A VAR ANALYSIS OF CROSS COUNTRY MONETARY SPILLOVER EFFECTS: THE CASE OF BARBADOS AND THE US

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Abstract

This paper attempts to provide an empirical assessment of the cross country spill over effects from the US to the Barbadian economy. These effects are measured with regard to movements in real money balances, real output, and interest rates. Vector autoregressions, along with impulse response functions and Granger Causality are used to identify both the long run and short run responses of the Barbadian economy to changes in output, money and interest rates in the US. The results indicate that changes in US interest rates may have a negative effect on the Barbadian economy while changes in US money balances could have a positive long run effect.

I. Introduction

Barbados, with its population of 259, 000, and an area of 430 square kilometres is one of the smaller and more open economies in the world. These characteristics make it extremely susceptible to external shocks. One only has to examine Barbados' history over the last twenty five years to appreciate the vulnerability of the island. The 1974-75 recession, one of the earliest on record, was initiated by the oil-shock in 1973. This, along with the sharp increase in indirect taxes due to the implementation of the Common External Tariff led to a hike in prices and subsequently, higher unemployment and a contraction in output. Haynes (1997) notes that the second recorded recession took place during 1981-82 and although this was again fuelled by an oil shock, contractionary measures by industrialised countries helped to precipitate the downturn. The third, and most recent recession took place between 1990 and 1992. A substantial decline in investment, coupled with slow growth and a fall off in tourism were the main factors responsible for the downturn in the economy.

Despite the negative outcomes which have occurred as a result of shocks to external economies, few researchers have attempted to model the spillover effects to Barbados. This paper attempts to fill the gap in the research by empirically examining the effects that changes in US output, real money balances and interest rates can have on the Barbadian economy. Although some economists may argue that it is possible to intuitively determine the impact that changes in outside economies could have on Barbados, mathematical research is nevertheless important as it can serve to (i) validate this intuition, and (ii) provide a more precise estimation of the magnitude and time frame within which we can expect spillovers, thereby allowing decision makers to formulate more effective policies.

In the following section, a brief review of the literature, both empirical and theoretical is undertaken. This search leads to the specification of a money demand model which posits a stable long run relationship between real money balances, real income and interest rates. The variables are tested for Granger causality and the existence of a cointegrating relationship using the methodology developed by Johansen (1988) and Johansen and Juselius (1990). Next, impulse response functions of the VAR are constructed to derive the short run and long run patterns of shocks to the system of variables. The following sections report on implications of the results, and finally, some conclusions are drawn.

II. Literature Review

An analysis of the prevailing Caribbean literature has revealed that there is a paucity of research on the spillover effects to Caribbean countries from monetary shocks to external economies. Indeed, most of the work to date has focused on the uses of monetary policy and the effects that these policies have had within specific Caribbean countries. In the following paragraphs, a brief review of the existing work in other international economies will be conducted, and the theoretical foundation on which the paper is based will be examined.

Some of the earliest theoretical research on the international transmission of monetary influences dates back to Hamada (1976), who postulated that monetary policies selected without taking into consideration the policies of other external economies would not be optimal. He later extended this analysis (Hamada (1985))to accommodate both fixed and floating exchange rate regimes with the same results.

Kimbrough (1993) used a hypothetical two country model with flexible exchange rates to determine how changes in world economic conditions change equilibrium positions when cross country interdependencies exist. He noted that given other countries' policies, unanticipated changes in tastes and technology will alter the macroeconomic policies of all countries in the world economy due to economic interdependence among them. As a result of this policy interdependence, Kimbrough postulated that initial policy changes in one country would give rise to additional shifts in monetary and fiscal policies in the second country, which may in turn affect the original policies adopted by the first country. This process was expected to continue until a new equilibrium set of policies is attained.

Laufer and Sundararajan (1994) examined the international transmission of economic disturbances between Germany, France and the US. The results suggested that an increase in output from either Germany or France would have a negative effect on US output. Despite this contraction in US output, overall output of the world economy was still expected to be expansionary. The authors also found that the fixed exchange rate regime served as an important tool for dampening the impact of US shocks in outputin Germany and France.

More recently, Bartolini and Drazen (1997) theorised that when international interest rates are low, emerging markets experience a capital inflow and engage in widespread policy of free capital mobility. However, in the presence of higher world interest rates, the authors postulate that only sufficiently committed countries allow free capital mobility, whereas others impose controls to trap capital onshore, thereby signaling future policies affecting capital mobility.

Empirically, Mixon, Pratt, and Wallace (1979) used the VAR framework to examine the spillover effects of changes in US money on output in the UK. Their study had two main objectives:

i. To test the hypothesis that US money affects UK income under fixed rates, and
ii To determine whether the causality pattern was sensitive to a change in the exchange rate regime.

Quarterly data was used in this analysis and comprised the fixed exchange rate period from 1962 to 1979, a transition period from 1971 to 1974 and a flexible exchange rate period from 1974 to 1977.

The results indicated that US monetary policy had little direct impact on UK nominal income during the period of the fixed exchange rate regime. However, when the flexible exchange rate subperiod was included in the analysis, it was found that monetary policy had a significant impact on UK income. The authors speculated that during the fixed exchange rate period, US money must first affect US nominal income or UK money before affecting UK nominal income. In contrast, under the flexible rate regime, US monetary policy will affect the US-UK exchange rate, causing changes in UK imports, exports, and income. More specifically, a positive was found to exist between US money and UK income during this period.

Chung (1993) used the VAR methodology to investigate the interdependence of monetary policies in Germany, Japan and the US (the G-3 countries). The author assumed that a G-3 country has two target variables (output and trade balance) and one policy instrument, (monetary policy). The reaction function of a country was assumed to be that function which minimised the quadratic loss of target variables subject to the monetary policies in the three countries. The quadratic loss function was expressed as;

$$L_{it} = \theta_y y_{it}^2 + \theta_x x_{it}^2 \qquad \text{i.}$$

where y_i is the output in country i, x_i is the trade balance in country i, and θ_i is the weight. Each target variable was assumed to be a function of money supplies in the G-3 countries. This is represented by the following equations:

$$y_{it} = y_i(m_t^g, m_t^j, m_t^s, m_{t-L}^g, m_{t-L}^j, m_{t-L}^s) \qquad \text{ii.}$$

$$x_{it} = x_i(m_t^g, m_t^j, m_t^s, m_{t-L}^g, m_{t-L}^j, m_{t-L}^s) \qquad \text{iii.}$$

where m^g, m^j, and m^s represent money supplies in Germany , Japan and the US, respectively while L is the lag operator. This analysis was conducted using quarterly data over the periods 1960 to 1972 and 1973 to 1989. Chung concluded that there is a high degree of monetary interdependence among the G-3 countries. The results of the impulse response functions indicated that monetary innovations in one country appeared to have contractionary effects in the other countries. They also suggested that the capacity of a central bank in each country to control its own economic destiny was limited by the influence of monetary policies abroad.

Tieslau (1997) conducted an empirical assessment of the cross country spillover efects between the US and Canada with respect to the movements in real money balances, interest rates (3 month treasury bill rate) and real output. Vector autoregressions, along with impulse response functions and Granger causality were used to assess both the short run and long run responses of Canadian and US output changes in money and credit conditions in each of the economies. The data used in the analysis consisted of quarterly observations spanning the first quarter of 1950 to the first quarter of 1995. The results indicated that in both the short and long run, movements to real Canadian money balances had a positive effect on real US output. Although movements to Canadian interest rates had a negative impact on real US output in the short run, there was a significant and positive effect in the long run. Examination of the effects of a shock to US interest rates on Canadian output, revealed a positive response in the short run but a strong negative effect in the long run. Additionally, an increase in US money balances was found to have a positive effect on Canadian output in the short run, but a significant and increasingly negative effect in the long run.

Theoretical Foundation

Economic theory postulates that at least in the long run, a stable relationship should exist between real money balances, interest rates (the opportunity cost of holding money), and real income. This relationship is referred to as the long run money demand function and may be expressed algebraically in equation (1) below:

$$m_t = \beta_1 y_t + \beta_2 r_t + \varepsilon_t \qquad (1)$$

where m_t is real money balances, y_t is real output, and r_t is the interest rate. Additionally, β_1 measures the income elasticity of the demand for real balances and is expected to be positive, β_2 measures the interest elasticity of demand and should be negative reflecting the inverse relationship between the demand for real balances and the opportunity cost of holding money, and ε_t is a stationary white noise disturbance. For the purpose of this analysis however, the Barbadian function will be written as:

$$m_t{}^B = \beta_1 y_t{}^B + \beta_2 r_t{}^B + \varepsilon_t{}^B \qquad (2)$$

and the US counterpart will be given by:

$$m_t^U = b_3 y_t^U + b_4 r_t^U + e_t^U \qquad (3)$$

The variables of interest may now be collected into the vector process:

$$Z_t^{'} = \left[y_t^B \;\; y_t^U \;\; m_t^B \;\; m_t^U \;\; r_t^B \;\; r_t^U \right] \qquad (4)$$

and it is these variables which comprise the VAR to be analysed. In particular, the K-period lagged VAR of Z_t is given by:

$$z_t = \sum_{k=1}^{K} \Pi_k z_{t-k} + E_t \qquad (5)$$

This can also be expressed in matrix form as:

$$\begin{bmatrix} y_t{}^B \\ y_t^U \\ m_t{}^B \\ m_t^U \\ r_t{}^B \\ r_t{}^U \end{bmatrix} = \begin{bmatrix} \Pi_{11}(B) & \Pi_{12}(B) & \Pi_{13}(B) & \Pi_{14}(B) & \Pi_{15}(B) & \Pi_{16}(B) \\ \Pi_{21}(B) & \Pi_{22}(B) & \Pi_{23}(B) & \Pi_{24}(B) & \Pi_{25}(B) & \Pi_{26}(B) \\ \Pi_{31}(B) & \Pi_{32}(B) & \Pi_{33}(B) & \Pi_{34}(B) & \Pi_{35}(B) & \Pi_{36}(B) \\ \Pi_{41}(B) & \Pi_{42}(B) & \Pi_{43}(B) & \Pi_{44}(B) & \Pi_{45}(B) & \Pi_{46}(B) \\ \Pi_{51}(B) & \Pi_{52}(B) & \Pi_{53}(B) & \Pi_{54}(B) & \Pi_{55}(B) & \Pi_{56}(B) \\ \Pi_{61}(B) & \Pi_{62}(B) & \Pi_{63}(B) & \Pi_{64}(B) & \Pi_{65}(B) & \Pi_{66}(B) \end{bmatrix} \begin{bmatrix} y_t{}^B \\ y_t^U \\ m_t{}^B \\ m_t^U \\ r_t{}^B \\ r_t{}^U \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \\ \varepsilon_{6t} \end{bmatrix} \qquad (6)$$

In this specification, "B" represents the lag operator so that $\Pi_{ij}(B) Z_i = \Pi_{1j} Z_{i,t-1} + \Pi_{2j} Z_{i,t-2} \ldots + \Pi_{kj} Z_{i,t-k}$ and Π_{1j} represents the j^{th} variable in i^{th} equation. However, the values of these coefficients are not analysed to any great extent as it is difficult to glean any useful information from them. For the purpose of this paper, the VAR framework is used to perform tests for cointegration and Granger causality and also in the construction of impulse response functions to determine the spillover effects from the US economy onto the Barbadian economy.

III. Data and Methodology

The data used in this analysis consists of quarterly observations which span the period from the first quarter of 1974 to the fourth quarter of 1998. The sources of the data are the International Financial Statistics of the International Monetary Fund and the Annual Statistical Digest of the Central Bank of Barbados. The variables are: real money balances measured using narrowly defined M1 (currency held by the public + demand deposits), interest rates measured by the short-term three-month treasury bill rate, and real output measured as the gross domestic product in constant prices. Both the US output and money variables are seasonally adjusted while of the Barbados variables, only real output was adjusted for seasonality. These adjustments were made using the quarterly seasonal adjustment programme (census X-11) of the US Bureau of the Census Statistical Department. The X11 programme is provided with Eviews 3.0, the econometric software used in this study. The econometric tests applied to these variables are described below:

Tests for Causality

One way to assess the degree to which movements in one or more variable lead to or cause movements in other variables is to test for the presence of Granger causality (Granger, 1969). Our main interest is in determining whether the monetary variables are able to influence the output variables. However, since feedback effects and simultaneous causality are possible in this system analysis, we must consider whether the output variables are able to influence the monetary variables. Consider the VAR described in equation (6). If m_t^B, m_t^U, r_t^B, and r_t^U are able to determine y_t^B, and y_t^U then these variables should be of use in jointly determining the values of y_t^B, and y_t^U. Therefore, the test of Granger causality involves testing the null hypothesis that the coefficients in the upper right hand (2 x 4) sub matrix are equal to zero. Similarly, the test of Granger causality of y_t^B and y_t^U on m_t^B, m_t^U, r_t^B, and r_t^U involves testing the null hypothesis that the coefficient at the bottom left hand (4 x 4) sub matrix are equal to zero.

It is important to note that the statement "X Granger causes Y" does not imply that Y is the effect or the result of X. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

Hence, any empirical evidence that indicates m_t^U and r_t^U, Granger cause y_t^B is not enough to prove conclusively that movement in US monetary variables cause movements (in the traditional sense) in Barbados output. This is because these tests may be interpreted as meaning either that m_t^U and r_t^U cause y_t^B , or more appropriately that m_t^U and r_t^U simply precede y_t^B. This is why we employ two additional econometric techniques to investigate the presence of cross-country influences.

Cointegration

The existence of a cointegrating relationship between a set of variables implies that there exists some linear combination of these variables that converges to a stable equilibrium in the long-run. If a cointegrating relationship can be found to exist among a set of variables this will provide additional evidence in favour of some form of causality among these variables. This is so because the presence of a cointegrating relationship implies the existence of Granger causality in at least one direction. The cointegrating vector also makes it possible to obtain information on the direction and magnitude of the long-run relationships that exist among these variables. More specifically, if we are able to find two statistically significant cointegrating vectors, then we would hope that one would represent the US money demand function and the other, the Barbadian money demand function. Evidence of long-run effects is determined by estimating the parameters of the cointegrating vectors and subsequently testing the statistical significance of the estimated parameters on the US variables which enter into the Barbadian cointegrating vector.

We employ the Johansen (1988) methodology to test for the presence of cointegration among the variables and to estimate the parameters of the cointegrating vector(s). The Johansen procedure is based on the maximum likelihood estimation of the VAR system. The var in equation 5 can be expressed in the cointegrating form

$$\Delta Z_t = a + ct + \Pi Z_{t-1} \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-1} + \varepsilon_t \qquad t=1,2$$

where $$\Pi = -(I_{n+1} - \sum_{i=1}^{p} \Phi_i) \quad \text{and}$$

$$\Gamma_i = \sum_{j=i+1}^{p} \Phi \qquad j = 1,\dots,p-1$$

are the (n+1) * (n+1) matrices of the long-run multiplier and the short-run dynamics coefficients respectively.

Since the matrix π controls the cointegration properties, the rank (r) of π determines the number of cointegrating vectors in the system. There are three cases:

Case 1 π is full rank and any linear combination of Z_{t-1} is stationary. There we can run a normal VAR in levels.

Case 2 π has reduced rank, then there are some linear combinations of Z_t that are stationary, so Z_t is cointegrated. VAR in levels is consistent but inefficient (Pesaran et al, 1996) and we must estimate the vector error correction model (VEC).

Case 3 ∏ has zero rank, so no linear combinations of Z_t are stationary. ΔZ_t is stationary with no cointegration. In this case we can run a normal VAR in first differences.

Under case 2, the matrix π can be expressed as $\pi = \alpha\beta$ where α and β are both (k+1) x r matrix of full column rank; β is the matrix of cointegrating vectors and α is the matrix of "weighting elements".

The test statistic for determining the cointegrating rank based on the hypothesis that the rank is at most (k-r) against the alternative that the rank is (k-r-1), is the trace statistic given by

$$Q_t = -T * \sum_{i=t-1}^{k} \log(1-\lambda_i)$$

and the maximum λ eigenvalue statistic given by

$$Q\max = -T\log(1-\lambda_{t+1}) = Q_T - Q_{T-1}$$

where λ is the i-th largest eigenvalue. The critical values in both cases can be found in Osterwald-Lenum (1992).

Impulse Response Functions

An impulse response function traces the effect of a one standard deviation shock to one of the innovations on current and future values of the endogenous variables. A shock to the i-th variable directly affects the i-th variable, and is also transmitted to all of the endogenous variables through the dynamic structure of the VAR. Hence, the impulse response functions are the dynamic multipliers of the VAR which embody the current and subsequent effects of a one-time shock to one of the variables in the system on each of the remaining variables in the vector process. The methodology involves perturbing the estimated VAR, on an equation-by-equation basis, by shocking the estimated standard error of each equation with a one standardised deviation perturbation. Then, the responses of the dependent variables of the VAR to these standardised shocks are measured overtime to assess the dynamic workings of the system of equations. The responses which occur in the initial periods after the shock will detail the behaviour of the system in the short-run; the responses which occur in later period provide insight into the long-run effects. In this way it is possible measure not only the magnitude of the responses of the output variables to shocks to the monetary variables, but also the duration of these responses.

IV. ESTIMATION RESULTS

Since the main justification for embarking on cointegration analysis is the non-stationary properties of the series, we begin by first investigating the order of integration of the individual series. This is based on the Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests. The ADF is based upon the regression model

$$\Delta x_t = \alpha + \beta_t + \delta x_{t-1} + \sum_{j-1}^{j} \delta x_{i-j} + \varepsilon_t$$

where J is chosen to be sufficiently large to ensure that the error term is free of significant serial dependence. When J=0 the Dicky-Fuller test is obtained and J>0 defines the ADF test. The null hypothesis that X_t follows a random walk is rejected if the coefficient on X_{t-1} is significantly negative. The PP test, like the ADF test, is a test of the hypothesis ρ=1 in the equation

$$\Delta X_t = \mu + \rho X_{t-1} + \varepsilon_t$$

The test procedure is essentially the same as that for the ADF test. The reason for using both tests is that the PP test allows for serial correlation and the possibility of heteroscedasticity. The results for both are reported in Table 1 along with the critical values. The results are strongly supportive of the notion that each of the variables, with the exception of the Barbados interest rate, are I(1). The Barbados interest rate is I(0).

Granger Causality

Table 2 contains the results of our test for Granger causality. The results indicate that it is possible to reject the null hypotheses that real output and interest rates in the US do not Granger cause real output in the Barbadian economy. Interest rates in the US were also found to influence Barbadian interest rates. These results are interesting and quite intuitive. A plot of both interest rates (Chart 1) reveals a striking pattern of the local economy interest rate following, with some degree of lags, the US interest rate. This is supported by a plot of cross correlogram between the two rates (Chart 2) which shows the lag effect exists for up to three years. These results provide the first evidence of significant cross-country effects; we next consider more specific empirical tests which will detail the direction and magnitude of these cross-country effects.

Cointegration

We proceed next to the tests for the presence of cointegration among the variables in the vector process Z_t. The results (Table 3) indicate that the null hypothesis of two cointegrating vectors cannot be rejected at the 95% level of confidence. The estimated parameters of the cointegrating vector pertaining to Barbados, which reflect the long-run relationship are also presented in Table 4. It should be noted that these estimates are unique only up to some arbitrary normalisation and it is common to normalise on the coefficient of real money balances. In this way it is possible to interpret the resulting estimated equations as money demand functions. However, since our interest lies primarily in determining how the monetary variable effect output, we have chosen to normalise the coefficients on real output.

The parameter estimation provides additional evidence of the significant effects of the US money market on the Barbadian economy in the long-run. First, these results indicate that US real money balances have a positive and statistically significant effect on Barbados output in the long-run though this magnitude is very small. This finding supports the traditional view that increases in real money balances lead to increases in real output (both domestic and foreign real output). One direct channel for this is that US citizens with larger money balances can travel more and hence the Barbadian tourism sector benefits.

Secondly, the results indicate that US interest rates have a positive and statistically significant effect on Barbadian output in the long-run. This result is quite interesting and with a little thought, quite intuitive. Now this should not be interpreted as US interest rates causing an increase in the Barbados output (remember that a VAR only shows statistical relationships) for the channel is much more than this. Consider an increase in the interest rate in the US. This has a positive effect on the price level in the US [figure 1]. This increase in the price of US goods leads to expenditure switching away from US goods to the 'rest-of-the-world" goods, of which Barbados is a part. Hence this leads to an increase in output in Barbados. This we termed the "direct expenditure switching effect". Now, expenditure switching would also have a negative effect on output in the US and via this channel (2), a negative input on the Barbadian output. This we termed the "indirect expenditure switching effect". Hence, the net effect would depend on which channel has the greater influence. Therefore, the reason why the interest rate (US) has a positive sign in this model is because of the presence of the US GDP variable, hence the interest rate is capturing that part of the expenditure switching effect not explained by the GDP variable, i.e. the direct expenditure switching effect. Expectations are that GDP would have a greater effect because of the more direct links between the US and the Barbados economy (e.g. tourism), hence the overall (net) effect of an increase in the interest rate of the US should cause output in Barbados to decline. This was confirmed econometrically by omitting the GDP variable[1] from the model and we found that the coefficient on the interest variable turned negative. Another possible explanation for this result is that higher interest rates may lead to a reduction in investment in Barbados as persons find it more profitable to invest abroad.

Several interesting observations can be made from these findings. The result that changes in the US money balances and interest rates are able to influence economic activity in Barbados supports the long-held view that there can be significant

[1]Any intervening variable along the channel will absorb the effect, hence if we take out the GDP variable then the interest rate will capture the combined effect.

transmissions from large economically dominant economies to smaller economies. For interest rates, the effects transmitted from the US Central Bank to the Barbadian economy appear to have an overall detrimental effect, highlighting the need for Barbadian authorities to respond to US policy with appropriate counterbalancing actions.

Impulse Response Functions

Finally, we present the results of the impulse response functions which show both the short-run and long-run responses of Barbados real output to movements in the US monetary variables. Figure 2 presents the impact on Barbadian real output of a one-time shock to real US money balances and interest rates. With regard to money balances there is a sharp negative effect in the short-run but a positive long-run effect. The interest rate effect is positive in the short-run and continue to be positive in the long-run. When the GDP variable is omitted from the system the interest rate has a positive short-run effect and a significant and increasing negative effect in the long-run.

V. Conclusion

The paper used the conventional theory of money demand within the VAR framework to construct a model of the spillover effects to Barbados given changes in US monetary policy. The results of the Granger causality tests, cointegration analysis and the impulse response functions, imply that in the absence of counter-balancing policy actions, movements in US interest rates could adversely affect Barbadian real output in the long-run. Additionally, real money balances had a positive effect on the Barbadian economy in the long-run. All of these findings provide some evidence that Barbadian monetary policy should take into account the actions taken by the US Central Bank to avoid the possible negative spillover effects.

Finally, although this model generates some interesting results, it could be expanded to include other money market variables. Alternatively, other Caribbean countries could be included in this study to determine the region wide effects of US monetary policy actions.

Appendix

Table 1 - Test For Stationarity

SERIES		ADF		PP	
		NO TREND	TREND	NO TREND	TREND
BRGDP		-0.420186	-1.506184	-0.663324	-2.171173
D(BRGDP)		-3.855106	-3.939661	-7.842645	-7.873558
USRGDP		1.505841	-2.158904	1.837626	-1.590857
D(USRGDP)		-3.290311	-3.635633	-6.10046	-6.267736
BM		1.761085	-0.415619	2.194932	-0.487161
D(BM)		-2.439417	-3.290818	-9.379129	-10.13221
USM		-1.199941	-1.199941	-1.296658	-0.566982
D(USM)		-2.173142	-2.336423	-3.578851	-3.733446
BTBR		-3.692033	-3.689603	-3.017917	-3.012893
D(BTBR)		-4.836526	-4.793124	-5.6227	-5.587414
USTBR		-2.411702	-3.290741	-2.202026	-2.737562
Mackinnon	1%	-3.5239	-4.0909	-3.5188	-4.0853
Critical	5%	-2.9023	-3.4730	-2.9001	-3.4704
Values	10%	-2.5882	-3.1635	-2.5871	-3.1620

D represents the first difference of the variable

Table 2 - Granger Causality Matrix

P - Statistics pertaining to hypothesis, "Column entry does not cause row entry"

	BRGDP P	USRGDP	BM	USM	BTBR	USTBR
BRGDP		0.00707	0.09438	0.07866	0.02765	0.01975
USRGD	0.70689		0.10281	0.96516	0.18897	0.0574
BM	0.16996	0.20331		0.2418	0.41828	0.60586
USM	0.39566	0.04049	0.98832		0.51143	0.11211
BTBR	0.74951	0.55981	0.00501	0.58883		0.03694
USTBR	0.73184	0.21841	0.42709	0.19676	0.07088	

Shaded cells indicate rejection of the null hypothesis at the 5% level.

Table 3 - Johansen Cointegration Test

Null hypothesis about the number of cointegrating equation.						
	r = 0	r ≤ 1	r ≤ 2	r ≤ 3	r ≤ 4	r ≤ 5
Trace statistic	0.499032	0.361184	0.149828	0.120524	0.097030	0.020823
Likelihood Ratio	(152.21)	(84.47)	(40.56)	(24.65)	(12.07)	(2.06)
Critical Values 5%	94.15	68.52	47.21	29.68	15.41	3.76
1%	103.18	76.07	54.46	35.65	20.04	6.65

Table 4 - Normalised Cointegrating Vector for Barbados

y*	y	m*	m	r*	r
1	—	0.038907	7.42E-05	-7.820473	6.584323
		(0.01786)	(1.9E-05)	(1.87611)	(1.19675)
		(2.17907)	(3.91950)	(-4.16846)	(5.50185)

Chart 1 - Comparison of Treasury Bill Rates

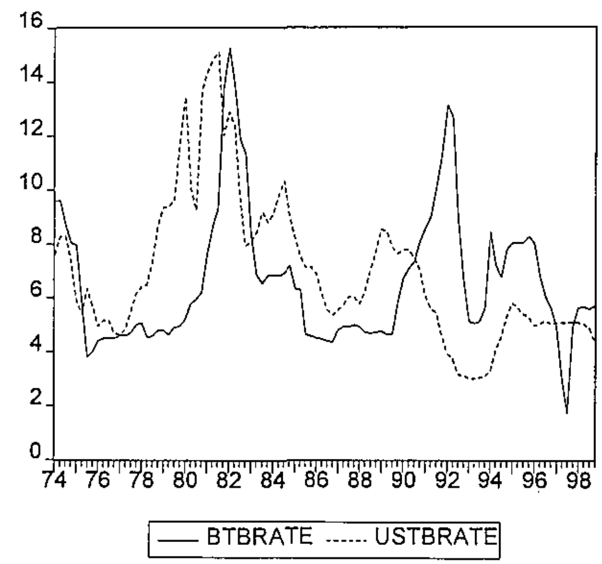
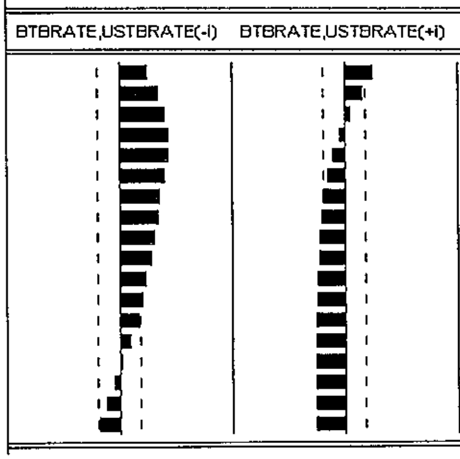


Chart 2 - Cross Correlogram of US and Barbados Treasury Bill Rates

Correlations are asymptotically consistent approximations



i	lag	lead
0	0.2584	0.2584
1	0.3513	0.1673
2	0.4203	0.0614
3	0.4483	-0.0383
4	0.4469	-0.1057
5	0.4190	-0.1459
6	0.3742	-0.1897
7	0.3497	-0.2205
8	0.3240	-0.2346
9	0.2810	-0.2370
10	0.2468	-0.2410
11	0.2194	-0.2495
12	0.1728	-0.2578
13	0.1049	-0.2637
14	0.0265	-0.2668
15	-0.0437	-0.2668
16	-0.1124	-0.2638
17	-0.1732	-0.2584

Figure 1 - Transmission Diagram for Increase in US Interest Rates on BDS GDP

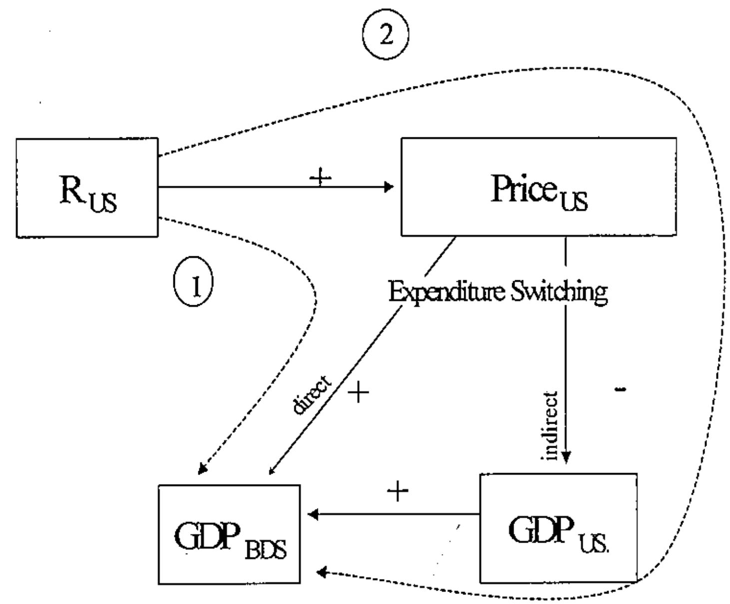
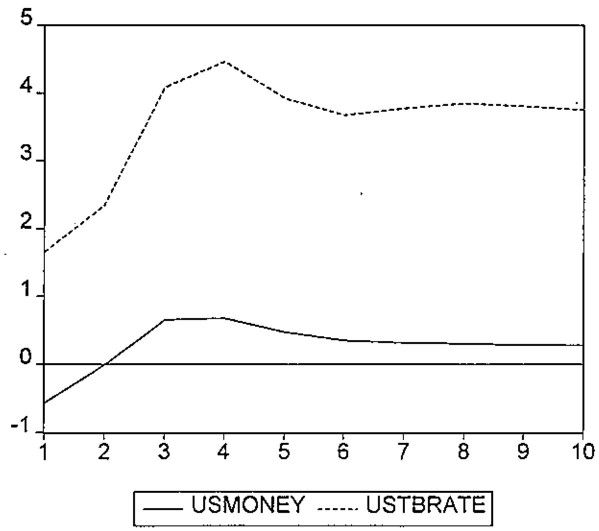


Figure 2 - Response of BDSGDP to a Shock in US GDP and US Interest Rates



References

Bartolini, L., and Drazen, A., 1997 " When liberal policies reflect external shocks, what do we learn?" Journal of International Economics, Vol. 42 pp 249-273.

Borda, P., Manioc, O., and Montauban, J., 1998 "How can Monetary Policy Affect Economic Activity," Central Bank of Barbados Working Papers.

Brown, L., 1985 "An Examination of Monetary Policy in Jamaica, 1981-1985,"Paper presented at the XXVIII Annual Conference of the Caribbean Centre for Monetary Studies, Nassau, 1985 mimeo.

Campbell, T., 1993, "A Review of Monetary Control Instruments," Central Bank of Barbados, mimeo, November.

Chung, J., 1993 "Monetary Interdependence Among G-3 Countries," Applied Economics, Vol.25 pp 681 - 688.

Farrell, T., 1981 "The Money Supply Process and Monetary Equilibrium in the Open Petroleum Economy," Paper presented at the XIII Annual Caribbean Centre for Monetary Studies in Trinidad, mimeo.

Fleming, J., 1962 "Domestic Financial Policies Under Fixed and Under Floating Exchange Rates," IMF Staff Papers, Vol. IX No.3.

Granger, C., 1969 "Investigating Cuasal Relations by Econometric Models and Cross Spectral Models," Econometrica Vol. 37 pp 424 - 438.

Hamada, K., 1976 "A Strategic Analysis of Monetary Interdependence," Journal of Political Economy, Vol. 84 August pp 677-700.

Hamada, K., 1985 "The Political Economy of International Monetary Interdependence," Cambridge MIT Press.

Harris, E., 1986 "Monetary Policy in Guyana (1974-1985)" Paper presented at the XXVIII Annual Conference of the Caribbean Centre for Monetary Studies, St. Kitts, 1986 mimeo.

Holder, C., and Haynes, C., 1986 "Monetary and Fiscal Policy in Barbados 1970-1984 ," Central Bank of Barbados Working Papers.

Haynes, C., 1997 "The Evolution of the Financial Sector in Barbados (1970-1996)," **The Financial Evolution of the Caribbean Community (1970-1996)**, eds. Clarke, L., and Danns, D., pp. 143 - 168.

Joefield-Napier, W., 1979 "A Quarterly Model of the Trinidad and Tobago Economy: (1970-1979) Paper presented at the XI Annual Conference of the Caribbean Centre for Monetary Studies, St. Kitts, 1979 mimeo.

Joefield-Napier, W., 1980 "Installment Credit and Monetary Policy in Trinidad and Tobago (1970-1979), Paper presented at the XII Annual Conference of the Caribbean Centre for Monetary Studies, St. Kitts, 1980 mimeo.

Johansen, S., 1988 "Statistical Analysis of Cointegration Vectors," Journal of Economic Dynamics and Control," Vol. 12 pp 231 - 254.

Johansen, S., and Juselius, K,. 1988 " Maximum Likelihood Estimation and Inference on Cointegration: Applications to the Demand for Money," Oxford Bulletin of Economics and Statistics, Vol. 52 pp 169 - 210.

Khan, G., 1998, " Monetary Transmission Mechanisms, Their Operation Under Fixed and Floating Rate Regimes - The Experience of a Group of CARICOM Countries," Caribbean Centre for Monetary Studies, Occasional Paper Series Number 6.

Kimbrough, K., 1993, "Optimal Monetary Policies and Policy Interdependence in the World Economy," Journal of International Money and Finance, Vol.12 No.2 pp 227 - 248.

Laufer, K., and Sundararajan, S., 1994 "The International Transmission of Economic Shocks in a Three Country World Under Mixed Exchange Rates," Journal of International Money and Finance, Vol.13 No.4 pp 429 - 446.

McClean A.W.A., 1985 "Monetary Dynamics in Barbados: The Evidence from Cointegration and Analysis and Error Correction Modelling," University of the West Indies mimeo.

Mixon, J., Pratt, L., and Wallace, M., "Cross National Money to Income Causality:US Money to UK Income" Journal of Money, Credit and Banking, Vol. XI No.4 pp 419 - 426.

Ramsaran, R., 1991 "Factors Affecting Income Velocity of Money in the Commonwealth Caribbean," Paper presented at the Annual Conference of the Caribbean Centre for Monetary Studies, Belize, mimeo.

Robertson, H., 1995 "New Financial Instruments and Innovations in the Jamaican Economy - Implications fro Monetary Policy and Financial Regulation," Paper presented at the XXVII Annual Conference of the Caribbean Centre for Monetary Studies, St. Kitts, 1995 mimeo.

Robinson, M., 1986 "A Review of Monetary Policies in the Jamaican Economy, 1980-, 1985," Paper presented at the XXVIII Annual Conference of the Caribbean Centre for Monetary Studies, St. Kitts, 1986 mimeo.

Thomas, D., 1990 "Costs and Constraints in the Application of Monetary Policy: Jamaica in the 1970s and 1980s" Paper presented at the XXII Annual Conference of the Caribbean Centre for Monetary Studies, Guyana, 1990 mimeo.

Tieslau, M., 1997, "A VAR Analysis of Cross Country Monetary Effects: The Case of Canada and the US," Department of Economics, University of North Texas, mimeo.

Tulseiram, P., 1981 " Monetary Policy in Developing Countries - The Case of Guyana" Paper presented at the XXVIII Annual Conference of the Caribbean Centre for Monetary Studies, Port of Spain 1981, mimeo.

Worrell, D.,1996 "Monetary Policy in Small Open Economies," Central Bank of Barbados Economic Review, Vol. XXII No.2 pp.13 - 18.

Zephirin, M., and Seeratan, D., 1997 "Financial Innovations in the Caribbean," Caribbean Centre for Monetary Studies, Monograph (Special Studies) Series No.25.