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TESTING FOR WEAK EXOGENEITY AND SUPEREXOGENEITY IN MONEY DEMAND FOR SOME CARIBBEAN COUNTRIES

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TESTING FOR WEAK- AND SUPER-EXOGENEITY CONDITIONS OF MONEY DEMAND FUNCTIONS IN SOME CARIBBEAN NATIONS

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Abstract

The paper examines the exogeneity conditions of money demand in Barbados and Jamaica. The results indicate that real income and price in the conditional error correction model (ECM) are weak-form exogenous. The foreign exchange markets are weak-form inefficient in Barbados, and weak-form efficient in Jamaica. The various stability tests indicate that the regression coefficients are constant, while the recursive estimates also indicate that the conditional ECM of money demand are structurally invariant. Thus real income and price are super-exogenous in both countries. The models in both countries are reliable for monetary policy and forecasting.

Keywords: Exogeneity, money demand, Barbados and Jamaica

INTRODUCTION

In econometric estimation of the conventional money demand function it is often not clear whether or not the money stock, price and real income are to be treated as exogenous. This difficulty renders the appropriate use of econometric techniques for estimating the money demand function questionable, which then makes the resulting estimates unreliable for policy analysis and recommendations.

The typical conventional money demand function assumes that explanatory variables such as interest rates, real income, and other related variables are exogenous. Thus the resulting formulated conventional money demand function is estimated by single equation estimating techniques. See Goldfeld (1973), and most of the previous studies in the Caribbean region such as Craigwell (1991). However, studies such as Sims (1972) questions the legitimacy in treating the money stock in the conventional money demand function as endogenous. According to Sims (1972), the real income rather than the money stock is endogenous, while the money stock is exogenous in such models. This means that it is inappropriate to use single equation estimating techniques to estimate the money demand function.

Other studies have also questioned the treatment of money stock as an endogenous variable in a conventional money demand function, but unlike Sims' (1972) study, price is considered to be endogenous, and money stock as exogenous because it is a controllable policy variable. See Cagan (1956), Carr, Darby and Thornton (1985), and Judd and Scadding (1982). However, it must be pointed out that the fact that the money stock is controllable does not mean that it is statistically exogenous. Infact, the money stock exhibits the characteristics of endogeneity more than exogeneity because Central Banks do not have a complete control over it, since the money multiplier which multiplies the monetary base or high-powered money to yield the money supply is endogenously determined by different agents, namely: the banks, nonbanking public, and Central banks. Additionally, although controllability is associated with exogeneity, Engle, Hendry, and Richard (1983) have demonstrated that if monetary aggregates are controllable, it does not mean that they are automatically exogenous.

The controversies surrounding the inadequate knowledge of which variables in conventional money demand function ought to be treated as exogenous or endogenous, have led some economists to suggest that the conventional money demand function must be specified as a complete structural model which incorporates both money demand and supply. In the structural form of such a model, relevent variables such as real income, price, money stock, and interest rates could all be treated as endogenous variables. See Brunner and Meltzer (1969).[1]

Interestingly, as rightly observed by Goldfeld (1973), the long-run estimates from both single and simultaneous equation techniques often yield results which are very similar. Thus the additional cost incurred for rightly modelling and estimating simultaneous equation models does not warrant the extra effort needed to correct the possibility of simultaneous bias which may results from the improper use of single equation estimating techniques.

Notwithstanding the above modelling controversies, variables in the conventional money demand function cannot be arbitrarily treated as exogenous and/or endogenous, because the exogeneity and endogeneity concepts are conditional. It is important to test to validate whether the price and/or real income in conditional money demand function are weak- and super-exogenous. Using appropriate estimating techniques to establish the exogeneity conditions of the

[1]Bourne (1974) and Howard (1980) used simultaneous equation estimating techniques in their studies for Jamaica and Guyana respectively.

model before estimation will lend further confidence in the final use of the resulting estimates for policy analysis. Additionally, when the explanatory variables in the model satisfy the super-exogeneity property, the model automatically will be structurally invariant, and therefore can be used for policy exercises and forecasting without being subjected to the policy deficiencies cited in the Lucas critique.

In the following paper, the exogeneity property of the money demand function is empirically tested in detail for the first time in the Caribbean for Barbados and Jamaica. Note that empirical tests of the exogeneity property of the money demand function are generally very limited as observed by Fisher (1993), and absent in most of the previous studies in the Caribbean region.

Following the introduction, weak-exogeneity, stability of parameters of interest, and super-exogeneity of prices, and real income are discussed in section 2. In section 3, the empirical results designed within an error correction framework are discussed. The paper is concluded with a summary of the basic findings in section 4.

2. WEAK-, AND SUPER-EXOGENEITY

The concepts of weak-exogeneity, constancy, structural invariance, and super exogeneity are defined, discussed and demonstrated in Engle, Hendry, and Richard (1983). For this study we shall employ the concepts by assuming that the long-run conventional money demand function is as follows:

$$m_t = F(p_t, y_t, R_t) + \epsilon_t, \qquad F_p, F_y > 0, \text{ and } F_R < 0 \qquad (1)$$

where

m_t = the narrow nominal money stock/supply (M1)

p_t = the price level measured by the consumer price index (CPI)

y_t = the real income measured by the gross domestic product (GDP)

R_t = the nominal interest rates

ϵ_t = the error term with white noise innovations

Small case letters denote logarithmic form of the variables, and subscript t denotes time period. The information set Λ includes R_t, foreign exchange rates (xr_t), foreign exchange risk ($\hat{\sigma}_t$), other important current variables, and past information on all relevant variables in the entire model.

Suppose equation (1) can be expressed to have the following normal distribution:

$$\begin{bmatrix} m_t \\ p_t \\ y_t \end{bmatrix} / \Lambda \sim N\left(\begin{bmatrix} \mu^m{}_t \\ \mu^p{}_t \\ \mu^y{}_t \end{bmatrix}, \begin{bmatrix} \sigma^{mm}{}_t & \sigma^{mp}{}_t & \sigma^{my}{}_t \\ \sigma^{pm}{}_t & \sigma^{pp}{}_t & \sigma^{py}{}_t \\ \sigma^{ym}{}_t & \sigma^{yp}{}_t & \sigma^{yy}{}_t \end{bmatrix} \right) = N(\mu, \Sigma) \qquad (2)$$

where every mean (μ) and covariances (Σ) are conditioned on information set Λ.

Our money demand function given in equation (1) conditions nominal money stock on prices, real income and other relevant information. Thus we have

$$m_t/z_t, \Lambda_t \sim N[\mu^m{}_t + \delta_t(z_t - \mu^z{}_t), \zeta_t] \qquad (3)$$

where $z_t = (p_t, y_t)$, $\delta_t = \sigma^{mz}{}_t/\sigma^{zz}{}_t$, and $\zeta_t = \sigma^{mm}{}_t - (\sigma^{mz}{}_t)^2/\sigma^{zz}{}_t$. The regression coefficient of m_t on z_t is conditioned on Λ_t, with ζ_t as the conditional variance.

To obtain an equation that relates the conditional means of m_t on z_t to a set of variables $x_t \epsilon \Lambda_t$, with our parameters of interest given as β and γ, our money demand function can be expressed as

$$\mu^m{}_t = \beta\mu^z{}_t + \gamma x_t \qquad (4)$$

where the function is in logarithmic form, and x_t includes other relevant explanatory variables that expresses money demand behaviour in the two countries under study, and β which is the parameters of interest is a function of marginal density of z_t which is denoted by λ_{2t}.

Now by substituting equation (4) into (3), and arranging to obtain the conditional distribution of m_t on z_t we arrive at the following conditional equation:

$$m_t/z_t, \Lambda_t \quad \sim N[\beta_t\mu^z_t + \gamma_t x_t + \delta_t(z_t - \mu^z_t), \zeta_t]$$

$$= N[\beta_t z_t + \gamma_t x_t + (\delta_t - \beta_t)\{z_t - \mu^z_t\}, \zeta_t] \quad (5)$$

For an appropriate regression analysis of $m_t/z_t,\Lambda_t$ that can be used for policy recommendations, z_t must meet both weak- and super-exogeneity properties.

Following Engle and Hendry (1993, p.124), equation 5 can be efficiently estimated if and only if $\beta_t(\lambda_{2t}) = \delta_t$, which implies that μ^z_t, and σ^{zz}_t are excluded from the conditional model. Thus z becomes weak-exogenous for the parameters of interest β and γ. In addition to z_t being weak-exogenous, the regression coefficients δ_t of z_t in equation (3) must be constant such that $\delta_t = \delta\ \forall t$. This condition implies also that the covariances are constant such that $\zeta_t = \zeta\ \forall t$, if $\sigma^{mm}_t = \zeta + \delta\sigma^{zz}_t$. In this study, we have assumed homoscedasticity process to simplify the analysis, although heteroscedasticity process can also be used for the test with some difficulty. See Engle and Hendry (1993).

The super-exogeneity condition of z_t is satisfied if z_t is weak-exogenous, has constant regression coefficients (δ), and finally has invariance parameters of interest (β_t) with respect to policy changes (λ_{2t}). Note that if the parameters of interest are invariant, then although the parameters of interests can vary with time, their variations would be independent of any variations in the marginal density of x_t (λ_{2t}), meaning that there shall be complete absence of cross-restrictions.

In the empirical analysis following, we have used the methods of Wu (1973) and Hausman (1978), and Engle and Granger's (1987) to test for weak-exogeneity of price and real income conditioned on the nominal money stock. Chow's stability and predictive adequacy tests are used to establish the stability of the regression coefficients. The structural invariance of the model which basically involves the ability of the model to predict beyond the sample range of estimation is tested by Brown et al.'s (1975) recursive regression estimates.

Data Source(s)

The main source of data is various issues of International Financial Statistics published by the International Monetary Fund. The quarterly data of the GDP is generated from its annual series. See Diz (1970).

3. DISCUSSION OF THE ESTIMATED RESULTS

The stationarity properties of the variables are tested by the GLS estimates from a response surface regressions which relate the critical values to the sample sizes. See MacKinnon (1991). The unit root test results are reported in Table 1. The results of the Dickey-Fuller (DF) and augmented DF (ADF) tests with lag-length of four indicate that with the exception of the level form exchange rates in Barbados, none of the level form variables are significant at a 0.05 level for both cases with and without a trend in both Barbados and Jamaica. However, all of the first difference form of the variables are significant at a 0.05 level for both cases with and without a trend in both countries.

The results of the exchange rates indicate that the foreign exchange market is weak-form inefficient in Barbados, but weak-form efficient in Jamaica as the level form of the exchange rates are stationary in Barbados while exhibiting random walk behaviour in Jamaica.

The Error Correctiom Model

The general formulation of the conditional process of the error correction model (ECM) of the money demand function is

$$\Delta m_t = \eta_0(L)\Delta p_t + \eta_1(L)\Delta y_t + \eta_2(L)\Delta r_t + \eta_3(L)\Delta xr_t + \eta_4(L)\Delta\sigma^2_t$$
$$+ \tau_0 + \tau_1 EC_{t-1} + \tau_2 s1 + \tau_3 s2 + \tau_4 s4 + \xi_t \qquad (6)$$

where $EC_{t-1} = m_t - \alpha_0 - \alpha_1 p_t - \alpha_2 y_t - \alpha_3 r_t - \alpha_4 xr_t - \alpha_5 \sigma^2_t$, L denotes a lag operator such that $Ly_t = y_{t-1}$, and $L^n y_t = y_{t-n}$. The error correction term (EC_t) above is used for Jamaica with $\tau_2 = \tau_3 = 0$, while the restrictions $\alpha_1 = \alpha_2 = 1$, and $\alpha_3 = \alpha_4 = \alpha_5 = 0$ are imposed for Barbados with $\tau_4 = 0$. The a priori expectations are as follows: $\eta_0(1)$ and $\eta_1(1) \geq 0$, and $\eta_2(1)$ and $\eta_3 \leq 0$. The rest of the parameters can assume any signs and still be plausible and consistent with economic theory. For a dynamic stability and cointegration, $-1 \leq \tau_1 < 0$. The lag lengths of the polynomials are restricted to a maximum of four because the study employs quarterly series.

The results of the ECM derived from Hendry's general-to-specific modelling procedure are reported in Table 2 for the change in nominal money stock (Δm_t), and inverted equations for change in price (Δp_t) and real income (Δy_t). All a priori expectations hold true as specified in equation (6). The significance of the coefficients of EC_{t-1} term confirm the existence of cointegration in both Barbados and Jamaica. See Engle and Granger (1987), and Banerjee et al. (1993).

The OLS estimation results of the ECM of the conditional money demand in both countries are robust and have signs that conform to a priori expectations. There are no serial

Table 1: Univariate unit root tests, 1962.1-1995.3

	Barbados		Jamaica		Barbados		Jamaica	
	With Trend				Without Trend			
Vars.	DF	ADF.4	DF	ADF.4	DF	ADF.4	DF	ADF.4
m	-1.33	-0.82	-0.46	-0.64	-1.48	-2.23	2.47	2.01
y	-0.69	-1.38	-1.06	-1.65	-4.42	-3.65	-1.09	-1.54
p	-2.27	-3.61	-0.22	-1.06	-6.63	-3.74	6.28	2.15
r	-2.03	-3.02	-2.20	-1.43	-1.99	-2.98	0.10	1.05
xr	-6.94	-4.27	-1.13	-2.04	-7.11	-4.47	1.77	0.28
σ^2	---	---	0.79	-3.00	---	---	1.68	-2.73
Δm	-9.73	-4.21	-11.6	-5.01	-9.32	-3.24	-11.0	-4.29
Δy	-5.54	-3.93	-7.12	-3.17	-4.63	-2.66	-7.14	-3.20
Δp	-8.18	-3.47	-5.02	-4.19	-8.00	-3.13	-4.16	-3.21
Δr	-5.43	-5.11	-7.47	-7.23	-5.46	-5.14	-7.49	-7.01
Δxr	10.51	-4.54	-7.44	-4.33	10.43	-4.43	-7.28	-4.13
$\Delta\sigma^2$	---	---	-5.97	-3.98	---	---	-5.89	-3.78

Notes: The first difference operator is represented by Δ. All of the variables (Vars.) except xr_t are integrated of degree unity I(1). The absolute form of MacKinnon's 95 percent confidence values obtained from surface response GLS estimates for the Dickey-Fuller (DF) and augmented DF (ADF) are 3.4 and 2.9 respectively.

The fourth order ADF test statistic is given by the t-ratio of φ_2 in the ADF regression with trend

$$\Delta h_t = \varphi_0 + \Delta_1 t + \varphi_2 h_{t-1} + \Sigma\kappa_j \Delta h_{t-j} + v_t, \ \forall j \epsilon [1,4]$$

The DF test is achieved by setting κ:s $= 0$ so that there are no augmentations, and the DF and ADF tests without trend is achieved by setting $\varphi_1 = 0$. The t-ratio of $\varphi_2$if it is negative and significant implies that there are no unit root in h_t.

Table 2: OLS estimates of the ECM of Δm., and inverted equations Δp. and Δy..

Regres.	Barbados Δm_t	Δp_t	Δy_t	Jamaica Δm_t	Δp_t	Δy_t
Const.	-0.448	6.219	0.216	-0.023	0.034	0.024
	[3.193]	[1.351]	[2.815]	[2.146]	[14.895]	[9.355]
Δp_t	0.006		-0.008	1.014		-0.630
	[1.723]		[4.464]	[4.237]		[11.05]
Δy_t	0.454	-26.378		0.908	-0.804	
	[2.199]	[4.464]		[3.269]	[11.05]	
Δm_t		6.045	0.132		0.129	0.091
		[1.723]	[2.199]		[4.237]	[3.269]
Δxr_t				-0.146	0.121	0.048
				[2.046]	[5.141]	[2.139]
Δr_t	-0.009	0.240	0.003	-0.007	0.008	-0.001
	[1.478]	[1.265]	[1.011]	[2.676]	[0.872]	[0.107]
$\Delta\sigma^2_t$				0.002	0.006	0.002
				[2.682]	[2.495]	[1.030]
EC_{t-1}	-0.220	1.998	0.101	-0.202	0.071	0.057
	[3.101]	[0.854]	[2.611]	[3.758]	[3.702]	[3.327]
s4				0.107	-0.010	-0.005
				[8.665]	[1.772]	[0.979]
s2	0.034	-0.461	-0.004			
	[2.225]	[0.948]	[0.526]			
s1	0.064	-1.294	0.002			
	[3.906]	[2.394]	[0.249]			
$\chi^2_{SC}(4)$	0.227	6.993	8.347	1.840	58.889	41.716
$\chi^2_{FF}(1)$	0.010	0.551	1.732	0.054	1.396	7.457
$\chi^2_N(2)$	3.717	3.285	57.252	0.022	20.225	2.782
$\chi^2_H(1)$	1.168	0.238	10.190	0.137	0.737	34.166
$\chi^2_{SIV}(1)$						
R^2	0.270	0.23	0.268	0.498	0.711	0.539
DW	1.978	1.516	1.300	1.868	0.931	1.047
RSS	0.242	235.442	0.070	0.402	0.051	0.040

Notes: Lagrange multiplier test of residual serial correlation is χ^2_{SC}, Ramsey reset test of functional form using the square of fitted values is χ^2_{FF}, normality test based on skewness and kurtosis of residuals is χ^2_N, heteroscedasticty test based on the regression of squared residuals of squared fitted values is χ^2_H. RSS is the residual sum of squares, s1, s2, and s4 are seasonal dummies for the first, second and fourth quarters respectively. The t-ratios and degrees of freedom are in the square brackets and parentheses respectively.

correlation and heteroscedasticity problems, and the functional forms are well specified and normal. White's (1980) test for general forms of heteroscedasticity which require no specification of the nature of the heteroscedasticity is used.[2] The adjusted coefficients of determination (R^2) are greater than the Durbin-Watson (DW) statistics which lend credence to the absence of spurious results.

The coefficients of EC_{t-1} in the change in money demand of the conditional process are -0.22 and -0.20 in Barbados and Jamaica respectively, an indication of relatively slow adjustment, and they are both significant at a 0.05 level. These results compare favourably with the studies of other countries while contrasting sharply with Craigwell's (1991) results in Jamaica which ranges from about sixty-five percent to ninety-five percent. See Domowitz and Elbadawi (1987, pp.264, 266), and Huang (1994).[3]

The Exogeneity Test

Weak-exogeneity of price and real income is tested by examining the coefficients of EC_{t-1} in the inverted price and real income equations derived from the conditional money demand ECM of equation (6). The results reported in Table 2 in both countries show that the coefficients of EC_{t-1} in both inverted price and real income equations have the wrong signs, although both inverted equations are significant and maintained satisfactory functional forms.

The results of the estimates signalled mild heteroscedasticity but severe serial correlation

[2]Craigwell (1991, p.29) could not use the general form of White's (1980) heteroscedasticity test because his sample size was under-sized. For Craigwell's method see Domowitz and Elbadawi (1987, p.265).

[3]Engle and Hendry (1993, pp.133, 136) obtained EC_{t-1} term that ranges from -0.10 to -0.08 for similar studies in the U.K.

problems. As a results, we employed dynamic OLS (DOLS) technique developed by Newey and West (1987) which uses adjusted standard errors with twelve truncation lags and Parzen's weight to resolve both the serial correlation and heteroscedasticity problems. It is clear from the results in Table 2 that the inverted price and real income equations are not cointegrated, while the money demand equation is. Thus confirming that neither price nor real income are endogenous in both countries. See Engle and Granger (1987).

We have also employed the method of Wu (1973) and Hausman (1978) to test for weak-exogeneity, and power of exogeneity. The instruments for estimating Δp_t are Δp_{t-2}, Δm_{t-1}, Δr_{t-1}, s1 and s2, and that of estimating Δy_t are Δy_{t-1}, Δr_{t-1}, Δm_{t-1}, Δy_{t-3}, s2 and s1 in Barbados. In the case of Jamaica, the instruments for estimating Δp_t and Δy_t are Δp_{t-1}, Δp_{t-2}, Δy_{t-1}, Δy_{t-2}, Δm_{t-1}, Δm_{t-2}, and s4. The residuals calculated from the regression equations Δp_t and Δy_t above are $\Delta p_{\epsilon t}$ and $\Delta y_{\epsilon t}$ respectively for both countries. The results of the estimates of the ECM with joint test of zero restrictions on the coefficients of $\Delta p_{\epsilon t}$ and $\Delta y_{\epsilon t}$ as measured by the LM-test. LR-test, and F-test are reported in Table 3. The joint test of restrictions on the coefficients of $\Delta p_{\epsilon t}$ and $\Delta y_{\epsilon t}$ are insignificant in both countries. Thus indicating that both price and real income are weak-exogenous in both countries.

The power of weak exogeneity was tested by replacing Δp_t and Δy_t of the conditional equation of Δm_t in both countries by $\Delta p_{\epsilon t}$ and $\Delta y_{\epsilon t}$, respectively. The results reported in Table 3 show that the coefficients of $\Delta p_{\epsilon t}$ and $\Delta y_{\epsilon t}$ are significant at a 0.05 level in Jamaica, and at a 0.10 level in Barbados. Thus confirming that the exogeneity tests have power in both countries.

Comprehensive Stability and Super-Exogeneity Tests

The stability of both parameters and equations are crucial in formulating and implementing macro-economic policies, particularly for small island economies that underwent drastic structural, economic and political changes in the mid 1970s, late 1980s and early 1990s.

We have employed both Chow's (1960) test which is more powerful if the date of the structural break is known, and Brown et al.'s (1975) structural stability test which is based on the ability of the model to predict outside the sample range of estimation. In the Chow test, we have used two dates to split the sample size in both countries. In Jamaica, we used 1977 which marked the date of the adoption of the IMF policies, and 1989 which marked the end of Seaga's decade of JLP government, and the return of Michael Manley's PNP to power when the country adopted a full-fledged World Bank and IMF's liberalization and privatization policies. In Barbados, we use 1986 and 1990 as the strucural break points. The 1986 marked the institutionalization of bargaining and contracting mechanisms in the economy to fix wages in the labour market, while 1990 was the year the severe short-fall in foreign exchange in the country was resolved by rationing foreign exchange among banks with the Central Bank adopting a hands-off position.

The Chow tests of stability of the regression coefficients of the conditional ECM of equation Δm_t in Barbados are $F(7, 69) = 1.466$ over the period 1974.1-1986.4, and $F(7, 69) = 1.095$ over the period 1974.1-1990.4, and in Jamaica are $F(8, 111) = 0.904$ over the period 1962.2-1989.4, and $F(8, 111) = 1.414$ over the period 1962.2-1977.4, and neither can be rejected even at a 0.10 significant level. Thus, the results firmly indicate that the regression coefficients are stable.

The goodness-of-fit of the ECM of equation Δm_t in both countries are tested further by employing out-of-sample forecasting performance as a criterion. The adequacy of prediction tests

Table 3: Weak-exogeneity and Power of Exogeneity test results of Δp_t and Δy_t conditional on Δm_t

	Weak-Exogeneity		Power of Exogeneity	
Variables	Barbados	Jamaica	Barbados	Jamaica
Δp_t	-0.004	0.901		
	[0.382]	[3.542]		
Δy_t	0.750	0.402		
	[1.352]	[0.687]		
Δr_t	-0.005	-0.007	-0.008	-0.007
	[0.730]	[2.753]	[1.324]	[2.597]
Δxr_t		-0.146		-0.067
		[1.981]		[0.923]
$\Delta \sigma^2_t$		0.002		0.003
		[2.575]		[4.240]
EC_{t-1}	-0.204	-0.192	-0.209	-0.152
	[2.839]	[3.506]	[2.914]	[2.765]
s4		0.105		0.110
		[8.171]		[8.433]
s2	0.029		0.033	
	[1.920]		[2.190]	
s1	0.042		0.065	
	[1.926]		[4.190]	
Δp_{et}	0.012	0.448	0.007	0.865
	[0.980]	[1.216]	[1.907]	[2.364]
Δy_{et}	-0.374	0.784	0.394	0.753
	[0.624]	[1.225]	[1.757]	[2.262]
intercepts	-0.390	-0.015	-0.413	0.016
	[2.666]	[1.274]	[2.923]	[2.379]
R^2	0.270	0.498	0.260	0.450
DW	1.859	1.894	1.905	1.793
$\chi^2_{SC}(4)$	1.515	1.875	0.621	2.362
$\chi^2_{FF}(1)$	0.000	0.255	0.287	0.560
$\chi^2_{N}(1)$	4.873	0.185	3.043	1.100
$\chi^2_{H}(1)$	1.504	0.211	1.426	0.018
Joint test of zero restrictions on the coefficients of additional variables.				
$\chi^2_{LM}(2)$	2.381	2.313		
$\chi^2_{LR}(2)$	2.416	2.334		
F	1.093	1.085		

Notes: See Table 2.

are F(16, 103) = 1.244 using sixteen observations covering 1990.1-1993.4, and F(64, 55) = 1.444 using sixty-four observations covering 1978.1-1993.4 in Jamaica. In Barbados, the results are F(31, 45) = 0.762 covering the period 1987.1-1994.3, and F(15, 61) = 0.820 covering the period 1991.1-1994.3. In both countries the null hypothesis of adequate prediction cannot be rejected even at a 0.10 significant level.

The root mean sum of squares of predictive errors are 0.074 from 1990.1-1993.4, and 0.263 from 1978.1-1993.4 in Jamaica; and 0.060 from 1987.1-1994.3, and 0.058 from 1991-1994.3 in Barbados. Thus the out-of-sample forecasting performance of the model in both countries are excellent.

The structural stability of both equations and parameters have been tested by using two different dates to split the sample sizes in both countries. However, it is possible that other dates could be used as well as structural break points. For instance, 1973 and 1978 which were marked by the price hikes of the Oil and Petroleum Exporting Countries (OPEC), and short-fall in agricultural products world-wide due to poor weather which resulted in internationally transmitted inflation could be used as 'structural' break points.[4] Notwithstanding the different impact of the international transmitted inflation, and natural disasters that had plagued the region over the years, we decided to use an alternative stability tests for the study which do not require a definite knowledge of specific dates when structural break occurred, namely: the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests of structural stability. We have reported the CUSUMSQ test of recursive residuals in both countries by plotting it against

[4]We note though that it has been argued elsewhere that Barbados weathered the ill-effects of the international transmitted inflation by adopting appropriate economic policies during the 1970s. See Worrel (1996).

time because it is more robust. See Figures 1 and 2. In both countries, the CUSUMSQ of equation Δm_t are within the 95 percent boundaries, which mean that there are neither systematic changes nor sudden departures from constancy of the regression coefficients. The CUSUMSQ test of inverted equation Δp_t shown in Figures 3 and 4 for Barbados and Jamaica respectively, and that of inverted equation Δy_t shown in Figures 5 and 6 for Barbados and Jamaica respectively are unstable. Thus inverted equations Δp_t and Δy_t exhibit systematic changes and sudden departures from constancy of the regression coefficients.

The ECM of the conditional equation Δm_t is used to establish super-exogeneity conditions of Δp_t and Δy_t by recursively estimating the coefficients on Δp_t and Δy_t in equation Δm_t in both countries. See Figures 7 and 8 for Barbados and Jamaica respectively on Δp_t, and Figures 9 and 10 for Barbados and Jamaica respectively on Δy_t. It is clear from Figures 7, 8, 9, and 10 that the coefficients of the recursive estimates of regressors Δp_t and Δy_t are stable.

The recursive estimation of the coefficients on Δm_t in the inverted model for Δp_t and Δy_t in Barbados are in Figures 11 and 12 respectively, while in Jamaica the same Δp_t and Δy_t are in Figures 13 and 14 respectively. In all cases for both countries, the recursive coefficients on Δm_t are unstable.

For further validation of the structural invariance of the conditional ECM of Δm_t relative to inverted equations Δp_t and Δy_t, we used 1990 and 1989 as structural break points for Barbados and Jamaica respectively. The out-of-sample predictive adequacy tests for inverted equation Δp_t are $F(15, 61) = 2.267$ over 1991.1-1994.3 for Barbados, and $F(16, 104) = 6.536$ over 1990.1-1993.4 for Jamaica, while similar tests for inverted equation Δy_t are $F(15, 61) = 4.730$ for Barbados, and $F(16, 104) = 3.571$ for Jamaica. In all of the cases for both countries, the out-of-sample predictive adequacy tests are rejected at a 0.01 significant level. Thus the empirical tests confirm clearly that price and real income are super-exogenous in the conditional ECM of equation Δm_t for both countries.

4. CONCLUSION

The conditional ECM of money demand is well estimated for both countries as evidenced by the insignificant functional form and normality tests. There are no serial correlation and heteroscedasticity problems in both studies.

The DF and ADF tests clearly signal that the level form foreign exchange rates are stationary in Barbados, while exhibiting random walk behaviour in Jamaica. Thus, the FEM is weak-form inefficient in Barbados, and weak-form efficient in Jamaica.

The methods of Wu (1973), Hausman (1978), and Engle and Granger (1989) tests show price and real income to be weak-form exogeneous in the conditional ECM of money demand in both countries. However, the power of exogeneity is stronger in Jamaica than Barbados as evidenced by their different significance levels.

The CUSUM and CUSUMSQ tests of recursive residuals indicate that the parameters of the conditional ECM of money demand are stable or 'constant' in both countries, although only the CUSUMSQ tests are reported in the study. Additionally, the out-of-sample predictive adequacy tests also confirm that the ECM of Δm_t in both countries are structurally invariant.

Further tests from the estimated recursive coefficients of Δp_t and Δy_t in the conditional ECM of Δm_t show that the parameters are more stable relative to the recursive estimated coefficients of Δm_t in the inverted equations Δp_t and Δy_t respectively for both countries. However, the results are more clearer for Jamaica than Barbados. Thus the structural invariance of the conditional ECM of money demand is more definitive for Jamaica than Barbados. Notwithstanding, we can safely conclude that real income and price in the conditional money demand functions in both countries are weak-form exogenous, and have power. The conditional ECM of money demand in both countries also have structurally invariant parameters. Finally, real income and prices are super-exogeneous in both countries, especially for Jamaica. The conditional ECM of money demand in both countries can be relied upon for monetary policy and forecasting.

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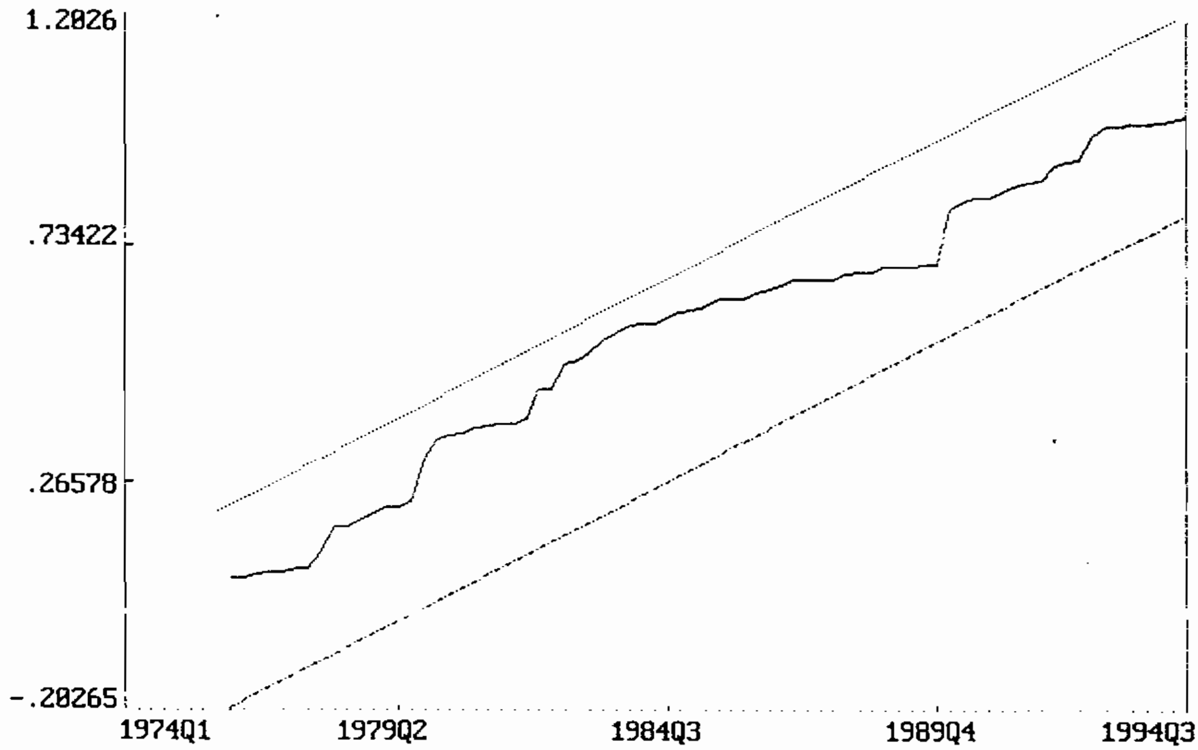
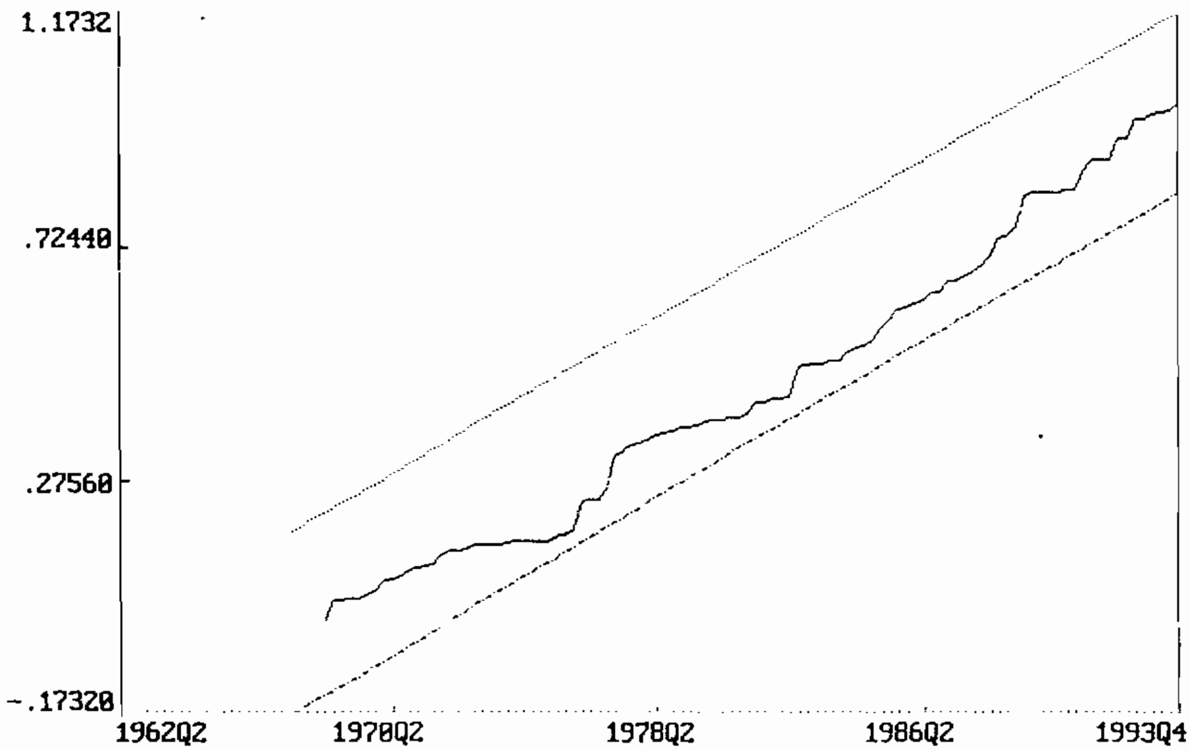
APPENDIX

Figure 1: The CUSUMSQ of recursive residuals of ECM of eqn. M for Barbados



The straight lines represent critical bounds at 5% significance level

Figure 2: The CUSUMSQ of recursive residuals of ECM of eqn. M for Jamaica

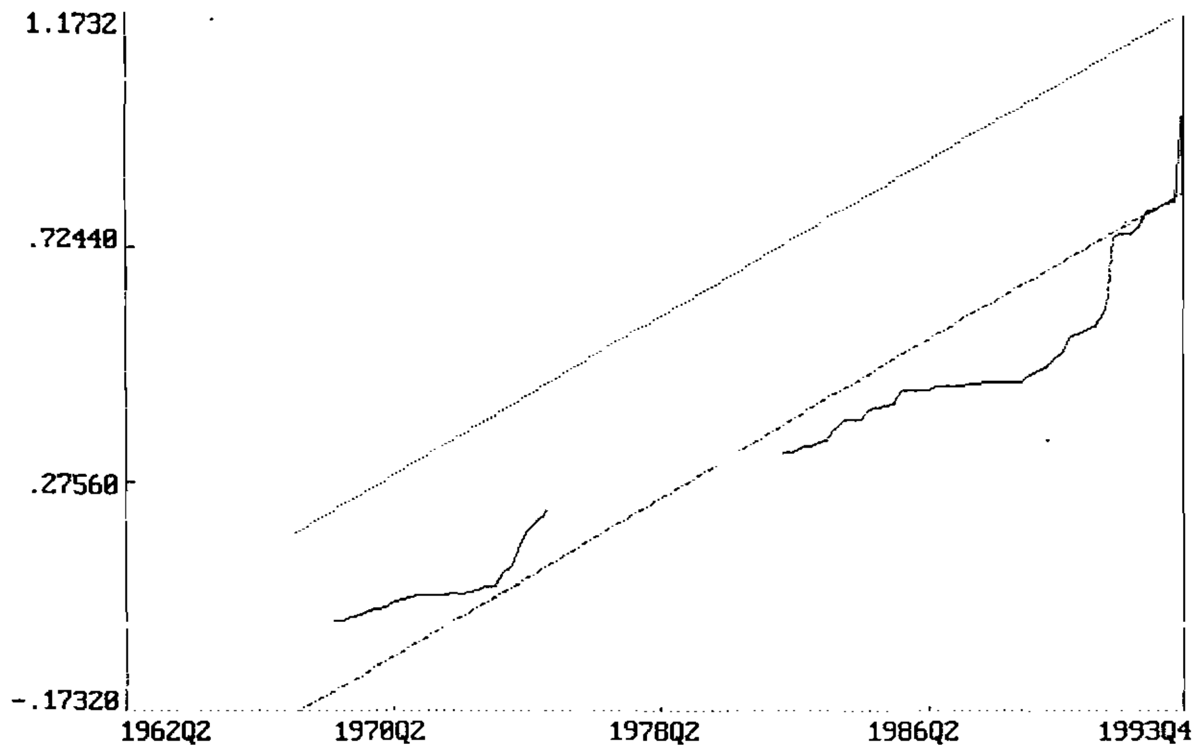


The straight lines represent critical bounds at 5% significance level

Figure 3: The CUSUMSQ of recursive residuals of ECM of eqn. P for Barbados

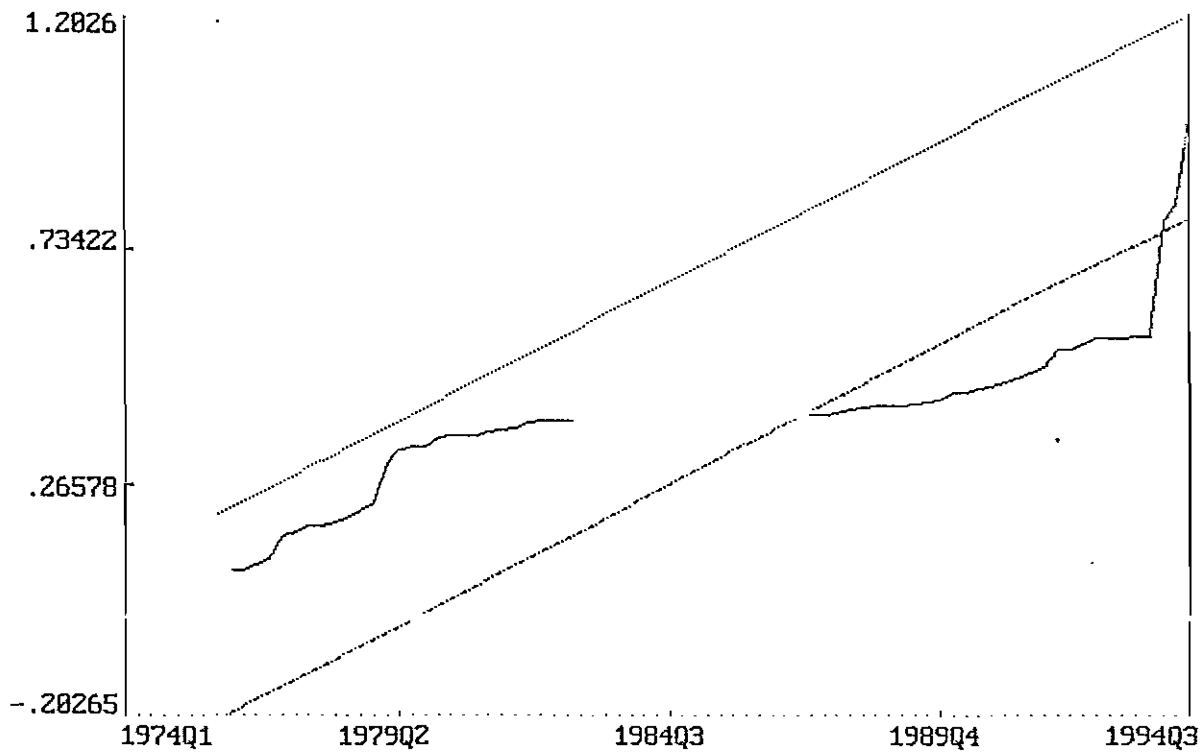
The straight lines represent critical bounds at 5% significance level

Figure 4: The CUSUMSQ of recursive residuals of ECM of eqn. P for Jamaica



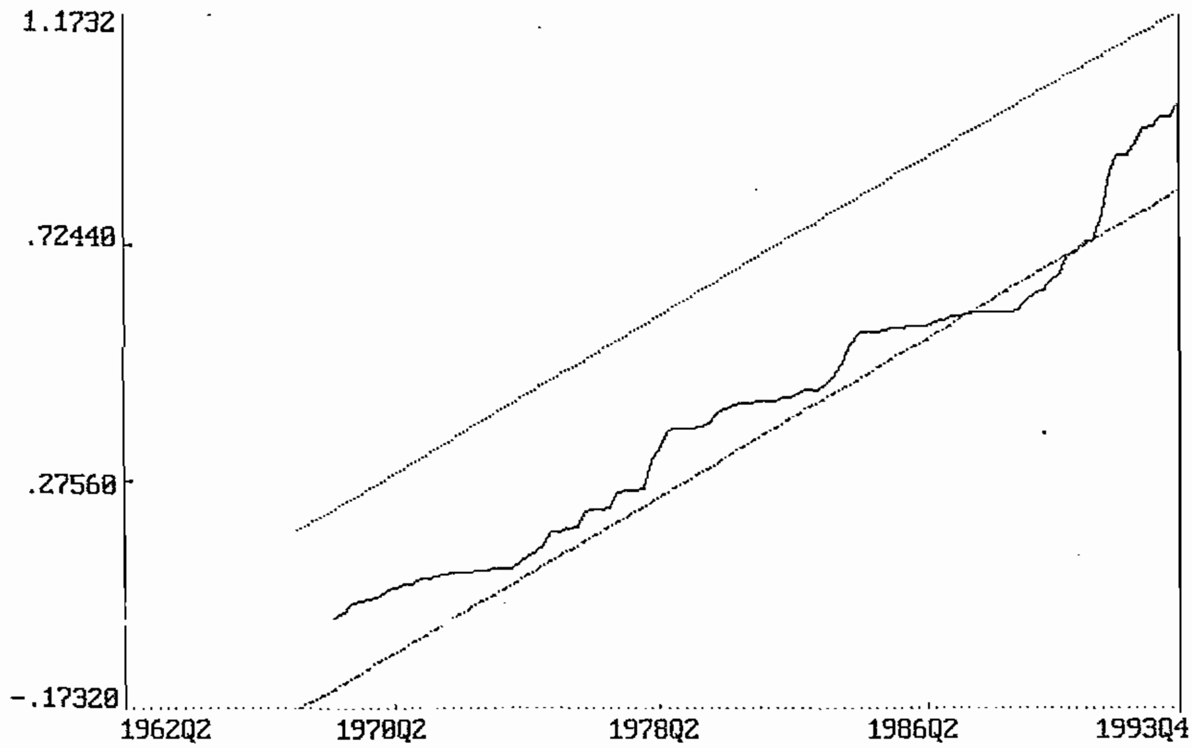
The straight lines represent critical bounds at 5% significance level

Figure 5: The CUSUMSQ of recursive residuals of ECM of eqn. Y for Barbados



The straight lines represent critical bounds at 5% significance level

Figure 6: The CUSUMSQ of recursive residuals of ECM of eqn. Y for Jamaica



The straight lines represent critical bounds at 5% significance level

Figure 7: The coef. of P in ECM of the conditional money demand equation and its 2 standard errors (S.E.) bands based on recursive OLS for Barbados

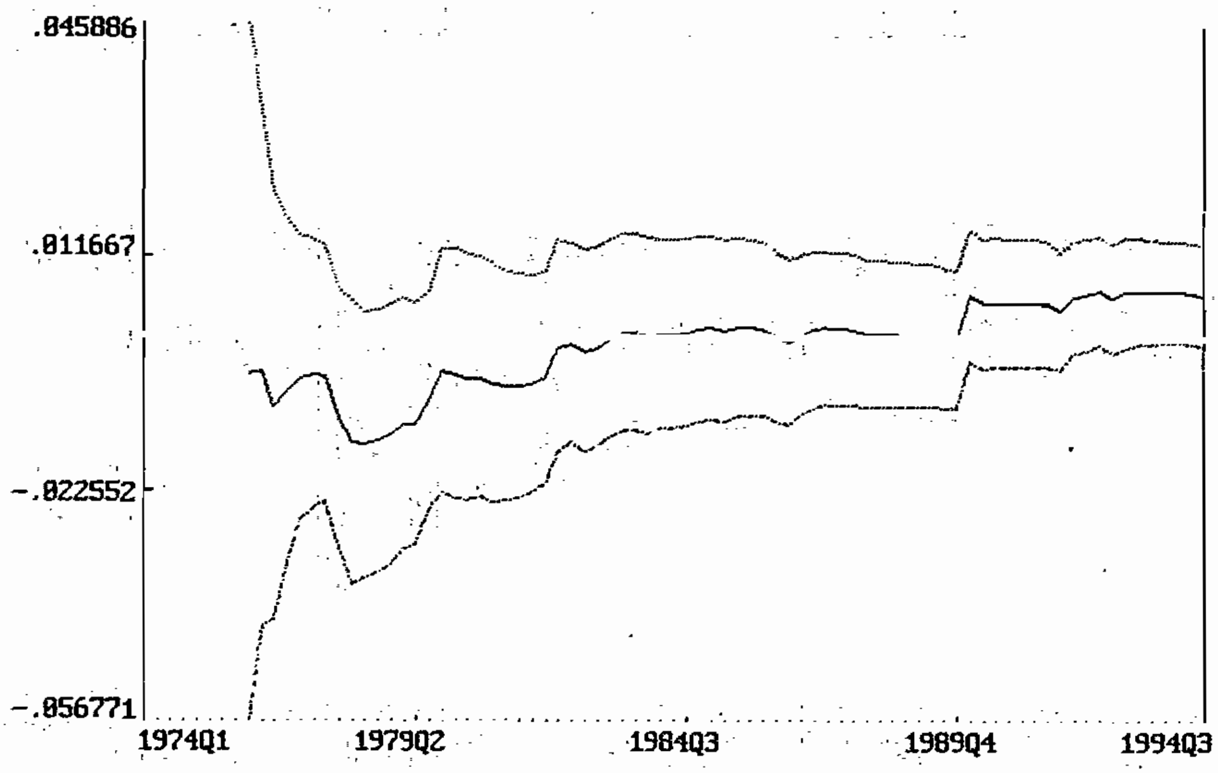


Figure 8: The coef. of P in ECM of the conditional money demand equation and its 2 standard errors (S.E) bands based on recursive OLS for Jamaica

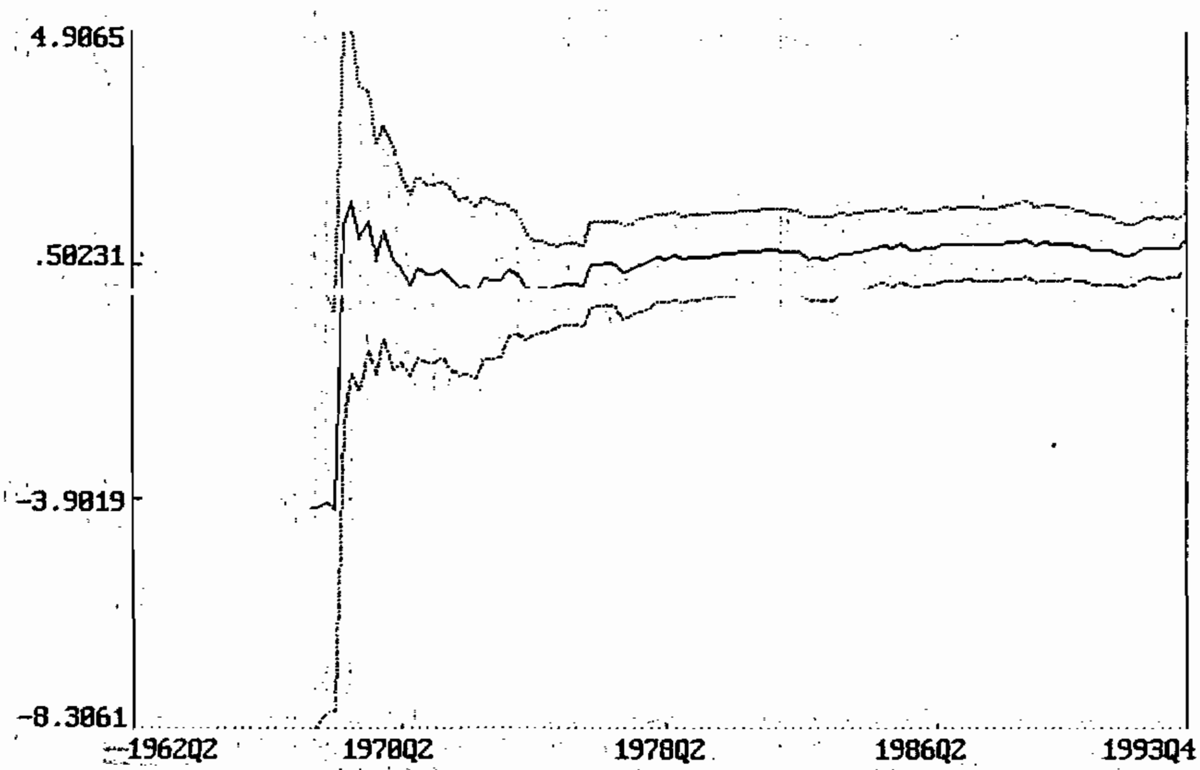


Figure 9: The coef. of Y in ECM of the conditional money demand equation and its 2 S.E. bands based on recursive OLS for Barbados

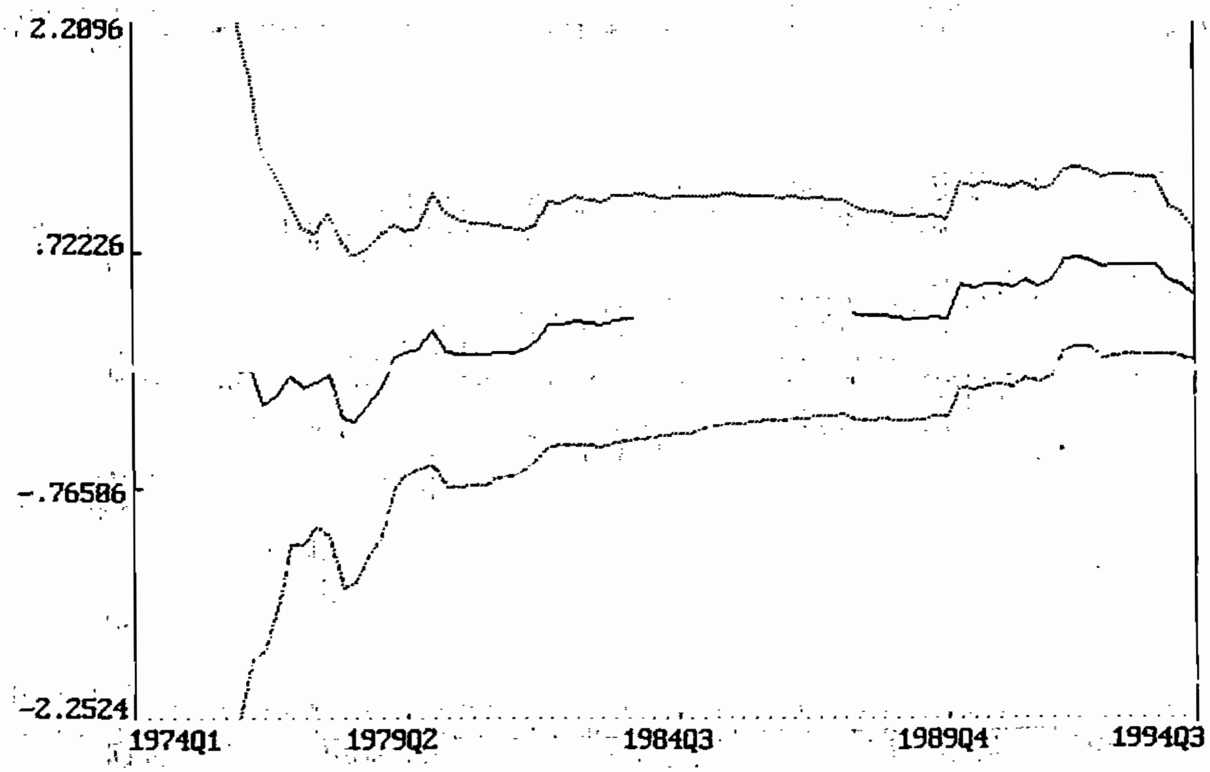


Figure 10: The coef. of Y in the ECM of the conditional money demand equation and its 2 S.E. bands based on recursive OLS for Jamaica

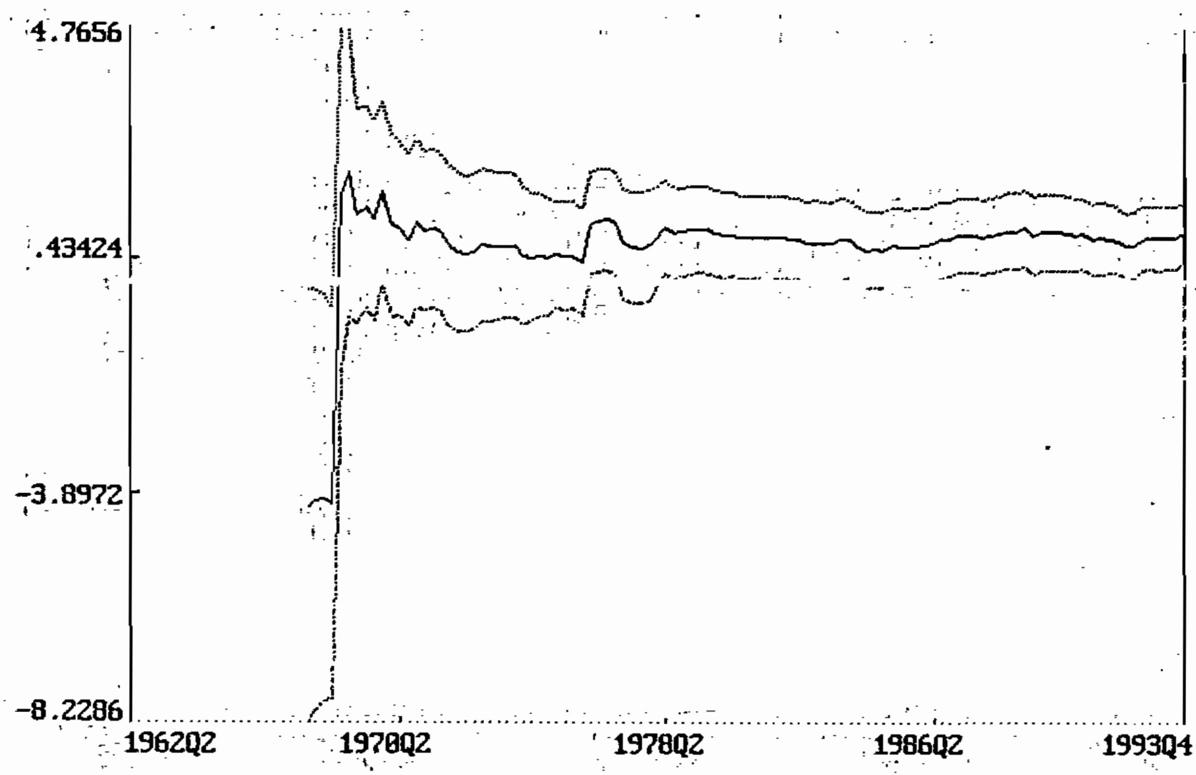


Figure 11: The coef. of M in inverted equation for P and its 2 S.E. bands based on recursive OLS for Barbados

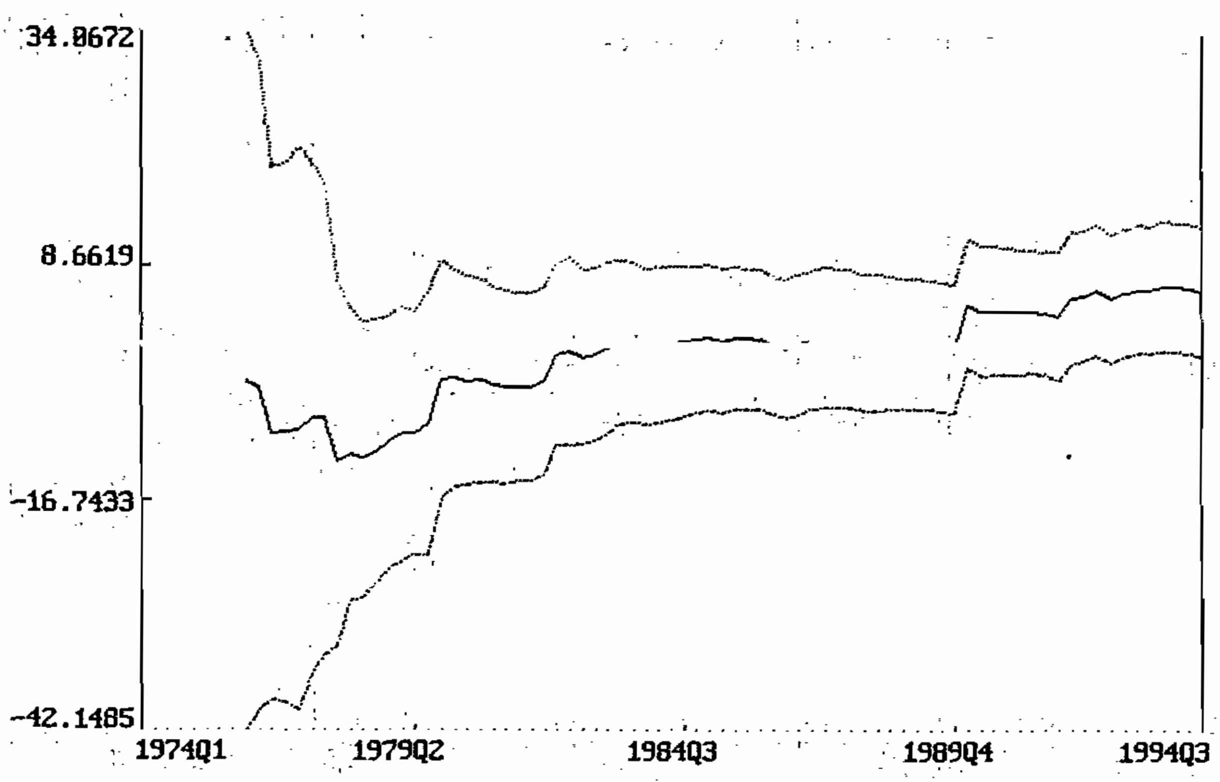


Figure 12: The coef. of M in inverted equation for Y and its 2 S.E. bands based on recursive OLS for Barbados

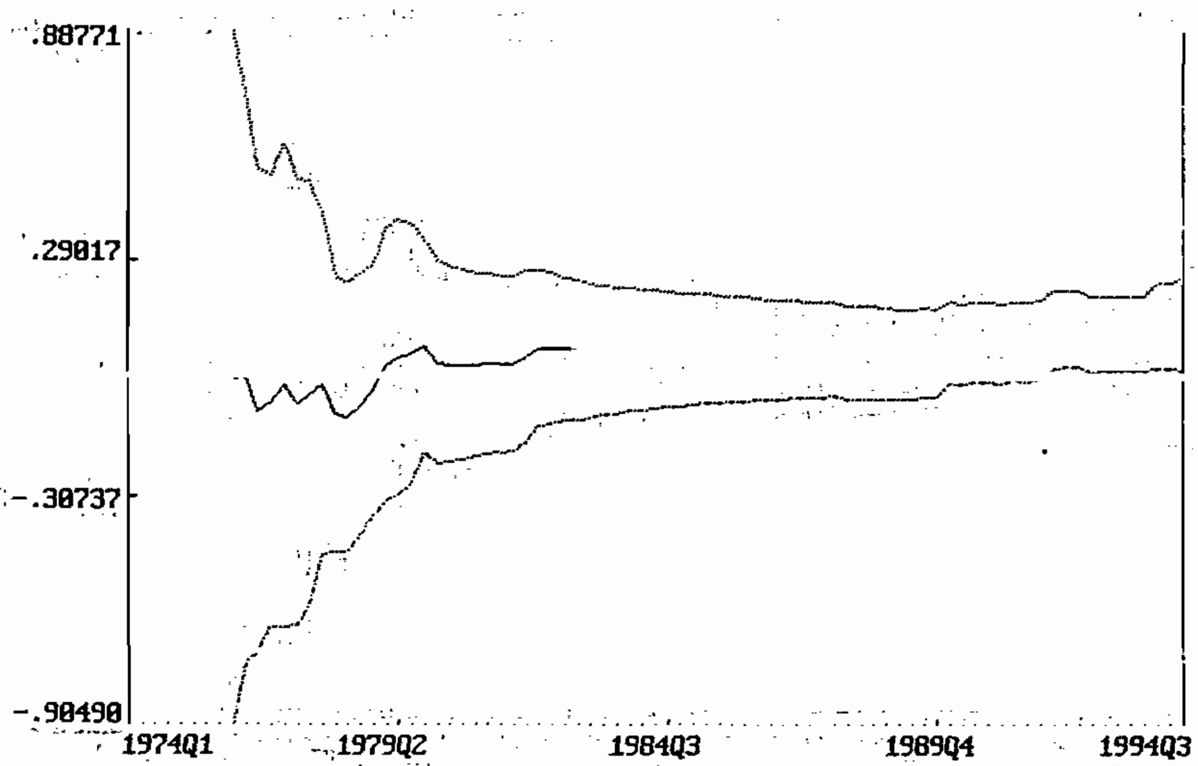


Figure 13: The coef. of M in inverted equation for P and its 2 S.E. bands based on recursive OLS for Jamaica

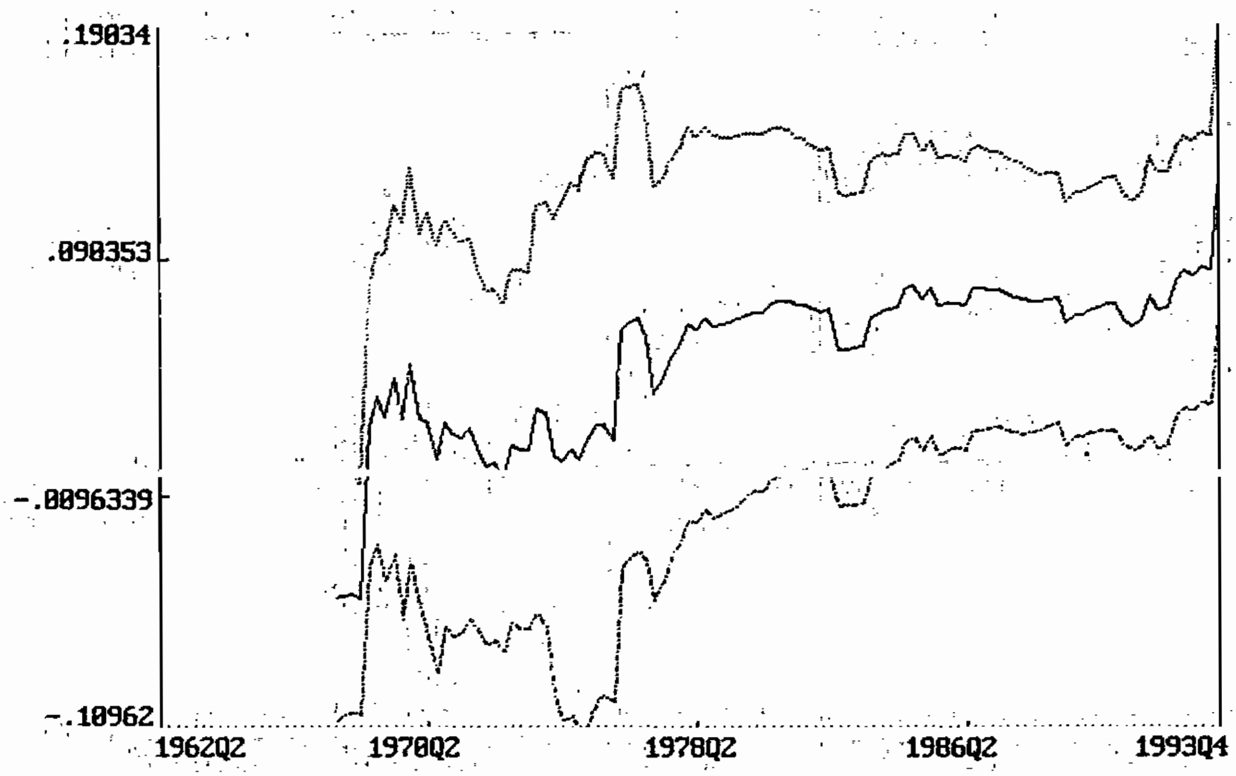


Figure 14: The coef. of M in inverted equation for Y and its 2 S.E. bands based on recursive OLS for Jamaica