenditure. Hence, in equation 3, the capital stock is treated as an exogenous variable. That is, our model abstracts from the effect of the rate of interest on the capital stock.

The theoretical underpinnings of equation 5, a wage function, have been presented in Downes and McClean (1987). The wage function has been deduced from a bargaining model of wages, in which the wage rate is postulated to be negatively related to employers' resistance to wage increases and positively related to trade-union pushfulness for wage increases. Any variable that impacts negatively (positively) on the profitability of firms will increase (reduce) the resistance of employers to wage increases and impact negatively (positively) on the wage rate. Any variable that impacts negatively (positively) on the absolute or relative standard of living of workers will increase (reduce) trade-union pushfulness and impact positively (negatively) on the wage rate.

Equation 6 is an indirect representation of the demand for labour. It depicts the relevant marginal productivity condition for the optimum of the firm.[4] Equations 7-9 have been presented in a manner that highlights the implicit dynamics of the model, in regard to money and the balance of payments. Equation 7, which models the balance-of-payments process (i.e. the foreign-exchange market) indicates that, in an equilibrium context, the money supply is not a determinant of private expenditure or net capital flows. It also indicates that the emergence of monetary disequilibrium induces changes in private expenditure and net capital flows. The balance-of-payments and money-market equations may be reformulated in equilibrium terms by setting ϵ, $\dot{E}^e$, $\dot{P}_a^e$, dNFA and dH equal to zero. The final equation is the differential form of the Central Bank's balance sheet constraint.

The product market equilibrium condition is notably absent from the foregoing set of structural equations. Infinite elasticity of foreign demand for SOE exports, ipso facto, means that, in an aggregative SOE model, demand for the domestic product is permanently larger than supply. Hence, there is no possibility of product market equilibrium as conventionally portrayed. In the SOE case, the "ex post" income expenditure identity may be reformulated as an excess-supply relation for exports. Such an equation has not been included, because it does not constitute a necessary part of our model, in the sense that a solution for the value of exports is not required for the solution to any other variable in our model.[5]

In its static equilibrium aspect, the model is slightly decomposable. Equations 1-7 constitute a sub-system that simultaneously determines P_a, W, W_G, N, q, y and r. Given solution values for P_a, y and r, a solution for H may be found from equation 8. Hence, our model implies that P_a, y and r enter the money demand function as predetermined variables.. To solve for NFA, equation 9 may be reformulated in levels of the variables.

The model implies that, in the transitional period between equilibria, there is a dynamic process of mutual adjustment linking the money market (equation 7) and the foreign exchange market (equation 8) that is conditioned by the Central Bank's balance-sheet identity (equation 9) and by equations 1-6. Hence, the model embraces but does not necessitate cyclical responsiveness of the rate of interest to monetary disequilibrium. In other words, the model indicates that the role played by the rate of interest in short-run monetary dynamics should be regarded as an empirical issues. In the next section we present an econometric analysis of these matters.

3. Econometric Analysis

Before we can test the foregoing hypotheses, the first issue that must be confronted pertains to the choice of empirical counterparts to the theoretical constructs in our model. The Retail Price Index (Consumer Price Index) is the only available quarterly series on aggregate prices in Barbados. It, therefore selects itself as the price variable. In Barbados, commercial-bank three-month time deposits are the evident alternative to holding money. We, therefore, modeled the interest-rate effect around interest rates on three-month deposits. We chose as arguments of the money-demand function, the minimum interest rate on three-month deposits and a spread variable (S) defined as the ratio of the maximum to the minimum interest rate on three-month deposits.[6] Nominal GDP deflated by the Consumer Price Index was used as a proxy for real income.[7] A narrow measure of the money supply (M1) was adopted.

We then tested for the order of integration of the logarithms of these five variables, using quarterly data for the period 1974:1 to 1994:4. The results obtained from Dickey-Fuller (DF) test and Augmented Dickey-Fuller (ADF) tests, the latter with four lags, are reported in Table 1.[8] They indicate that the Spread variable is I(0) (integrated of order zero) and all other variables are I(1)[9]. All four tests rejected the null hypothesis that the Spread variable was non-stationary. In the case of the other variables, the DF test without trend rejected the null hypothesis of non-stationarity of lnP. However, this seems to be a statistical artifact. The three other tests did not reject non-stationarity of lnP, and every test failed to rejected non-stationarity of the levels of lnM, lnr and lny. All four tests rejected the null hypothesis of non-stationarity of the first difference of every variable.

Table 1
Tests For Unit Roots: 1974:1 - 1994:4

Variables	DF		ADF(4)	
	Without Trend	With Trend	Without Trend	With Trend
lnM	-2.1911	-1.5974	-2.3912	-1.1382
dlnM	-9.4375	-9.7735	-3.8182	-4.4613
lnP	-5.9445	-2.4540	-1.9813	-.38064
dlnP	-6.3843	-7.2667	-3.5576	-4.1212
lny	-1.7147	-2.8345	-2.3742	-2.0470
dlny	-11.0960	-11.0249	-3.0823	-3.3897
lnr	-2.6084	-2.5230	-2.4162	-2.4582
dlnr	-8.1696	-8.1504	-4.2963	-4.2609
lnS	-3.6777	-3.6503	-3.5138	-3.6411
95% c.v.	-2.8963	-3.4639	-2.8981	-3.4666

These results indicate that for the five variables in our long-run money demand model to be cointegrated, the sub-set of four I(1) variables must be cointegrated. Hence, cointegration of lnM, $\ln P_a$, lnr and lny constitute necessary assurance against the prospect of spurious regression. If time-series variables are cointegrated, their secular trends adjust in accordance with an equilibrium constraint and the cyclical components of the series fit into a dynamic error-correction process (see Engle and Granger (1987), Granger (1986) and Hendry (1986)). To check for cointegration among the four I(1) variables, we estimated the associated co-integrating regression equation using ordinary least squares, and performed Engle-Granger (Dickey-Fuller) tests on the residuals. The results are presented as equation 10.

$$
\begin{gathered}
lnM_t = 11.5295 + 1.0330\, lnP_t + 1.2106\, lny_t - .10094\, lnr_t \\
\bar{R}^2 = .98924 \quad F(3,80) = 2544.9 \quad DW = 1.2947 \\
DF = -6.3695(-4.2326) \quad ADF(4) = -4.2473(-4.2395)
\end{gathered}
\tag{10}
$$

The DF and ADF tests both reject the hypothesis of non-stationarity of the residuals, at the five percent level. Hence, cointegration among the four variables is indicated. The relatively high value of the Durbin-Watson statistic is also indicative of cointegration. If the four I(1) variables are cointegrated, then the five variables are cointegrated. We then applied the Johansen maximum likelihood procedure with eight lags[10] and with lnS included in the VAR, as an additional I(0) term (see Johansen (1988)). We used the procedure to identify the number of cointegrating vectors, investigate the issue of simultaneity and to obtain the residuals of the cointegrating vector for use as an error-correction mechanism (ECM).

Table 2
Johansen Maximum Likelihood Procedure (Non-trended case)
Cointegration LR Tests
76 observations from 76Q1 to 94Q4. Maximum lag in VAR = 8

List of variables included in the cointegrating vector:
lnM lnP lny lnr Intercept
Additional I(0) variable included in the VAR: lnS
List of eigenvalues: .61957 .40541 .21294 .034495 -.0000

Null	Alternative	Statistic	95% C. V	Statistic	95% C. V.
r = 0	r = 1	73.4497	28.1380	133.8272	53.1160
r<= 1	r = 2	39.5114	22.0020	60.3776	34.9100
r<= 2	r = 3	18.1982	15.6720	20.8661	19.9640
r<= 3	r = 4	2.6679	9.2430	2.6679	9.2430

The results of two cointegration LR tests, based respectively on the maximal Eigenvalue and the trace of the stochastic matrix, are reported in Table 2. Both test rejected, at the 5% level, the null hypothesis of at most two cointegrating vectors against the alternative of three, and neither rejected at most three against the alternative of four cointegrating vectors. The three cointegrating vectors and the associated estimated adjustment matrix are presented in Tables 3 and 4 respectively. In regard to the cointegrating vectors, only Vector 2 has the expected sign for the interest rate variable in a money-demand function, the normalized value for the coefficient of lnP is the closest of the three to the conventionally hypothesized value of unity, and the coefficient of lny also has the most plausible value. Hence, it is indicated that Vector 2 pertains to the demand for money.

Table 3
Estimated Cointegrated Vectors in Johansen Estimation(Normalized in Brackets)
76 observations from 76Q1 to 94Q4. Maximum lag in VAR = 8

Variables	Vector 1	Vector 2	Vector 3
lnM	4.8119 (-1.0000)	9.3691 (-1.0000)	1.4391 (-1.0000)
lnP	-4.5708 (.94990)	-9.7163 (1.0371)	-1.1373 (.79023)
lny	-7.1315 (1.4821)	-12.0779 (1.2891)	-4.4575 (3.0974)
lnr	-.043089 (.0089546)	1.1731 (-.12521)	-.079311 (.055110)
Intercept	-48.0227 (9.9800)	-102.2899 (10.9178)	1.1850 (-.82343)
Additional I(0) variable included in the VAR: lnS			

The adjustment matrix also provides persuasive evidence in support of this interpretation. Vector 2 indicates that there is significant negative feed-back. This accords with the hypothesized endogeneity of the money stock and with our theory of demand-centred money-market adjustment. The relatively small values of the other elements in Vector 2 indicate that the second cointegrating vector does not enter any of the equations pertaining to the other variables. When an ECM enters more than one equation, the parameters are cross-linked between the equations and weak exogeneity is violated. In such circumstances, OLS estimates of the parameters of the model would be inefficient (see Phillips and Loretan (1991)).

Table 4
Estimated Adjustment Matrix in Johansen Estimation(Normalized in Brackets)
76 observations from 76Q1 to 94Q4. Maximum lag in VAR = 8

Variables	Vector 1	Vector 2	Vector 3
lnM	.019400	-.21348	.10003
lnP	.0064410	-.9692E-3	.017345
lny	.076738	.019621	.046937
lnr	.80201	-.059011	-.16815

We based the dynamic structure of our short-run equation on an error-correction model, with contemporaneous and lagged conditioning variables (see Hendry, Pagan and Sargan (1984) and Miller (1991)). The ECM lagged one period and four lags of all other variables were included in the general error-correction model. All I(1) variables were entered as first differences, and the I(0) variables were entered as levels.

Table 5 reports the estimated general error-correction model, together with Lagrange Multiplier test statistics pertaining to: the overall relevance of each variable, χ^2; residual serial correlation, χ^2_{SC}; Ramsey's RESET test of functional form, χ^2_{FF}; a test for normality, χ^2_N; a test for heteroscedasticity, χ^2_H. The bracketed terms under the coefficients are standard errors. The square-bracketed terms next to test statistics are P-values.

Table 5
Generalized Error-Correction Model: Ordinary Least Squares Estimation
Dependent Variable: ΔlnM
75 observations used for estimation from 76Q2 to 94Q4

Lag	1	ECM	ΔlnM	ΔlnP	Δlny	Δlnr	lnS
0	-.018511 (.017898)			1.1723 (.44241)	.68950 (.25301)	-.15438 .046924	.18137 (.058791)
1		-1.3144 (.26039)	.52886 (.21629)	-.35891 (.42494)	-.68191 (.26773)	.039053 (.056289)	-.057970 (.071906)
2			.40579 (.18277)	.47490 (.40941)	-.63919 (.23889)	-.059909 (.049661)	.067841 (.070909)
3			.40955 (.14917)	.39712 (.38856)	.12815 (.20647)	-.079273 (.048526)	-.023665 (.070170)
4			.22424 (.12457)	.73439 (.41286)	.31098 (.24638)	.046000 (.037920)	-.14117 (.054431)
χ^2	1.6022 [.206]	25.6584 [.000]	10.6197 [.031]	21.4666 [.001]	40.4471 [.000]	22.7751 [.000]	25.1346 [.000]
R^2 = .74052 F(25, 49)=5.5934[.000] DW=1.9728							
$\chi^2_{SC}(4)$=6.5043[.165] $\chi^2_{FF}(1)$=.40930[.522] $\chi^2_N(2)$=.26780[.875] $\chi^2_H(1)$=5.9580[.015]							

The tests pertaining to the overall significance of each variable's lag coefficients rejected the null hypothesis in all six cases. The Lagrangean multiplier tests accepted the null hypotheses of uncorrelated residuals, correct functional form and normality. The test for heteroscedasticity, rejects the null of homoscedastic errors, at the 5% level but accepts it at the 1% level. Hence, the model is an acceptable over-paramerterised model of short-run money demand.

The next step in our analysis was the reduction of the model, by systematically eliminating redundant regressors. Our elimination procedure entailed the sequential exclusion of regressors, until all regressors were significant at about the one percent level. Thereafter, as a final check, variable addition tests were performed on groups of previously excluded regressors, on a variable by variable basis.. The results of the reduced model so obtained are reported in equation 11.

$$
\begin{aligned}
lnM = & -.01044 - .6897ECM(-1) + 1.5293\Delta lnP + .8449\Delta lnP(-2) + 1.0855\Delta lny + .4851\Delta lny(-3 \\
& \quad (.01568) \quad (.1112) \quad (.3726) \quad (.3717) \quad (.1362) \quad (.1079) \\
& -.13901\Delta lnr + -.06752\Delta lnr(-2) - .07508\Delta lnr(-3) + .09612 lnS - .09749 lnS(-4) \\
& \quad (.0295) \quad (.02949) \quad (.02799) \quad (.02935) \quad (.02636)
\end{aligned}
\tag{11}
$$

$$R^2 = .62544 \quad F(10,64) = 10.6867 \quad DW = 2.0602$$
$$\chi^2_{SC}(4) = 4.3473 \quad \chi^2_{FF}(1) = .97814 \quad \chi^2_{N}(2) = .40036 \quad \chi^2_{H}(1) = 1.6285$$

The model performs well on all tests. There is no indication of serial correlation, heteroscedasticity, skewness or kurtosis and the functional form has been well accepted. The coefficient of the error-correction mechanism indicates a high speed of adjustment of the actual to the desired money stock.

We then conducted stability and predictive failure tests, using 1986:4 and 1990:4 respectively as break points. Table 6 presents regression estimates and diagnostic statistics for the sub-periods ending 1986:4 and 1990:4. For ease of comparison, estimates for the entire sample period are also included in the table.

Table 6
Sub-Sample Estimates of Reduced Model
Dependent Variable: ΔlnM

Regressors	76Q2-86Q4	76Q2-90Q4	76Q2-94Q4
1	-.0055051 (.022760)	-.013356 (.020084)	-.010437 (.015679)
ECM(-1)	-.61854 (.17030)	-.65730 (.13962)	-.68969 (.11124)
ΔlnP	1.1723 (.57806)	1.3487 (.47251)	1.5293 (.37255)
ΔlnP(-2)	.92878 (.52738)	1.1359 (.43641)	.84492 (.37172)
Δlny	1.0413 (.17790)	1.0008 (.15827)	1.0855 (.13618)
Δlny(-3)	.51121 (.13630)	.43960 (.11860)	.48510 (.10793)
Δlnr	-.028455 (.084678)	-.17276 (.052589)	-.13901 (.029503)
Δlnr(-2)	-.11215 (.073205)	-.10914 (.048171)	-.067519 (.029493)
Δlnr(-3)	-.11310 (.064371)	-.070076 (.046407)	-.075079 (.027991)
lnS	.051414 (.065570)	.099549 (.051501)	.096121 (.029346)
lnS(-4)	-.053832 (.054113)	-.11419 (.046543)	-.097491 (.026357)
76Q2-86Q4	R^2=.65733 F(10, 32) = 6.1385 DW = 2.1987 $\chi^2_{SC}(4)$=5.2473 $\chi^2_{FF}(1)$=.31830 $\chi^2_N(2)$=2.7028 $\chi^2_H(1)$=.99949 F_{PP} (32, 32) = .79095[.745] F_{SS} (11, 53) = .40410[.948]		
76Q2-90Q4	R^2=.62736 F(10, 48)= 8.0810 DW=2.1035 $\chi^2_{SC}(4)$=2.9527 $\chi^2_{FF}(1)$=.22440 $\chi^2_N(2)$=.21908 $\chi^2_H(1)$=2.1712 F_{PP} (16, 48) = .67448[.804] F_{SS} (11, 53) = .80264[.637]		

The sub-samples produced results similar to the full-sample. The two Chow tests provided no evidence of predictive failure or structural instability. Hence, we conclude that the reduced model is an acceptable baseline model.

The results in equation 11 indicate that the coefficients of the contemporaneous value and the fourth lag of the spread term are almost of equal and opposite magnitude. A Wald test for a zero restriction of the sum of the two coefficients does not reject the restriction. Hence, we obtained a more parsimonious model by replacing the contemporaneous value and the fourth lag of the logarithm of the spread variable, by the first seasonal difference of its logarithm. When this model is estimated, the lag coefficients of lnP and lnr become insignificant at the five percent level, but remain significant at the ten percent level. These variables were, therefore, excluded and the model re-estimated. Equation 12 reports estimates of the final model, together with diagnostic statistics, including statistics pertaining to a non-nested test of the model against the baseline model.

$$\begin{gathered}\Delta lnM = \underset{(.00772)}{.00568} - \underset{(.1168)}{.6884}ECM(-1) + \underset{(.3833)}{1.4371}\Delta lnP + \underset{(.1433)}{1.1613}\Delta lny \\ + \underset{(.1134)}{.504}\Delta lny(-3) - \underset{(.02998)}{.1045}\Delta lnr + \underset{(.01737)}{.0425}SDlnS \\ R^2=.53773 \quad F(6,68)=13.1833 \quad DW=1.8495 \\ \chi^2_{SC}(4)=4.6830 \quad \chi^2_{FF}(1)=.75461 \quad \chi^2_{N}(2)=.55865 \quad \chi^2_{H}(1)=.13226 \\ AIC=-3.6278 \quad SC=.52727 \\ DF=-8.2545 \quad ADF(1)=-6.6429 \quad ADF(4)=-5.2871\end{gathered} \tag{12}$$

The model has been well accepted by all diagnostic tests. The DF and ADF statistics indicate cointegration. The results of the model selection tests were mixed. The Akaike's Information Criterion (AIC) favours the baseline model and the Schwarz's Bayesian Information Criterion (SC) favours the more parsimonious model.

Satisfied as to the existence of a stable error-correction mechanism, we next relaxed the restriction imposed by the ECM, by replacing it with the logarithms of the money stock and the arguments of the money demand function lagged one period. On this occasion, we used the seasonal difference of the spread variable in the VAR. We first estimated the general unrestricted model (GUM) with four lags, but an F-test for the joint significance of the fourth lags accepted the zero restriction. We then re-estimated the GUM with three lags, with results as shown in table 7.

TABLE 7
Generalized Unrestricted Model
Dependent variable: ΔlnM
80 observations used for estimation from 75Q1 to 94Q4

Variables	0	(-1)	(-2)	(-3)	F
1	14.474 (2.8917)				25.0546
lnP		1.3483 (1.3483)			26.2942
lny		1.6799 (.32801)			26.2305
lnr		-.14667 (.0331)			19.6051
lnM		-1.3133 (.24701)			28.2668
ΔlnM		.60407 (.20541)	.3735 (.17909)	.27562 (.1480)	2.8946
ΔlnP	1.3169 (.4503)	-.32648 (.44122)	.0091379 (.44521)	.32087 (.4009)	2.6389
Δlny	1.1133 (.20924)	-.59558 (.28016)	-.45041 (.25464)	.29039 (.2026)	10.7089
Δlnr	-.0441 (.0389)	.0993 (.0501)	.0022636 (.045976)	-.03496 (.0388)	2.8637
SDlnS	.0247 (.0356)	.00701 (.0390)	.050856 (.03706)	-.00204 (.0366)	1.4706
$\bar{R}^2$ = .47397 F(23, 56) = 4.0949 DW = 2.1059					
$\chi^2_{SC}(4)$=4.0291 $\chi^2_{FF}(1)$=1.1373 $\chi^2_N(2)$=.57432 $\chi^2_H(1)$=.006103					

The standard error of the coefficient of lnM suggests that the coefficient is not significantly different from -1, and a Wald test accepted a restriction of -1 on this coefficient. We, therefore, re-estimated the model with this restriction, by using lnM as the dependent variable and omitting lnM(-1) form the regressors. The results are shown in table 8.

Table 8
Generalized Restricted Model
Dependent variable: lnM

Variables	0	(-1)	(-2)	(-3)	F
1	10.9355 (.76404)				204.8520
lnP		1.0200 (.0467)			477.9828
lny		1.2904 (.1158)			124.2576
lnr		-.11493 (.0218)			27.7480
ΔlnM		.38602 (.1130)	.19986 (.11606)	.1563 (.1148)	4.0633
ΔlnP	1.2088 (.4445)	-.1966 (.4315)	.12961 (.43727)	.3138 (.4030)	2.3110
Δlny	1.0121 (.19446)	-.3899 (.2297)	-.30401 (.22819)	.3334 (.2008)	16.6663
Δlnr	.060008 (.0371)	.0644 (.0421)	-.0204 (.042579)	-.0361 (.03897)	2.4942
SDlnS	.038065 (.0342)	-.00404 (.0382)	.0461 (.037067)	-.01277 (0358)	1.2656
$\bar{R}^2=.99154$ F(22, 57) = 421.8233 DW = 2.1985					
$\chi^2_{SC}(4)=4.6633$ $\chi^2_{FF}(1)=.87093$ $\chi^2_{N}(2)=.26577$ $\chi^2_{H}(1)=.62212$					

We reduced the generalized restricted model (GRM) by the reduction procedure outlined earlier. Table 9 reports estimates, for three sample periods, of the final and fully data accepted model. The regressors in this model were selected at a 0.1% significance level. Equation 13 presents a less stringently reduced version, in which all regressors are significant at about the 1% level. This equation is also well accepted by every test except Ramsey's RESET test of functional form misspecification.

$$\underset{.63474}{lnM = 10.0619} + \underset{.030820}{.93844 lnP(-1)} + \underset{.093258}{1.4179 lny(-1)} - \underset{.016793}{.12784 lnr(-1)} + \underset{.10596}{.30471 \Delta lnM(-1)}$$
$$\underset{.14551}{.75167 \Delta lny} - \underset{.14928}{.53571 \Delta lny(-1)} - \underset{.13584}{.33973 \Delta lny(-2)} - \underset{.032695}{.08388 \Delta lnr} + \underset{.018376}{.07268 SDlnS}$$
$$\bar{R}^2=.99112 \quad F(9,72)=1005.9 \quad DW=1.7195$$
$$\chi^2_{SC}(4)=2.1316 \quad \chi^2_{FF}(1)=10.2298 \quad \chi^2_{N}(2)=1.9407 \quad \chi^2_{H}(1)=1.0136$$

The results reported for the level and first-difference estimates of the logarithm of the money stock are consistent with one another and complementary. The first-difference estimates provide explicit information on the speed of adjustment of the actual money stock to the desired money stock, and the level estimates directly display the long-run money-demand coefficients. Both sets of equations indicate that changes in the money stock are induced predominantly by disequilibrium in the preceding period and current changes in income.

Table 9

Sub-Sample Estimates of Reduced Model

Dependent Variable: lnM

Regressors	74Q4-86Q4	74Q4-90Q4	74Q4-94Q4
1	10.3629 (1.1981)	10.5906 (.95986)	11.0494 (.59267)
lnP(-1)	.93896 (.058603)	.95155 (.057229)	.98124 (.030212)
lny(-1)	1.4000 (.184210	1.3629 (.14871)	1.2929 (.088352)
lnr(-1)	-.066737 (.026155)	-.074657 (.025916)	-.079391 (.015384)
ΔlnM(-1)	.40016 (.12305)	.32514 (.11801)	.35197 (.10158)
Δlny	1.1610 (1.1610)	1.1340 (.17107)	1.0461 (.13999)
Δlny(-3)	.57417 (.14126)	.49255 (.14532)	.49387 (.12763)
74Q4-94Q4	$\bar{R}^2$=.98969 F(6, 74) = 1281.1 DW = 1.8389 χ^2_{SC}(4)=2.1302 χ^2_{FF}(1)=.0027983 χ^2_N(2)=.078571 χ^2_H(1)=.15041 DF = -8.2055 ADF(1) = -5.3724 ADF(4) = -4.4978		
74Q4-90Q4	$\bar{R}^2$=.98861 F(6, 58) = 927.0239 DW = 1.7238 χ^2_{SC}(4)=3.9444 χ^2_{FF}(1)=.13936 χ^2_N(2)=.35219 χ^2_H(1)=.36503 F_{PF} (16, 58) = .78615 F_{SS} (7, 67) = .63192 DF = -6.8998 ADF(1) = -4.8739 ADF(4) = -4.4209		
74Q4-86Q4	$\bar{R}^2$=.98654 F(6, 42) = 587.3014 DW = 1.8279 χ^2_{SC}(4)=1.3791 χ^2_{FF}(1)=.18560 χ^2_N(2)=1.3922 χ^2_H(1)=2.6297 F_{PF} (32, 42) = 1.3902 F_{SS} (7, 67) = .36582 DF = -6.3316 ADF(1) = -4.7785 ADF(4) = -3.3789		

3. Concluding Remarks

In general, our econometric findings accord fully with our theory of money in the Barbadian economy. The evidence supports the view that, in an equilibrium context, the arguments of the money demand function enter the money market as predetermined variables. In particular, the evidence confirms our hypothesis that money is not a determinant of the price level. Our results also indicate that the rate of interest and prices play no significant role in short-run money-market adjustment, other than that of contributing to the determination of the level of the desired money stock.

The policy inferences of our theoretical model have been supported by the evidence. Our finding confirm that monetary policy should be dedicated to balance-of-payments management and should not be targeted at any of the arguments of the money-demand function. In particular, expansionary monetary measures should always be avoided, because disequilibrium in the Barbados money-market is corrected through a process in which the actual money stock gravitates to the desired level with rapidity and without any significant money-demand response. Hence, the process of adjustment to excess money entails a balance of payments deficit.

Our specification of the money-demand function has been well accepted by the data. The focus of the study was not about choosing between fundamentally different formulation of the money-demand function. However, our study constitutes a good point of departure for further investigation of such issues. It also points the way for research into price formation and interest rate determination.

1.GDP data for Barbados is published on an annual basis only. Coppin's quarterly series was obtained by applying one quarter of annual GDP to every quarter.

2.In the context of this model, income tax payable on the earned income is considered to be equivalent to a payroll tax on workers.

3.For a discussion of pricing policy in the distributive sector in Barbados, see McClean (1981).

4.For a similar approach to the modeling of the demand side of the labour market, see Sargent, Thomas J. (1979)

5.For similar reasons, a net-wage equation corresponding to equation 3 has not been included in our model. Our purpose is to explicate monetary processes. The export and net-wage equations are not essential to this exercise. They are of greater import to an investigation of issues pertaining to fiscal policy.

6.The ratio was chosen in preference to the difference because the reported maximum and minimum interest rate on three-months deposits have occasionally been the same, and this would create problems for a model based on the logarithm of all variables. Since the focus of this study was not the identification of the best specification of the money-demand function, we did not investigate alternative specifications.

7.Quarterly data on GDP are not available for Barbados. We, therefore, distributed annual, nominal GDP equally across the four quarters of the year. Given an almost monotonic increase in the price level, this procedure would generally result in higher levels of real income in earlier quarters of the year. This accords fairly closely with the Barbadian experience. Hence, we do not anticipate that errors in the measurement of quarterly GDP would have biased our regression estimates, significantly. However, this is a matter that warrants further investigation.

8.All computations in this study were done using Microfit. The critical values of various statistics reported in the study are those supplied by Microfit.

9.A variable is said to be I(1) (i.e. integrated of order 1) if it has to be differenced once to achieve stationarity. A variable is said to be stationary, if it varies randomly around a constant mean. A variable that is stationary is said to be I(0).

10.The use of eight lags in the VAR for the Johansen procedure should produce better results than a shorter lag length, because of the nature of error pertaining to measurement of quarterly income.

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