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THE DETERMINANTS OF THE REAL EXCHANGE RATE: THE EXPERIENCE OF BARBADOS

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The purpose of this paper is to test the proposition that a devaluation increases the real exchange rate unless offset by strong growth either in money wages at home or in worker productivity abroad. This simple proposition is based, in part, on two notions. The first is that the real exchange rate measures the prices of goods abroad relative to prices of goods at home. The second is that variables which affect either foreign or domestic prices will in turn have an impact on the real exchange rate. With foreign and domestic prices being influenced by fundamental variables like money wages, worker productivity and the price for goods externally relative to those at home, it is expected that the real exchange rate would appreciate when the fundamental variables make domestic prices rise faster than foreign prices. Conversely, when the fundamental variables cause foreign prices to rise faster than domestic prices, the real exchange rate is expected to depreciate. With the real exchange rate serving as a proxy for competitiveness, it is anticipated that as the real exchange appreciates, the competitive position of the home country internationally deteriorates. However, when the real exchange rate depreciates, the home country competitive position abroad improves.

To facilitate discussion and analysis, this paper is organised into three sections. In Section 1, a simple model of real exchange rate determination is sketched. Section 2 then uses data from 1974 to 1989 to test the model developed in Section 1. In this section the Augmented Dickey-Fuller test for non-stationarity of variables is applied. Finally, in Section 3, the principal findings of the study are summarised.

1. MODEL

The hypothesis that the real exchange rate depreciates when the spot exchange rate is increased, or as productivity in home country rises

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relative to productivity abroad, or as money wages in home country fall relative to those abroad, can be sketched by the following set of equations.

Equation (1) defines the real exchange rate:

(1) $R = SP^*/P$ Definition of Real Exchange Rate,

where R = the real exchange rate; P* = the foreign price level; P = the domestic price level; and S = domestic price for foreign currency. According to Dornbusch and Fischer, and Dornbusch and Helmers, equation (1) simply says that the real exchange rate is determined by the ratio of foreign prices to domestic prices expressed in terms of home country currency. With this measure, when R increases in value the real exchange rate depreciates in value and the home country competitive position internationally improves. Conversely, as R falls in value, the real exchange rate appreciates. As a result, the home country loses its competitiveness internationally.

Equation (2) is the domestic price equation:

(2) $P = AWR^{\alpha 1}$ Domestic Price Equation,

where P = domestic prices; A = the average product of labour in home country; W = money wages; and R = the price of goods externally relative to those at home from the home country perspective.

Equation (3) is the foreign price equation:

(3) $P^* = A^*W^*R^{*\alpha^*1}$ Foreign Price Equation

where P* = foreign prices; A* = the average product of labour in foreign country; W* = money wages in foreign country; R* = the price of goods externally relative to those at home from the foreign country perspective = - R; and * denotes the foreign variable.

According to equations (2) and (3), one should expect domestic and foreign prices respectively to rise as domestic and foreign wages rise. Prices are however expected to fall in home and foreign country, respectively, as each country experiences increases in productivity. In keeping with Shone (1989), the price level is expected to rise as R increases. This result is anticipated because as the foreign price level or as the domestic price for foreign currency increases the cost of imported goods rises. To the extent that this occurs, the overall price level in the economy is expected to increase.[1] The specification of the

above price equation could be further enriched by including other variables that have been identified by Downes (1985), Holder and Worrell (1985), Downes, Holder and Leon (1991), and Downes, Worrell and Scantelbury-Maynard (1993) in their studies of the inflationary process in Barbados and other Caribbean countries.

By expressing equations (1), (2) and (3) in logarithmic form and then by substituting equations (2) and (3) into (1), the following equation for the determination of the real exchange rate is derived (see Shone, 1989, pp. 397-398).

$$(4) \quad r = \beta_1 \tilde{S} + \beta_2 (\tilde{W}^* - \tilde{W}) + \beta_3 (\tilde{A} - \tilde{A}^*)$$

where r = the log of the real exchange rate; $\tilde{S}$ = the log of the spot exchange rate; $\tilde{W}$ = the log of money wages; $\tilde{A}$ = the log of labour productivity; and * denotes the foreign variables. Equation (4) states that the real exchange rate will improve, i.e., depreciate, if the nominal exchange rate is increased, or foreign wages are higher than wages at home, or worker productivity in home country is greater than worker productivity in foreign country.[2]

2. EMPIRICAL ANALYSIS

The behaviour of Barbados' (BDS) bilateral real exchange rate with respect to the United States of America (USA), the United Kingdom (UK), and Trinidad and Tobago (TT) for the period 1974-1989 is depicted in Figures 1, 2 and 3. Two features emerge from this graphi-

FIGURE 1: BARBADOS/UNITED STATES OF AMERICA BILATERAL REAL EXCHANGE RATE

FIGURE 2: BARBADOS/UNITED KINGDOM BILATERAL REAL EXCHANGE RATE

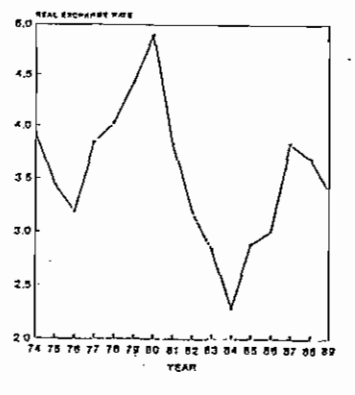


FIGURE 3: BARBADOS/TRINIDAD & TOBAGO BILATERAL REAL EXCHANGE RATE

cal presentation. First, the data suggest that there has been a steady appreciation of the bilateral real exchange rate between BDS and the USA. Between 1974 and 1989, the real BDS/USA bilateral exchange rate has appreciated by 25%. With the pegging of the Barbadian dollar to the American dollar in 1975 and with no change in the parity over the period analysed, much of the appreciation reflects higher rates of growth in prices for goods in BDS relative to the USA. With respect to the UK and TT, Barbados' real bilateral exchange rate has also appreciated by 14% and 21% respectively between 1974-1989. Second, the data in Table 2 also suggest that the bilateral real exchange rates for BDS/UK and BDS/TT have exhibited more variability than the BDS/USA real exchange rate. The higher variability in

TABLE 1: ANNUAL AVERAGE GROWTH RATES FOR MONEY WAGES AND LABOUR PRODUCTIVITY IN BARBADOS, UNITED KINGDOM, UNITED STATES OF AMERICA AND TRINIDAD AND TOBAGO FOR THE PERIOD 1974-1989

Country	Growth in Money Wages (%)	Growth in Labour Productivity (%)
Barbados	9.2	1.65
United Kingdom	12.6	1.75
United States of America	6.1	0.2
Trinidad and Tobago	14.4	-0.53

TABLE 2: DESCRIPTIVE STATISTICS FOR BARBADOS' BILATERAL REAL EXCHANGE RATES

Barbados' Bilateral Real Exchange Rate with Respect to:	Mean	Standard Deviation	Coefficient of Variation	Maximum	Minimum
United States of America	2.163	0.183	0.0846	2.641	1.987
United Kingdom	3.574	0.657	0.1838	4.886	2.281
Trinidad and Tobago	0.646	0.0673	0.1041	0.805	0.551

the case of the BDS/UK rate reflects fluctuations in the British pound relative to the American dollar in the post-Bretton Woods era. For TT, notwithstanding the devaluations of 1974, 1984 and 1987, much of the variability in the rate reflects changes in the prices for goods in TT relative to those in BDS. The impact of these three devaluations on the real exchange rate is reflected in the three major spikes that are present in the BDS/TT real exchange rate series as shown in Figure 3. The spikes in Figure 2, meanwhile, reflect occasions in 1980-81 and 1986-87 when the value of the British pound depreciated quite sharply against the American dollar in the open market. As a result, with the Barbados dollar being pegged to the American dollar, the changes in the UK/USA exchange rate also became mirrored in the BDS/UK bilateral exchange rate.

As far as money wages are concerned, Table 2 indicates for the period 1974-1989 that money wages in the USA, UK, TT and BDS grew at an annual average rate of 6%, 12.6%, 14.4% and 9.2%. In a real sense, wages in BDS rose less quickly than those in the UK and TT. When compared to the USA, the growth in Barbadian wages was higher. A look at the growth in labour productivity column in Table 2 reveals low or, in the case of TT, slightly negative annual average rates of growth in productivity for the same period 1974-1989. When compared to the UK, USA and TT, the 1.65% annual average rate of growth in labour productivity in Barbados was higher in all cases except the UK which had a 1.75% annual average growth rate in labour productivity. The labour productivity growth rates for the USA and TT were 0.2% and -0.53% respectively.

Given the dubious value of regression results that have been generated from time series data, which do not display constancy in mean and variance and are thereby non-stationary, the first test to be performed on the data is to check for stationarity or the lack of it. According to cointegration theory, even if the variables turn out to be non-stationary, valid estimation and inference would still be possible once the collection of non-stationary variables is cointegrated. This simply means that there exists a linear combination of these variables that is stationary. In this paper, to check for stationarity, the single series Dickey-Fuller test is employed using data for the period 1974-1989. In that test, the null hypothesis is that the series has a unit root and is therefore non-stationary. The results from this test are reported in Table 3. Based on the critical values for small samples provided by

TABLE 3: STATIONARITY TESTS: FULLER t-STATISTIC FOR UNIT ROOT IN A SINGLE SERIES

Variable	BD	USA	UK	TT
rer	X	-6.55	-1.96	-3.20
s	X	-27.29	-1.89	-1.61
p	-2.68	-2.07	-3.74	-2.04
w	-2.83	-2.84	-3.21	-3.82
A	-3.47	-2.50	-3.49	-2.63

Notes: Sample period is 1974-1989.
rer is log of Barbados' bilateral real exchange rate with respects to the USA, UK, and TT.
s is log of Barbados' nominal exchange rate with respect to the USA, UK, TT.
p is log of the respective countries' consumer price index
w is log of the respective countries' nominal wages
A is log of each country's average product of labour
BD refers to Barbados
USA refers to the United States of America
UK refers to the United Kingdom
TT refers to Trinidad and Tobago
Critical value for small sample size at the 5% confidence level from *Blangiewicz and Charemza* [1990]:
-1.90
Critical value for small sample size at the 10% confidence level from *Blangiewicz and Charemza* [1990]:
-1.55.

Blangiewicz and Charemza (1990), the results suggest that the hypothesis of a single unit root or non-stationarity can be rejected for all of the variables in the study.

The data for this analysis are drawn from four major sources: the International Monetary Fund, *International Financial Statistics* (IFS); Central Bank of Barbados, *Annual Statistical Digest* (ASD); Central Bank of Trinidad and Tobago, *Handbook of Key Indicators* (HKI); and the Central Bank of Trinidad and Tobago, *Annual Economic Survey* (AES). With this data, equation (4) is estimated by ordinary least squares for the period 1974-1989. Because of the limited size of the sample and the ensuing possibility that the precision of the estimators could be low, notwithstanding their unbiasedness, efficiency and best linear unbiasedness, the results should be viewed as being provisional rather than definitive. Table 4 reports results for each of the three bilateral real exchange rates. Those results indicate that the real exchange rate is significantly affected by the nominal exchange rate in all three cases. The relative wage variable is also statistically significant for each of the three bilateral exchange rate equations. The relative productivity variable is statistically significant in the BDS/UK and BDS/TT bilateral exchange rate equations. The relative productivity variable is not statistically significant in the BDS/USA bilateral real exchange rate equation. For each of the bilateral exchange rate equations, the fit between actual and predicted values is quite good with adjusted R^2 values ranging from a low of 0.84 for the BDS/USA bilateral exchange rate equation to 0.98 for the BDS/UK exchange rate equation. The adjusted R^2 for the BDS/TT exchange rate equation is 0.93. At the 1% level, the hypothesis of no autoregression is not rejected for any of the equations. To further test for serial correlation, the Lagrange Multiplier (LM) test is performed for each of the three bilateral real exchange rate equations. The results from that test indicate that one cannot reject the null hypothesis of zero autocorrelation. The Box-Pierce Q-statistic also supports the notion of serial independence of the residuals. At conventional levels, the Engle's ARCH test also fails to reject the null hypothesis that the disturbance term exhibits constant variance. For each estimated equation, the Jarque-Bera statistic also suggests that the null hypothesis that the residuals are normally distributed cannot be rejected. Beyond this, the results for the Chow tests suggest that the

TABLE 4: ESTIMATES FOR THE BILATERAL REAL EXCHANGE RATE EQUATION

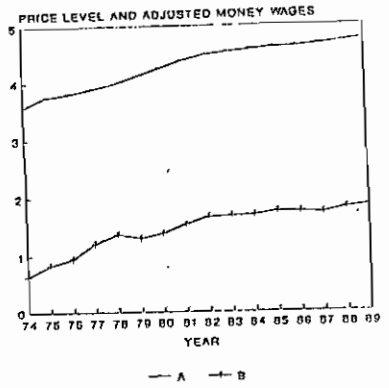
Variables	BDS/USA	BDS/UK	BDS/TT
Constant Term	0.03	-0.17	1.69
	(0.78)	(-2.09)	(6.14)
$\bar{S}$	0.92	1.06	0.84
	(6.95)	(24.48)	(12.89)
$\bar{W}^*-\bar{W}$	0.38	0.35	0.27
	(4.08)	(6.06)	(9.06)
$\bar{A}-\bar{A}^*$	-0.02	0.20	0.23
	(-0.25)	(2.01)	(6.99)
adjusted -R^2	0.84	0.98	0.93
D.W.	2.13	1.60	1.98
F-Statistic	28.44	240.39	53.67
S.E. of Regression	0.02	0.02	0.02
BPQS(X^2_2)	0.51	1.04	0.53
ARCH(X^2_2)	0.66	0.75	1.31
LM(X^2_2)	0.61	1.27	2.73
NORM(X^2_2)	0.02	2.15	0.93
CHOW[F(7,6)]	0.07	0.97	1.65
RMSE	0.001	0.001	0.002

Notes: Sample period is 1974-1989
- $\bar{S}$ is the log of E, where E is the nominal exchange rate
- $\bar{W}$ is the log of W, where W is wages in nominal terms
- $\bar{A}$ is the log of APL, where APL is the average product of labour
- * denotes the foreign variable
- R^2 is the coefficient of determination
- D.W. is the Durbin-Watson Statistic
- S.E. of regression is the standard error of regression
- BDS refers to Barbados
- USA refers to the United States of America
- UK refers to the United Kingdom
- TT refers to Trinidad and Tobago
- BPQS is the Box-Pierce Q-statistic
- ARCH is Engle's Autoregressive Conditional Heteroskedasticity statistic
- LM is the chi-square for the Lagrange Multiplier test for serial correlation
- NORM is the Jarque-Bera statistic for normality of the residuals
- CHOW is the F-statistic for the Chow Test for structural change or stability
- RMSE is root mean square prediction error
- Figures in parentheses below the estimated coefficients are the t-statistics.

model is stable. The low value for the RMSE, meanwhile, also suggests that the predictive accuracy of the model is high.

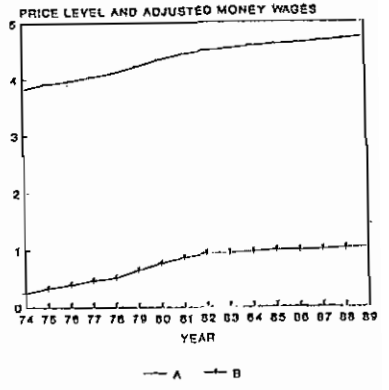
To evaluate the model further, Figures 4, 5 and 6 sketch the movement of the price level and money wages adjusted for worker

FIGURE 4: BARBADOS PRICE LEVEL & MONEY WAGES ADJUSTED FOR WORKER PRODUCTIVITY



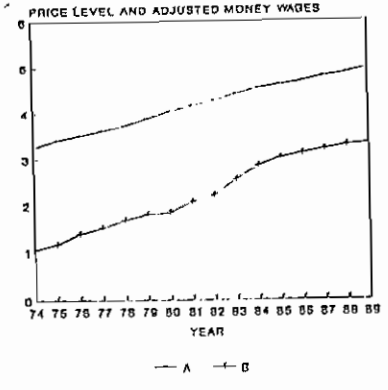
A-log of the price level
B-difference between the log of money wages and worker productivity.

FIGURE 5: UNITED STATES PRICE LEVEL & MONEY WAGES ADJUSTED FOR WORKER PRODUCTIVITY



A-log of the price level
B-difference between the log of money wages and worker productivity.

FIGURE 6: TRINIDAD AND TOBAGO PRICE LEVEL & MONEY WAGES ADJUSTED FOR WORKER PRODUCTIVITY



A-log of the price level
B-difference between the log of money wages and worker productivity

productivity. From theory, it is expected that prices would rise as increases in money wages exceed the contribution of workers to the production process. For each of the four countries, a common feature of the illustration is the very close movement of the price level series and the series on money wages adjusted for worker productivity. To the extent that the close movement of the variables reflects the influence of wages adjusted for worker productivity on the price level, it would seem that policies designed to boost competitiveness through the use of income policies may not be totally inappropriate. However, the major issue here is how long can the authorities restrain wage increases. For, as the experiences of the USA in the early 1970s, Brazil in 1986, and Peru in 1985 have shown, the income policies may only be able to temporarily reduce the rate of inflation if there is no underlying change in monetary and fiscal policy.

Given these results, three points are worth emphasising. The first is that both the nominal exchange rate and an income policy can be used to correct misalignment in the real exchange rate. The second is that exchange rate policy and incomes policy do not appear to be equally effective in influencing the real exchange rate. The results seem to suggest that an adjustment in the nominal exchange rate would have a stronger effect on the real exchange rate than policies which control wage increases or are designed to enhance worker productivity. The third point is that the impact on the real exchange rate depends on relative changes in wages and productivity at home compared with those abroad. Equal changes in wages and productivity at home and abroad will leave the real exchange rate unaffected.

3. SUMMARY

This study makes three points. First, it suggests that the real exchange rate can be influenced by exchange rate policy or incomes policy or some combination of the two policies. Second, the results seem to suggest that adjustments in the nominal exchange rate might be more effective in correcting real exchange rate misalignment than incomes policy. Third, it indicates that Barbados' competitive position with regards to the USA, UK and TT has eroded over the time period 1974-1989.

NOTES

1. See Shone (Chap. 3) for more discussion on the relationship between competitiveness and the price level.
2. Hsieh in a study on Germany and Japan also relates real exchange rate movement to the exchange rate and wages and productivity at home relative to those abroad. Focusing on a variety of structural variables, among other things, Edwards (1989) has done extensive work on real exchange rate movement in developing countries. Krumm (1993) has also looked at the role of structural factors in explaining real exchange rate variability in the Philippines and in Tanzania.

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APPENDIX A: THE DATA

The data used in the regression analyses are drawn from various issues of four publications. For each country, the price series was taken from IFS line 64. The data on income was obtained from IFS line 99b for BDS, TT and the UK. The income information for the UK was taken from line 99 b.c. of IFS. Line 99f of the same publication provided information for each of the four countries' population. This variable was used as a proxy for labour force size in computing worker productivity. or the UK and the USA, the information on money wages was taken from IFS line 65c and line 65 ey, respectively. For BDS, this information was obtained from the *Annual Statistical Digest.* For TT, meanwhile, the data were obtained from the *Handbook of Key Indicators* and the *Annual Economic Survey.* The different bilateral exchange rates were taken from the Central Bank of Barbados, *Annual Statistical Digest.*

APPENDIX B: MODEL DERIVATION

The appendix derives the real exchange rate equation (4) that is estimated in the text.

The model as outlined in the text is based on the following set of simple relationships as presented by Shone (pp. 397-398):

(A1) $R = SP^*/P$ Definition of Real Exchange Rate
(A2) $P = AWR^{\alpha^1}$ Domestic Price Equation
(A3) $P^* = A^*W^*R^{*\alpha}{}_1$ Foreign Price Equation

where R = the real exchange rate; * the foreign variable; P = the domestic price level; S = domestic price for foreign currency; A = average product of labour in home country; W = money wages in home country; and R = the price of goods externally relative to those at home from the home country and the foreign country perspective.

When equations (A1), (A2) and (A3) are expressed in logarithmic form, one obtains:

(A4) $\log R = \log S + \log P^* - \log P$
(A5) $\log P = \log W - \log A + \alpha^1 R$
(A6) $\log P^* = \log W^* - \log A^* + \alpha^*{}_1 R^*$.

By substituting (A5) and (A6) into (A4), one now obtains:

(A7) $\log R = \log S + \log W^* - \log A^* + \alpha_1{}^* \log R^* - [\log W - \log A + \alpha_1 \log R]$
(A8) $\log R = \log S + \log W^* - \log A^* + \alpha_1{}^* \log R^* - \log W - \log A + \alpha_1 \log R$
(A9) $\log R = \log S + \log W^* - \log W + \log A - \log A^* + \alpha_1{}^* \log R^* - \alpha_1 \log R$
(A10) $\log R = \log S + \log W^* - \log W + \log A - \log A^* + \alpha_1{}^* \log R^* - \alpha_1 \log R$

By letting $R^* = -R$, one gets on substitution:

(A11) $\log R = \log S + \log W^* - \log W + \log A^* - \alpha^*{}_1 \log R - \alpha_1 \log R$

By arranging terms and simplifying, one gets:

(A12) $\log R + \alpha_1{}^* \log R + \alpha_1 \log R = \log S + \log W^* - \log W + \log A - \log A^*$

(A13) $1 + \alpha^* + \alpha) \log R = \log S + \log W^* - \log W + \log A - \log A^*$

$$\text{(A14)}\quad \log R = \left(\frac{1}{1+\alpha_1{}^*+\alpha_1}\right)\log S + \left(\frac{1}{1+\alpha_1{}^*+\alpha_1}\right)(\log W^* - \log W) + \left(\frac{1}{1+\alpha_1{}^*+\alpha_1}\right)(\log A - \log A^*)$$

$$\text{(A15)}\quad r = \beta_1 \bar{S} + \beta_2 (\bar{W}^* - W) + \beta_3 (\bar{A} - \bar{A}^*)$$

where $r = \log R$; $S = \log \bar{S}$; $W^* = \log \bar{W}^*$; $\bar{W} = \log W$; $\bar{A} = \log \bar{A}$; and $\bar{A}^* - \log A^*$.

Equation (A15) corresponds to equation (4) in the text.

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GOVERNMENT REVENUE AND EXPENDITURE CAUSALITY IN THE PRESENCE OF SEASONALITY IN BARBADOS*

Roland C. Craigwell, Hyginus Leon and Clyde Mascoll

ABSTRACT

This paper examines the causal relationship between government revenue and expenditure for Barbados. It is argued that institutional and economic factors create seasonal patterns in the data. Tests for seasonal unit roots and cointegration are used prior to implementing the test for Granger causality. The vector error correction model results indicate significant cointegrating terms and show a unidirectional causal influence from government revenue to total government expenditure. This unidirectional causal result suggests that revenue control could be used as an integral component of a tax reform programme.

Keywords: seasonal integration; cointegration; vector error correction model; Granger-causality.

INTRODUCTION

The purpose of this paper is to incorporate the effect of seasonal behaviour in examining the causal relationship between quarterly government revenue and government expenditure in Barbados. We argue that the Engle and Granger (1987) error correction model provides a more general framework for testing causality, since the "standard" Granger test (see Granger (1969), Guilkey and Salemi (1982)) is misspecified if the variables in the information set are cointegrated. In contrast to the use of ad hoc filtering, tests for seasonal roots are employed to determine the appropriate filter, and cointegration tests

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