LONG RUN PURCHASING POWER PARITY (PPP): The Caribbean Experience, 1973-1993

by

Anston Rambarran
Central Bank of Trinidad and Tobago

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ABSTRACT

This paper attempts to investigate the validity of long run PPP for five Caribbean currencies using low frequency data based on the effective exchange rate and effective price concepts. The empirical analysis is grounded in the theory of cointegration, and not only employs the traditional residual based tests of Engle-Granger approach, but also applies the relatively new Johansen test. The results are at best mixed. From the Engle-Granger tests one may tentatively conclude that nominal effective exchange rates and effective price levels are not cointegrated for the five currencies considered, implying that they drift apart from each other over time. The Johansen test results of the trivariate model, however, differ considerably with the evidence of cointegration generally supportive of the long run PPP relationship. Results from the bivariate and univariate models are not as favourable.

This notwithstanding, the macroeconomic policy implications of the validity of long run PPP for the Caribbean region are quite salient. For countries operating under fixed exchange rate regimes (Barbados and the OECS), the level of domestic prices is in the long run effectively determined by the foreign price level. As a consequence, the efficacy of domestic monetary and fiscal policies is weakened in terms of maintaining price stability, except to the extent that these policies can in some significant manner influence the international price level. For countries operating under flexible exchange rate regimes (Trinidad, Guyana, and Jamaica), the domestic price level is determined by the home country as the exchange rate moves to ensure PPP. Finally, it is evident that PPP is not sufficient as an explanation of exchange rate determination. Other factors that underscore the complexity of the issue such as uncovered interest parity, the risk premium, the role of news, the treatment of expectations, and the linkages between goods and asset markets need to be addressed.

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Introduction

Purchasing power parity (PPP) is one of the older and more controversial of hypotheses in the international finance literature. It appears in two forms, an absolute or strong version which states that the exchange rate equals the ratio of domestic to foreign prices, and a relative or weak version which states that the change in the exchange rate is equal to the inflation differential. Elements of the doctrine date to sixteenth century Spanish and English thought, and qualified pronouncements can be traced to classical economists, such as Wheately, Ricardo and Mill, in the early part of the nineteenth century.[1] However, its modern concept is almost intrinsically linked to the writings of the Swedish economist Cassel in the unsettled monetary aftermath of the 1920s. Cassel (1921) declared that:

> "(i) *the PPP exchange rate at which purchasing powers of different national currencies were equalized was the only equilibrium or desirable rate; and*
>
> (ii) *the actual nominal exchange rate would tend towards the PPP level over time, provided that government did not intervene to prevent it."*

The controversy associated with PPP arose because the doctrine specified a relationship between exchange rates and prices, but did not set forth an adjustment mechanism. As a result, some have argued that PPP is a theory of exchange rate determination while others have stated that it is simply an equilibrium relationship. It is not surprising, therefore, that its early literature has been characterized by a multiplicity

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* The author is an Economist in the Research Department of the Central Bank of Trinidad and Tobago. The views expressed are those of the author and not necessarily those of the Central Bank.

1 See Officer (1976) and Dornbusch (1987) for excellent historical reviews of PPP.

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of interpretations and a lack of professional consensus. It was not until the formulation of Balassa's productivity bias hypothesis, based on the Ricardo-Harrod concepts of divergent international productivity levels and international real income comparisons, that interest in PPP was revived and given some empirical content. Balassa (1964) argued that higher productivity growth in the traded sector relative to the non traded sector causes a higher relative price of non traded goods in rich countries. As a result, the actual value of the currency will be systematically above its PPP level and appear to be overvalued. This hypothesis has since found ample support in empirical work, although Officer (1984) questioned its validity.[2]

The collapse of the Bretton Woods system of fixed exchange rates, and the consequent move towards generalized floating by the industrialized countries in 1973 witnessed a resurgence of attention in PPP. It became a fundamental assumption in most modern theoretical models of exchange rate determination, including Dornbusch's (1976) overshooting model, Mussa's (1982) stochastic generalization of the Dornbusch model, and Lucas's (1982) two country model. At the policy level, PPP became essential to open economy macroeconomics, with PPP-oriented exchange rate rules used to determine appropriate exchange rate levels and to predict exchange rate movements. Indeed, McKinnon (1984) proposed PPP as the criterion for stabilizing exchange rates, in the quest for a nominal anchor for the new international monetary system.

Empirically, numerous studies have sought to determine the validity of PPP in the post Bretton Woods float, and all have reached different conclusions. Nonetheless, it should be noted that the appropriate technique depends on the particular version in which one is interested, and these early analyses were constrained by the absence of an appropriate theoretical and statistical framework for dealing with short run and long run real effects. The relative or weak version has been perhaps the most researched version of the doctrine. For countries experiencing hyperinflation, a positive correlation between the rate of domestic inflation and the nominal exchange rate has been historically well documented. However, for relatively low inflation countries, empirical tests of the validity of PPP as a short run proposition have failed in light of many complications, including transaction costs, impediments to trade, exchange market intervention, and the use of aggregative price indices. It is now recognized that a basic flaw of these tests was the failure to consider the possible nonstationarity of exchange rates and relative prices, which render invalid the standard hypothesis tests performed (Froot and Rogoff, 1994).

Many authors such as Genburg (1978) and Stockman (1980) state that at any instant deviations from PPP can be observed for most currencies. These deviations are typically both cumulative and persistent, with the real exchange rate remaining on either side of the parity for intervals of a year or more. As a consequence, the current consensus is that PPP is invalid as a short run hypothesis,[3]. but its validity in the long run still remains an open question.[4] Roll (1979), Frenkel (1981), and Adler and Lehmann (1983) have been unable to reject the hypothesis that the real exchange rate follows a random walk,[5] or more generally has a unit root component which implies that there is no tendency for PPP to hold in the long run. Since deviations from long run parity appear to be highly persistent, these authors have argued that the real exchange rate can be approximated by a martingale, a stochastic process in which successive increments are unpredictable. Overall, unit root tests on bilateral exchange rates for the industrialized countries have been unable to reject the hypothesis of a random walk for currencies floating against each other, while for currencies that are fixed or formally stabilized in a monetary system the evidence is mixed.

2 In recent years there has been a number of studies analyzing the impact of such fundamental factors as productivity, government expenditure, and the strategic pricing decisions of firms on real exchange rates. These studies include Marston (1987), Froot and Rogoff (1991), Kasa (1992), and Ghosh and Wolf (1994).

3 This consensus is shared at least by Dornbusch (1976), Artus (1978), Officer (1980), and Frenkel (1981).

4 The validity of PPP as a long run proposition is maintained by Gaillot (1970), Officer (1978, 1980), Hakkio (1982), and Rush and Husted (1985).

5 The random walk proposition is also based on a number of empirically questionable assumptions, e.g. interest parity holds, the forward exchange rate is an unbiased predictor of the future spot rate, the Fisher relationship holds, and real interest rates are constant.

Recently, attention has focused on the statistical verification of the long run correlation between nominal exchange rates and prices through the use of cointegration theory. The techniques allow for the abstraction of short run dynamics and is designed to test for long run equilibrium relationships where the adjustment mechanism remains unspecified.[6] Froot and Rogoff (1994) point out that studies of long run PPP using cointegration techniques reveal three common features. First, rejections of the hypothesis of non cointegration occur less frequently for currency pairs that are floating than that are fixed. Second, tests based on consumer price indices tend to reject the hypothesis of non cointegration less frequently than tests based on wholesale price indices. Third, rejections of the non cointegration hypothesis occur more frequently for trivariate systems than bivariate systems or where symmetry and proportionality conditions are imposed. This notwithstanding, estimates of the cointegrating vector vary significantly across the studies using post-Bretton Woods data and are often implausible from an economic point of view. Furthermore, it is not yet apparent that cointegration has provided consistent results, as well as produced any insights not available from random walk tests of the real exchange rate.

In summary, the innovations in econometric techniques and the development of new data sets with longer and more disaggregated time series have contributed to a new wave of research on PPP. The main result is that for the industrialized countries there seems to be long run convergence to PPP, especially in data sets that use at least some fixed exchange rate data. In the case of the less developing countries (LDCs) empirical tests of PPP are few, perhaps attributable to the notion that the prevalence of fixed exchange rate systems negated such a prospect. However, Bahmani-Oskooee (1993) argues that despite the preference of LDCs to peg their exchange rates to a major currency or to a basket of major international currencies they are generally unable to avoid fluctuations in their effective exchange rates since the major currencies float against each other. Moreover, Bennett (1988) states that the experience of Caribbean countries with managed floating exchange rate systems dates from 1973, following the collapse of the Bretton Woods system and the adoption of generalized floating. In effect these countries have been operating under what may be termed an indirect managed floating exchange rate regime, as their currencies are pegged to the US dollar which is floating against the currencies of all the major industrial countries. Furthermore, even though the United States remains the major trading partner in the Caribbean, a significant share of trade is conducted with other countries both regionally and extra-regionally. As a result, even with unchanged bilateral US exchange rates, the stability of effective exchange rates in the region depends to a large extent on the level of the US dollar relative to that of other major international currencies.

In recent years, an increasing number of developing countries have adopted market-determined exchange rates, and in the Caribbean three countries have moved towards a system of greater exchange rate flexibility as part of a package of structural adjustment measures. The first, Jamaica, introduced a flexible exchange rate system in September 1990, after experimenting with various exchange rate arrangements in the late 1970s. Guyana also explored several changes to its fixed parity before allowing the rate to be largely determined by market forces in September 1991, while Trinidad and Tobago introduced a managed floating exchange rate system in April 1993. The other countries of interest to this study, Barbados and the seven countries of the Organisation of Eastern Caribbean States (OECS), have maintained fixed parities with the US dollar albeit at levels unchanged since the delinking from the pound sterling in the 1970s. Further, the countries of the OECS, Antigua, Dominica, Grenada, Montserrat, St. Kitts/Nevis, St. Lucia and St. Vincent, maintain a monetary union under the auspices of the Eastern Caribbean Central Bank (ECCB) with a single currency functioning as legal tender.

Despite this apparent heterogeneity in exchange rate arrangements and the subsequent modalities associated with macroeconomic policy coordination, inevitably there is a commonality of exchange rate management in the manner espoused by Bennett

6 Studies that test whether nominal exchange rates and price levels are cointegrated include Huizinga (1987), Taylor (1988), Mark (1990), Fisher and Park (1991), and Cheung and Lai (1993).

(1988). If a long run equilibrium relation exists between the effective rate of inflation of each country and nominal effective exchange rate changes, then PPP-oriented exchange rate rules may serve as a guide to macroeconomic policy in the Caribbean. This is particularly important in view of the active consideration being given to the formation of an extended monetary union that requires convergence of economic performance and policy.

Accordingly, this study is an attempt to investigate the validity of long run PPP for five Caribbean currencies using low frequency (annual) data[7] based on the effective exchange rate and effective price concepts. The empirical analysis is grounded in the theory of cointegration, and not only employs the traditional residual-based tests of the Engle - Granger (1987) two-step procedure, but also examines the validity of long run PPP using a relatively new test for cointegration devised by Johansen (1991). The paper is organized as follows. Section II describes the analytical framework and reports on some useful summary statistics. Section III tests whether nominal effective exchange rates and effective price levels are cointegrated in the Engle - Granger sense, while Section IV tests for cointegration between these two sequences using the Johansen test. Concluding remarks are made in Section V.

II. The Analytical Framework and Simple Tests of PPP in the Short Run

This methodological framework follows that of Officer (1980) in which reference is to PPP in its relative form, and the exchange rate and price levels are redefined as index number ratios of current period to base period values. Let r_t denote the exchange rate (number of units of domestic currency per unit of foreign currency) in period t, and let p_t and p_t^* be the domestic and foreign price index in period t relative to the base period 0,

[7] Frankel (1986) argues that the validity of long run PPP is most accurately tested using annual data over an extended period, while Hendry (1986) states that simply increasing the sample size by temporal disaggregation, say, from years to months, is unlikely to reveal any long run relationship.

respectively. Then, the exchange rate index R_n and the relative price index P_n in the current period n are defined as $R_n = r_n / r_0$ and $P_n = p_n / p_n^*$, respectively.

This computation is the basis of testing the comparative static approach to PPP, where the closer R_n is to P_n, the stronger the predictive power of the hypothesis. The other elements of the approach include the choice of price measure, standard country, base and current periods, and sample of domestic countries. In the literature there is a debate on the appropriate choice of price index. In this study, the gross domestic product (GDP) deflator is selected because it is the only price concept with a strong foundation in PPP theory. Other studies, in contrast, have used the consumer price index (CPI) or wholesale price index (WPI), but the latter biases the result in favour of the theory because it is heavily weighted with traded goods. The standard country for the Caribbean region is the United States, while for a given domestic country, the optimal standard country is the one with which trade and payments links are strongest. This suggests the concept of the effective exchange rate, where the standard country's currency and price index are replaced by appropriately weighted averages of the currencies and price indices of the domestic country's main partners in trade and payments.

The definition and method of construction of the nominal effective exchange rate (NEER) and the effective price (EP) index follow. Building on previous notation, let

$NEER_{in}$	=	the nominal effective exchange rate for currency i in period n relative to period 0, number of units of domestic currency per unit of foreign currency.
R_{ijn}	=	exchange rate index between currency i and currency j in period n relative to period 0, number of units of currency i per unit of currency j.
w_{ij}	=	weight of currency j in the effective exchange rate index for currency i.

Then, by definition,

$$NEER_{in} = \Pi_j R_{ijn}^{w_{ij}}, \tag{1}$$

where $w_{ij} = 1$ and $w_{ii} = 0$. Officer (1980) indicates that a geometric weighted average should be used because it is subject to the properties of symmetry (interchangeability of currencies i and j), and reversibility (interchangeability of periods 0 and n). Assuming orderly cross rates involving the US dollar (denoted by subscript \$),

$$NEER_{in} = \Pi_j \left(R_{i\$n} / R_{j\$n} \right)^{w_{ij}}, \tag{2}$$

Thus, the NEER can be calculated from exchange rate data with the US dollar as the base currency. The effective price index EP can be similarly defined. Let,

EP_{in} = the effective price index for country i in period n relative to period 0, domestic price index divided by the foreign price index.

P_{kn} = price index of country k in period n relative to period 0.

Then,

$$EP_{in} = \Pi_i \left(P_{in} / P_{jn} \right), \tag{3}$$

The set of trading partners for each country in the sample include their four regional partners and six developed countries, namely, Canada, Germany, Japan, the Netherlands, the United Kingdom and the United States. The weight w_{ij} is proportional to the value of merchandise trade (exports plus imports) of country i with country j. In the computations the base and current periods play equal roles in determining the weights. Further, an intervening period between base and current period is used. An intervening period (say, period m) is similar to the current period in the sense that $NEER_{im}$ and EP_{im} can be calculated. Moreover, the weights can then be recalculated using the trade flows in period m in conjunction with the flows in period 0. This procedure has the advantage that the series can be linked using the intervening period, thereby incorporating any structural changes in the direction of trade. In this study, the year 1982 is used as the intervening period to which the linked series is then rebased, that is, 1982=100.

Table 1 describes the weighting pattern of the NEER and EP indices corresponding to the respective period for each country in the sample. A measure of the quality of the NEER and EP indices for a given country and period is the proportion of

Table 1

Weighting Patterns for Nominal Effective Exchange Rates[1]

Country	Period	Weighting Pattern[2]	Coverage (%)[3]
Trinidad & Tobago	1973-1982	0.54 US + 0.176 UK + 0.07 CAN + 0.16 GER + 0.037 JAP + 0.086 NET + 0.032 GUY + 0.019 JAM + 0.018 BAR + 0.006 OECS	86.3
	1982-1993	0.66 US + 0.076 UK + 0.043 CAN + 0.017 GER + 0.038 JAP + 0.047 NET + 0.029 GUY + 0.027 JAM + 0.032 BAR + 0.009 OECS	74.1
Barbados	1973-1982	0.357 US + 0.304 UK + 0.098 CAN + 0.02 GER + 0.022 JAP + 0.014 NET + 0.016 GUY + 0.117 TT + 0.014 JAM + 0.038 OECS	73.6
	1982-1993	0.448 US + 0.16 UK + 0.059 CAN + 0.03 GER + 0.031 JAP + 0.01 NET + 0.011 GUY + 0.189 TT + 0.015 JAM + 0.047 OECS	67.6
Guyana	1973-1982	0.28 US + 0.268 UK + 0.12 CAN + 0.034 GER + 0.032 JAP + 0.026 BET + 0.204 TT + 0.018 JAM + 0.01 BAR + 0.008 OECS	88.7
	1982-1993	0.346 US + 0.233 UK + 0.074 CAN + 0.036 GER + 0.056 JAP + 0.024 NET + 0.192 TT + 0.016 JAM + 0.011 BAR + 0.012 OECS	84.9
Jamaica	1973-1982	0.521 US + 0.186 UK + 0.143 CAN + 0.03 GER + 0.029 JAP + 0.025 NET + 0.007 GUY + 0.043 TT + 0.008 BAR + 0.008 OECS	68.9
	1982-1993	0.581 US + 0.144 UK + 0.093 CAN + 0.025 GER + 0.039 JAP + 0.036 NET + 0.005 GUY + 0.052 TT + 0.012 BAR + 0.013 OECS	72.4
OECS	1973-1982	0.315 US + 0.427 UK + 0.84 CAN + 0.003 GER + 0.016 JAP + 0.017 NET + 0.008 GUY + 0.067 TT + 0.017 JAM + 0.046 BAR	87.4
	1982-1993	0.397 US + 0.28 UK + 0.053 CAN + 0.041 GER + 0.042 JAP + 0.008 NET + 0.009 GUY + 0.105 TT + 0.028 JAM + 0.037 BAR	81.5

Sources: Calculated from IMF - **International Financial Statistics Yearbook** (various issues), and IMF and IBRD - **Direction of Trade Statistics Yearbook** (various issues)

Notes: (1) The same weighting patterns are used for the corresponding effective price indices.

(2) Obvious symbols are used to represent component countries in the effective exchange rate.

(3) Trade with countries included in the weighting pattern as a proportion of the domestic country's total trade.

total trade accounted for by the main trading partners. This measure is called the coverage of the indices and is listed in the final column of Table 1. Annual observations from 1973 to 1993 were used in estimation. Exchange rates and GDP data were obtained from the IMF's *International Financial Statistics Yearbook*, and the direction of trade weights taken from the IMF and IBRD's *Direction of Trade Statistics Yearbook.*

Defining the logarithm of the nominal effective exchange rate index as e, and the logarithm of the effective price index as π, then the absolute or strong version of PPP implies that the logarithm of the real effective exchange rate index q be zero. That is,

$$q_t = e_t - \pi_t = 0, \qquad (4)$$

The relative or weak version of PPP is equation (4) in first differences, that is,

$$\Delta q_t = \Delta e_t - \Delta \pi_t = 0, \qquad (5)$$

Table 2A reports the cross correlations of the logarithms of nominal effective exchange rate changes and effective inflation rates estimated from 3 leads to 3 lags. These calculations reveal that both exchange rate and price level changes are, by and large, uncorrelated at these leads and lags. Similarly, contemporaneous movements in nominal effective exchange rates and effective inflation rates appear to be uncorrelated, with the sample correlations ranging from -0.9095 for the US - Guyana pair to 0.1481 for US - OECS pair. Table 2B displays sample cross correlations between changes in real and nominal effective exchange rates from 3 leads to 3 lags. Here, the contemporaneous movements in real and nominal effective exchange rates are generally positively correlated for each of the five currencies, while correlations at non zero leads and lags are basically close to zero. Table 2C shows the sample standard deviations of effective inflation differentials and changes in the logarithms of nominal and real effective exchange rates. Real rates are significantly more variable than nominal rates, and changes in the nominal effective exchange rate vary in tandem with effective price level changes.

Table 2A
Cross-Correlations of Changes In Logarithms of Nominal Effective Exchange Rates and Effective Inflation Rates:
Corr (Δe_t, $\Delta\pi(t\text{-}k)$)

K= lag of prices relative to exchange rate

Country	-3	-2	-1	0	1	2	3
Trinidad	0.0250	0.0691	0.2223	0.0850	-0.0363	0.1406	0.0145
Barbados	0.1239	0.3571	0.2548	-0.1737	-0.2644	-0.5480	-0.0806
Guyana	-0.0738	-0.4805	-0.3044	-0.9095	-0.2456	-0.5926	-0.0389
Jamaica	0.5015	-0.0307	0.1614	-0.1119	0.0543	0.0774	0.1933
OECS	-0.0326	0.2099	0.0984	0.1481	-0.0336	0.2843	0.3675

Table 2B
Cross-correlations of Changes in Logarithms of Nominal Effective Exchange Rates and Real Effective Exchange Rates:
Corr (Δe_t, $\Delta q(t\text{-}k)$)

K= lag of real effective exchange rate to nominal effective exchange rate

Country	-3	-2	-1	0	1	2	3
Trinidad	-0.0491	-0.1001	-0.2221	0.7493	-0.0566	-0.1217	-0.0409
Barbados	-0.2538	-0.3249	-0.1301	0.6602	0.2649	0.4231	-0.0560
Guyana	0.0513	0.5116	0.1968	0.9819	0.1697	0.5615	0.0344
Jamaica	-0.5156	-0.2078	0.2446	0.9157	0.2805	-0.2529	-0.4939
OECS	-0.0982	-0.1914	0.0260	0.5404	0.1652	-0.02452	-0.3999

Table 2C

Sample Standard Deviations of Inflation Differentials and Changes in Logarithms of Nominal and Real Effective Exchange Rates

Country	Inflation Differential	Change in Logarithm of Nominal Effective Exchange Rate	Change in Logarithm of Real Effective Exchange Rate
Trinidad	0.0893	0.1083	0.1344
Barbados	0.0706	0.0372	0.0539
Guyana	0.2778	0.3462	0.6099
Jamaica	0.1087	0.2340	0.2688
OECS	0.0500	0.0391	0.0588

Source: Author Calculations

These summary statistics suggest that PPP breaks down in the short run for the sample of Caribbean currencies and why it may be reasonable to represent real effective exchange rates as a martingale. It appears that real effective exchange rate changes are in the main dominated by nominal effective exchange rate movements, given the relative low variability of inflation differentials. However, abstracting from the short run evidence, one may inquire if there is some sense in which PPP might fare better in the long run when there is a tendency for the real effective exchange rate to revert to parity. The economic rationale for such an inference begins with some shock, frequently monetary in origin, which causes the real effective exchange rate to deviate from one. Since PPP does not hold in the short run, these deviations can persist and cumulate. Economic forces such as international commodity arbitrage and the price-specie-flow mechanism then create a countervailing tendency for the real effective exchange rate to return to parity, though possibly with long and variable lags. Tests of these long run considerations now follow.

III. The Engle-Granger Tests of Cointegration

In the tradition of Engle and Granger (1987), a variable x_t is integrated of order one I(1), or simply integrated if it is non stationary in levels and stationary in first differences. That is,

$$x_t = \mu + x_{t-1} + u_t, \qquad (6)$$

or

$$x_t - x_{t-1} = \Delta x_t = \mu + u_t, \qquad (7)$$

where u_t has mean zero and variance σ_u^2, and where u_t is stationary. Two sequences of random variables $\{x_t\}$ and $\{y_t\}$ are said to be cointegrated if they are I(1) and there exists a linear combination,

$$z_t = x_t + \beta y_t, \qquad (8)$$

which is I(0), stationary or integrated of order zero. β is called the cointegrating parameter. In applications, economic theory might imply a long run or 'equilibrium' relationship between two variables, say $x_t + \beta y_t = 0$ However, at any point in time it is likely that the system will display deviations from the long run equilibrium, with z_t measuring the extent to which the system is out of equilibrium. A test of the long run consequences of the theory can be undertaken by examining whether $\{x_t\}$ and $\{y_t\}$ drift over time. If cointegrated, they cannot drift far apart from each other as they share a common long run component or stochastic trend.

To test for cointegration, $\{x_t\}$ and $\{y_t\}$ must first be determined to be I(1), which is equivalent to testing for unit roots A simple, asymptotically valid method of testing for unit roots is the augmented Dickey-Fuller (ADF) test. The ADF (m) test statistic τ proposed in Dickey and Fuller (1979) for testing the null hypothesis of unit roots is computed as the t ratio of the coefficient of u_{t-1} in the following OLS regression,

$$\Delta u_t = -\phi u_{t-1} + \sum_{i=1}^{m} \delta_i \Delta u_{t-i} + v_t, \qquad (9)$$

where $\{u_t\}$ represent observations on $\{x_t\}$ and $\{y_t\}$, m represents the highest order of the lags, and v_t is a random disturbance term. In practice, an intercept is often included in equation (9) to reflect the possibility that under the alternative of stationarity, the intercept is not zero. A further variation introduces a time trend to allow for trend-stationarity of the alternative. One can best decide which model is appropriate by thinking of equation (9) as the equation under the alternative and of the Dickey-Fuller test statistic as a Wald test. The distribution of τ in each case is not standard and the relevant critical values are given in Fuller (1976). If the calculated statistic is less than its critical value from Fuller's table, then u_t is stationary.

The next procedure is to test for the presence of a unit root in the residual of the cointegrating regression $y_t = \alpha + \frac{1}{\beta} x_t$, or $x_t = \alpha + \beta y_t$. If the series is not cointegrated then there must be a unit root in the residuals; this is therefore the null of non cointegration. If the series is cointegrated, then the residuals will be stationary. Again the ADF (m) test statistic τ is computed as the t ratio of the coefficient of u_{t-1} in equation

(9), where $\{u_t\}$ now represents the residuals from the regression. It can be shown that least squares is a superconsistent estimator of the true cointegrating constant β (Stock, 1987). The appropriate critical values are tabulated in Engle and Granger (1987), with more precise values given in MacKinnon (1990).

To test for PPP as a long run relationship, cointegration tests are conducted between $\{e_t\}$ and $\{\pi_t\}$.[8] The first two columns of Table 3 report studentized coefficients of ϕ_1 in ADF (2) tests for unit roots on $\{e_t\}$ and $\{\pi_t\}$. It is seen that for the five currencies considered the logarithm of the nominal effective exchange rate appear uniformly to be non stationary in levels and stationary in first differences. For the logarithms of the effective price level, the unit root hypothesis could only be rejected for the US - Guyana pair. This implies from the outset that there is no cointegration, and the country pair is excluded from further analysis.

The next test is performed by constraining the cointegrating constant to unity, in order to determine whether the real effective exchange rate has a unit root. Column 3 of Table 3 shows the t statistic on ϕ_1 when the cointegrating constant is restricted to unity. Using the response surface estimates given in MacKinnon (1990), the 5 per cent critical value is 3.6968 and there is no evidence of cointegration. Column 4 of Table 3 shows the studentized coefficients on ϕ_1 in ADF (2) tests for unit roots in the residuals, where the sequence $\{u_t\}$ is estimated from a regression of $\{e_t\}$ on $\{\pi_t\}$, and column 5 reports the results when $\{u_t\}$ is obtained from a regression of $\{\pi_t\}$ on $\{e_t\}$. For either regression, the null hypothesis of non cointegration can still not be rejected at the 5 per cent level of significance.

8 All the data series are seasonally unadjusted, so that the potential problem concerning distortionary effects of seasonal adjustment on unit root tests [Ghysels (1990)] can be ignored.

Table 3

Engle-Granger Cointegration Tests: Studentized Coefficients for $\emptyset_1$ in the Regression $\Delta U_t = -\emptyset_1 u_{t-1} + \emptyset_2 \Delta u_{t-1} + \emptyset_3 \Delta u_{t-2} + v_t$

Country	Augmented Dickey - Fuller Tests for Unit roots in e and π[1]		Augmented Dickey - Fuller Tests for unit roots in residuals from co-integrating regression[2]		
	U is the nominal effective exchange rate (u=e)	U is the effective price level (u=π)	U is the real effective exchange rate (U=q)3	U is the residual from regression of e on π	U is the residual from the regression of π on e
Trinidad	1.5964	1.8663	0.0331	0.7642	1.4001
Barbados	2.8454	1.5079	1.1155	0.1516	2.1999
Guyana	2.7457	3.7139*	-	-	-
Jamaica	2.5757	2.4015	0.3577	2.8131	2.3107
OECS	3.3810	2.3749	0.5726	0.8735	2.0543

Notes:
(1) A time trend is included in these regressions. The critical value from Fuller (1976) is 3.6921 for 18 observations at the 5% level of significance.

(2) The critical values for the ADF residual - based tests are computed using the response surface estimates given in Mac Kinnon (1990). The critical value at the 5 % level is 3.6968

(3) Critical values not available at 5% level of significance.

(4) A - indicates that the second stage of the co-integration was not required since the unit root hypothesis could be rejected for either variable in the bilateral relation.

(5) An asterisk indicates significance at the 5 % level.

The tentative conclusion drawn from the residual based tests is that nominal effective exchange rates and effective price levels are not cointegrated for the five currencies considered. It should be noted, however, that the inability to reject a null hypothesis does not imply its acceptance, and these results are not conclusive proof that the real effective exchange rate has a unit root. Moreover, Cheung and Lai (1993) demonstrate the low power advantage of the standard residual based tests for cointegration when compared to the relatively new Johansen test for cointegration. Monte Carlo experiments using a 5 per cent level of significance and an autoregressive parameter of $\rho = 0.9$, show that the ADF tests have rather low power against local alternatives, rejecting the false null hypothesis of non cointegration about only 5 per cent of the time. In contrast, the Johansen test appears to perform relatively well, rejecting the false null of non cointegration about 24 per cent of the time. In this regard, the validity of long run PPP in the Caribbean region is now examined by using the Johansen test for cointegration.

IV. The Johansen Test For Cointegration

Johansen's test for cointegration takes into account the error structure of the data processes and allows for interactions in the determination of the relevant economic variables. The estimation method is based on the error correction representation of the VAR (p) model with Gaussian errors,

$$\Delta x_t = \mu + \Gamma_1 \Delta x_{t-1} + \Gamma_2 \Delta x_{t-2} + \ldots\ldots + \Gamma_{p-1} \Delta x_{t-p+1} + \Pi x_{t-p} + B z_t + u_t, \qquad (10)$$

where x_t is an mx1 vector of I(1) variables, z_t is an sx1 vector of I(0) variables, $\Gamma_1, \Gamma_2, \ldots\ldots\ldots \Gamma_{p-1}, \Pi$ are mxm matrices of unknown parameters, B is an mxs matrix, and $u_t \approx N(0, \Sigma)$. The Johansen Maximum Likelihood Procedure estimates equation (10) subject to the hypothesis that Π has reduced rank, r < m which can be written as $H(r){:}\Pi = \alpha\beta'$, where α and β are mxr matrices. Johansen (1991) shows that under certain conditions, the reduced rank condition implies that the process Δx_t is stationary, x_t is non stationary and that $\beta' x_t$ is stationary. The stationary relations $\beta' x_t$ are referred to as the cointegrating relations.

The log-likelihood ratio test statistic for the hypothesis of at most r cointegrating vectors is, $-2lnQ_r = -T\sum_{j=r+1}^{n} ln(1-\phi_j)$, where ϕ_j is the maximal eigen value of the product moment matrices of the residuals. Critical values are given in Osterwald-Lenum (1990). The number of cointegrating vectors is determined sequentially. Starting with the hypothesis of no cointegrating vector (r = 0), if this is rejected then the hypothesis that there is at least one cointegrating vector $(r \le 1)$ is tested, and so on. The test results provide evidence in favour of cointegration only in the case where $0<r<m$. The Johansen test is performed in the VAR framework, and different values of the lag length k = 1 to 8 were considered. In most cases a lag of k = 4 is required to remove serial correlation in the residuals, so statistical results based on a VAR (4) model are reported.

Table 4 displays the values of the Johansen test statistic, $-2lnQ_r$, for at most r linearly independent vectors in the trivariate model $X_t = (e_t, p_t, p_t^*)'$, where p_t and p_t^* represent the logarithm of the domestic price level and the foreign price level, respectively. The Johansen test results differ considerably from those of the residual based tests. Significant evidence of cointegration is found with the results generally supportive of the long run PPP relationship. For all five currencies the hypothesis of no cointegrating vector (r = 0) can be rejected at the 5 per cent level of significance, indicating that the series in X_t is cointegrated. Further, in four out of five cases (Trinidad, Barbados, Guyana and the OECS) the hypothesis of at most one cointegrating vector $(r \le 1)$ was rejected, and in two out of five cases (Jamaica and the OECS) the hypothesis of at most two cointegrating vectors $(r \le 2)$ was rejected.

Table 4

Results of the Johansen test for Cointegration in the Trivariate Model

Country	n=3		
	Ho: $r \le 2$	$r \le 1$	r = o
Trinidad	1.6618	15.0808*	35.8483*
Barbados	0.6393	19.9308*	57.4578*
Guyana	10.7521	37.2741*	53.3952*
Jamaica	7.2660*	8.6962	30.9901*
OECS	14.0728*	32.0025*	78.6470*

Notes: (1) Critical values for the likelihood ratio statistic - 2ln Q_r $(0 \le r \le n)$ are based on the simulated values tabulated in Johansen and Juselius (1990, table A.2, p. 208).

(2) At the 5% level of significance, the critical values are as follows: for n-r=1, 3.7620; for n-r=2, 14.0690; and for n-r=3, 20.9670.

(3) * indicates significance at the 5% level.

Table 5

Results of the Johansen Test for Cointegration in the Bivariate and Univariate Models.

	n=2		n=1
Country	Ho: $r \leq 1$	r=0	r=0
Trinidad	0.02914	6.1256*	0.0023
Barbados	0.3742	8.0793*	0.8104
Guyana	0.5224	40.3211*	21.9413*
Jamaica	1.3871	12.7729*	1.0415
OECS	0.2276	26.5020*	3.3417

Notes: (1) Critical values for the likelihood ratio statistic $-2\ln Q_r$ $(0 \leq r \leq n)$ are based on the simulated values tabulated in Johansen and Juselius (1990, table A.2, p.208).

(2) At the 5% level of significance, the critical values are as follows: for n-r=1, 3.7620; for n-r=2, 14.0690

(3) * indicates significance at the 5% level

To illustrate the possible differences in test results among trivariate, bivariate, and univariate models, Johansen tests are conducted on the bivariate model with nominal effective exchange rates and effective price levels $X_t = (e_t, p_t - p_t^*)'$, and the univariate model of the real effective exchange rate $X_t = (e_t - p_t + p_t^*)'$. Table 5 shows that the results are not as favourable compared to the trivariate model. For the bivariate model, the hypothesis of no cointegrating vector was rejected in all five cases at the 5 per cent level of significance, but the hypothesis of at most one cointegrating vector could not be rejected. The results for the univariate model demonstrate only one case (Guyana) supportive of cointegration. In effect, imposition of the symmetry and proportionality restriction which leads to a bivariate or univariate model suggests the exercise of caution when interpreting the results of the cointegration tests. According to Cheung and Lai (1993) the imposition of such restrictions may bias the test towards finding no cointegration, which may be interpreted as rejections of the imposed restriction on the equilibrium condition rather than rejection of the equilibrium relationship.

V. Conclusion

This paper attempts to investigate the validity of long run PPP for five Caribbean currencies using low frequency data based on the effective exchange rate and effective price concepts. The empirical analysis is grounded in the theory of cointegration, and not only employs the traditional residual based tests of Engle-Granger approach, but also applies the relatively new Johansen test. The results are at best mixed. From the Engle-Granger tests one may tentatively conclude that nominal effective exchange rates and effective price levels are not cointegrated for the five currencies considered, implying that they drift apart from each other over time. The Johansen test results of the trivariate model, however, differ considerably with the evidence of cointegration generally supportive of the long run PPP relationship. Results from the bivariate and univariate models are not as favourable.

Nonetheless, some caution should be exercised in the interpretation of these results. One such caveat arises from changes in the exchange rate regime. As documented by Stockman (1983) and Mussa (1986), the behaviour of nominal and real exchange rates has differed significantly across periods of fixed and flexible exchange rate regimes. This also invokes another possibility that the 'true' long run may inevitably be longer than the 21 years of data exploited in the study. In this regard, the sample would effectively represent less than one observation on long run behaviour, and the probability of commiting Type I errors would be particularly relevant.

This notwithstanding, the macroeconomic policy implications of the validity of long run PPP for the Caribbean region are quite salient. For countries operating under fixed exchange rate regimes (Barbados and the OECS), the level of domestic prices is in the long run effectively determined by the foreign price level. As a consequence, the efficacy of domestic monetary and fiscal policies is weakened in terms of maintaining price stability, except to the extent that these policies can in some significant manner influence the international price level. For countries operating under flexible exchange rate regimes (Trinidad, Guyana, and Jamaica), the domestic price level is determined by the home country as the exchange rate moves to ensure PPP.

Heliwell (1979) indicates that from this perspective strict application of PPP entails no policy or welfare significance for the exchange rate since exchange rate risk is simply a consequence of relative and general price level variability. Of course, from a practical viewpoint the matrix of policy choices remains. Finally, it is evident that PPP is not sufficient as an explanation of exchange rate determination. Other factors that underscore the complexity of the issue such as uncovered interest parity, the risk premium, the role of news, the treatment of expectations, and the linkages between goods and asset markets need to be addressed.

REFERENCES

Adler, Michael and Bruce Lehmann, *Deviations from Purchasing Power Parity in the Long Run*, Journal of Finance 38, 1983.

Artus, J.R., *Methods of Assessing the Long Run Equilibrium Value of An Exchange Rate*, Journal of International Economics 8, May 1978.

Bahmani-Oskooee, Moshen, *Purchasing Power Parity Based on Effective Exchange Rate and Cointegration: 25 LDCs' Experience with its Absolute Formation*, World Development, Vol.21, No.6, June 1993.

Balassa, Bela, *The Purchasing-Power Parity Doctrine: A Reappraisal*, Journal of Political Economy, Vol.72, December 1964.

Bennett, Karl M., *The Caribbean Experience with Floating and Managed Floating Exchange Rates*, Department of Economics, University of Waterloo, 1988.

Cassel, Gustav, *The World's Monetary Problems*, E.P. Dutton and Co., New York (1921).

Cheung, Yin-Wong and Kon S. Lai, *Long Run Purchasing Power Parity During the Recent Float*, Journal of International Economics, Vol.34 No.1/2, February 1993.

Dickey, David A. and Wayne A. Fuller, *Distribution of the Estimators for Autoregressive Time Series with a Unit Root*, Journal of American Statistical Association 74, 1979.

Dornbusch, Rudiger, *Expectations and Exchange Rate Dynamics*, Journal of Political Economy, Vol.84, 1976.

________________, *Exchange Rate Economics: Where Do We Start?*, Brookings Paper on Economic Activity, 1980.

________________, *Purchasing Power Parity* in the John Eatwell, Murray Milgate and Peter Newman, eds., The New Palgrave, A Dictionary of Economics, Stockton, New York, 1987.

Engle, Robert F. and C.W.J. Granger, *Cointegration and Error Correction: Representation, Estimation and Testing*, Econometrica 55, 1987.

Fisher, E. and J. Park, *Testing Purchasing Power Parity under the Null Hypothesis of Cointegration*, The Economic Journal, 101, 1991.

Frankel, J., *International Capital Mobility and Crowding Out in the US Economy: Impoerfect Integration of Financial Markets or Goods Markets?* in R. Hafer (ed), How Open is the US Economy, Lexington Books, Lexington, 1986.

Frenkel, Jacob A., *The Collapse of Purchasing Power Parities during the 1970s*, European Economic Review 16, May, 1981.

Froot, Kenneth A., and Kenneth Rogoff, *Government Consumption and the Real Exchange Rate: The Empirical Evidence*, Harvard Business School, 1991.

____________________________, *Perspectives on PPP and Long Run Real Exchange Rates*, National Bureau of Economic Research, Working Paper No.4952, December 1994.

Gaillot, Henry, *Purchasing Power Parity As An Explanation of Long Term Changes in Exchange Rates*, Journal of Money, Credit and Banking, 1970.

Genburg, H., *Purchasing Power Parity Under Fixed and Flexible Exchange Rates*, Journal of International Economics 8, May 1978.

Ghosh, A., and H. Wolf, *Pricing in International Markets: Lessons from the Economist*, National Bureau of Economic Research Paper No.4806, 1994.

Ghysels, Eric, *Unit-Root Tests and the Statistical Pitfalls of Seasonal Adjustments: The Case of US Postwar Real Gross National Product*, Journal of Business and Economic Statistics 8, 1990.

Hakkio, Craig, *A Re-examination of Purchasing Power Parity: A Multi-Country and Multi-Period Study*, NBER Working Paper No.865, March 1982.

Heliwell, John F., *Policy Modeling of Foreign Exchange Rates*, Journal of Policy Modeling, Vol.1, No.3, September 1979.

Hendry, David F., *Econometric Modelling with Cointegrated Variables: An Overview*, Oxford Bulletin of Economics and Statistics 48, August 1986.

Huizinga, John, *An Empirical Investigation of the Long Run Behaviour of Real Exchange Rates* in K. Brunner and A. Meltzer, (eds.), Carnegie-Rochester Conference Series on Public Policy 27, 1987.

International Monetary Fund, *International Finance Statistics Yearbook*, various issues, Washington D.C.

________________________________, and International Bank for Reconstruction and Development, *Direction of Trade Statistics Yearbook*, various issues, Washington D.C.

Johansen, SØren, *Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models*, Econometrica 59, 1991.

____________________, and K. Juselius, *Testing Structural Hypotheses in a Multivariate Cointegration Analysis of PPP and UIP for the U.K.*, Journal of Econometrics 53, 1992.

Kasa, K., *Adjustment Costs and Pricing to Market: Theory and Evidence*, Journal of International Economics 32, 1992.

Lucas, Robert E. Jnr., *Interest Rates and Currency Prices in a Two-Country World*, Journal of Monetary Economics, Vol.10, 1982.

Mark, Nelson C., *Real and Nominal Exchange Rates in the Long Run: An Empirical Investigation*, Journal of International Economics 28, 1990.

Marston, R., *Real Exchange Rates and Productivity Growth in the United States and Japan*, in S. Arndt and J.D. Richardson, (eds.), Real-Financial Linkages among Open Economies, MIT Press, Cambridge, Mass., 1987.

McKinnon, Ronald I., *An International Standard for Monetary Stabilization*, Institute for International Economics, Washington D.C., 1984.

Mussa, Michael L., *A Model of Exchange Rate Dynamics*, Journal of Political Economy, Vol.90, 1982.

____________________, *Nominal Exchange Rate Regimes and the Behaviour of Real Exchange Rates: Evidence and Implications*, in Karl Brunner and Allan H. Meltzer, (eds.), Real Business Cycles, Real Exchange Rates and Actual Policies, Carnegie-Rochester Conference Series on Public Policy 25, North-Holland, Amsterdam, 1986.

Officer, Lawrence H., *The Purchasing-Power-Parity Theory of Exchange Rates: A Review Article*, IMF Staff Papers, Vol.23, No.1, March 1976.

____________________, *Effective Exchange Rates and Price Ratios Over the Long Run: A Test of the Purchasing-Power-Parity*, Canadian Journal of Economics, No.2, May 1980.

____________________, *Purchasing Power Parity and Factor Price Equalization*, Kyklos, 1984.

Roll, R., *Violations of Purchasing Power Parity and Their Implications for Efficient International Commodity Markets*, M. Sarnat and G.P. Szego (eds.), International Finance and Trade, Vol.1, Chapter 6, Cambridge, Mass.: Ballinger Publishing Company, 1979.

Rush, Mark and Steven Husted, *Purchasing Power Parity in the Long Run*, Canadian Journal of Economics, XVIII No.1, February 1985.

Stock, James H., *Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors*, Econometrica 55, 1987.

Stockman, A.C., *A Theory of Exchange Rate Determination*, Journal of Political Economy, Vo.80, August 1980.

Taylor, Mark P., *An Empirical Examination of Long Run Purchasing Power Parity Using Cointegration Techniques*, Applied Economics 20, 1988.