Can We Explain the Long-Term Real Equilibrium Exchange Rates through Purchasing Power Parity? An Empirical Investigation (1965 – 1995)

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Abstract

Purchasing Power Parity (PPP) is the most conventional and fundamental means through which the long-term equilibrium exchange rate can be explained. This article examines the monthly and quarterly data from January 1965 – January 1995 aiming at testing the validity of PPP as a long-term equilibrium condition for the bilateral exchange rates between US Dollar and the currencies of a set of five industrialized countries, namely Germany, France, Australia, Canada, and the United Kingdom, using Augmented Dickey Fuller (ADF) unit root test. Results indicate that both monthly and quarterly US Dollar – Canadian Dollar real exchange rates are stationary. In case of US Dollar – Australian Dollar real exchange rate, only monthly data is found to be stationary. Strong evidence emerges that US Dollar – French Franc, US Dollar – German Mark, and US Dollar – Great Britain Pound exchange rates are non-stationary, which invalidates the PPP hypothesis.

Keywords: *purchasing power parity, exchange rate determination, unit root test*

JEL Classification: C32, C52, E43

Introduction

Since the breakdown of the Bretton-Woods system of fixed exchange rate in the early 1970s, the movement of exchange rates has frequently been a topic of interest. This is because exchange rates affect all walks of life and daily transactions. Fluctuations in the exchange rate may have a significant impact on the macroeconomic fundamentals such as interest rates, prices, wages, unemployment, and the level of output. This may ultimately result in a macroeconomic

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disequilibrium that would lead to real exchange rate devaluation to correct for external imbalances (Parikh and Williams, 1998). Therefore, it is of immense importance to be able to explain the movement of exchange rates. There exist four mainstream methods through which long-run equilibrium exchange rate can be determined. These are the Balance of Payments Flow Approach, the Real Interest Rate Differential Model, the Purchasing Power Parity, and the Monetary Model.

Purchasing Power Parity is the most conventional and fundamental means through which the long-term equilibrium exchange rate can be explained. It states that the exchange rate between two countries should reflect the relative purchasing power of the two countries. The validity of this hypothesis is traditionally tested through examining the stationarity of the real exchange rate. A stationary real exchange rate indicates that there exists a long run relationship between nominal exchange rate and, domestic and foreign prices, which validates the PPP hypothesis and hence its use as a tool for determining the equilibrium exchange rate. Rejection of the PPP hypothesis not only invalidates its usefulness as an exchange rate determination tool, but also disqualifies the monetary approach, which requires that the PPP hypothesis holds.

The purpose of the present study is to test the hypothesis of PPP for the exchange rates between US Dollar and five currencies, namely French Franc, German Mark, Canadian Dollar, Australian Dollar, and the British Pound. This article is structured as follows. The next section reviews the empirical literature on exchange rate determination. Section III provides a brief account of different approaches of exchange rate determination. Section IV describes the data and methodology employed. Section V presents the empirical results emerging from the study, and the last section provides conclusions that emerge from the study.

1. Literature Review

There exists a rich literature on the validity of the PPP hypothesis. In general, studies have found evidence showing persistent deviations from PPP. Studies by *Roll* (1979), *Frenkel* (1981, 1986), *Adler* and *Lenmann* (1983), *Hakkio* (1984), and *Taylor* (1988) fail to reject the hypothesis that real exchange rate follows a random walk. Studies, by *Frenkel* and *Mussa* (1985), *Edwards* (1989), *Roll* (1979), and *Pippenger* (1982) reveal that deviations from PPP follow a random walk process which implies that the deviations from PPP are cumulative and permanent such that PPP does not hold. *Hakkio* (1984) finds evidence supporting PPP in the 1970s using cross-country tests. *Dockery* and *Georgellis* (1994) also verify the PPP doctrine for the Greek economy during the period between 1980 and 1992 period. However, *Krugman* (1978), *Dornbusch* (1980), and *Frenkel* (1981a, 1981b) find evidence against long-run PPP.

Studies by *Abouf* and *Jorian* (1990) find evidence that verifies long-run PPP based on multivariate unit root tests performed on first differences rather than levels. *Cheung* and *Lai* (1993) and *Chen* (1995) find some fragmented support for PPP based on cointegration analysis. *Lothian* and *Taylor* (1997), based on panel data, verified long-run PPP through use of multivariate unit root tests. *Cheung* and *Lai* (1998) find evidence in favour of mean reversion using fractional cointegration. In short, empirical results from the past studies have been mixed and conflicting.

Some studies focus on the development of econometric models based on economic fundamentals. *Mark* (1995), *MacDonald* (1996), *Uysal* and *Barty* (1997), and *Taylor* and *Peel* (2000) attribute the predominant source of real exchange rate fluctuations to the effect of real disturbances. On the other hand, *Michael et al.* (1997), *Taylor et al.* (2000), and *Taylor* and *Peel* (2000) investigated the issue of nonlinear adjustments for exchange rate movements post-Bretton-Woods era, which are beyond the scope of the present study.

2. Models of Exchange Rate Determination

2.1. The Balance of Payments Flow Approach

Under the Balance of Payments Flow approach, the domestic price of a foreign currency is determined by the intersection of the market demand and supply curves for that foreign currency (Copeland, 2000). This approach models the demand and supply for foreign exchange as determined by the flows of currency created by international transactions.

According to this model, the supply and demand for a currency arise from trade in goods and services, portfolio investment, and direct investment, i.e. the flows related to the balance of payments. Equilibrium exchange rates are determined when the balance of payments is in equilibrium. Exchange rates will move in response to a balance of payments imbalance and, therefore, will restore the equilibrium to the balance of payments. The Balance of Payment Flow Approach to Exchange Rate Determination can be summarized by the following equation:

$$e = b1\,(y - y^*) - b2\,(i - i^*) + b3(x - x^*) \qquad (1)$$

where

$b1 > 0, b2 > 0, b3 > 0,$
e – equilibrium real exchange rate,
y – national income,
i – interest rate,
x – the market's expectation of the future exchange rate,
$*$ – the foreign country variables.

According to the equation, a relative rise in domestic economic activity results in depreciation of the domestic currency, while a relative rise in domestic interest rates results in an appreciation of the domestic currency. Also, an expected appreciation of the domestic currency will result in an immediate rise in the domestic currency's value (Rosenberg, 1996).

2.2. The Real Interest Rate Differentials Model

According to the Real Interest Rate Differential model, the real exchange rate between two countries can be explained by changes in real long-term interest rate differentials assuming that the uncovered interest rate parity holds and the real exchange rate will adjust gradually to its long-run PPP equilibrium rate (Rosenberg, 1996). The relationship between the real exchange rate and the real long-term interest rate differential can be shown by the following equation:

$$e = e' + (i^* - i) + \emptyset \qquad (2)$$

where

e' – real long-run equilibrium exchange rate,
$(i^* - i)$ – real long-run interest rate differential between two countries,
$\emptyset$ – level of risk premium on domestic securities,
$*$ – the foreign country variables.

As the equation states, everything else being equal, real value of US Dollar would rise if there occurred a rise in relative US real long-term interest rates (Copeland, 2000).

2.3. Monetary Model

According to the Monetary Model of exchange rate determination, the exchange rate equals the ratio of the relative money stocks of two countries to relative money demands of these two countries. Assuming a stable demand for money, a vertical aggregate supply curve and purchasing power parity, this relationship can be shown by the following equation:

$$e = (M/M^*) / (ky/k^*y^*) \qquad (3)$$

where

M – money stock,
k – a positive parameter where * denotes inputs from foreign countries (Copeland, 2000).

2.4. Purchasing Power Parity

The real exchange rate for country *i*, if defined with respect to the US Dollar as the numeraire currency, is constructed as:

$$e_{it} = q_{it} (P_t^* / P_{it}) \tag{4}$$

where

e_{it} – real exchange rate,
q_{it} – nominal exchange rate,
P_t^* – US consumer price index (CPI),
P_{it} – the CPI for country *i*.

According to PPP, in the absence of transportation costs, tariffs and other barriers to trade, and with free trade, the same good should cost the same across national boundaries. Markets enforce the law of one price, because the pursuit of profit tends to equalize prices of identical goods in different countries. Even though short run deviations from PPP may occur, the PPP relationship is expected to hold in the long run.

Under absolute PPP the nominal exchange rate is proportional to a ratio of domestic to foreign price levels:

$$q_t = \alpha + \beta_0 p_t - \beta_1 p_t^* + u_t \tag{5}$$

where

q_t – nominal exchange rate,
p_t – domestic prices,
p^*_t – foreign prices,
u_t – the error term.

All variables above are measured in logs in equation (4), which is referred to as a trivariate relationship. A bivariate relationship between the nominal exchange rate and the domestic to foreign price ratio is given by:

$$q_t = \alpha + \beta (p_t - p_t^*) + u_t \tag{6}$$

This PPP framework does impose an a priori restriction on the cointegrating vector. The difference between the PPP framework represented by equation (5) and (6), is that in the latter the symmetry condition on the price coefficients has been imposed. Another specification of PPP that is commonly used in unit root tests is given by

$$q'_t = \beta_0 + \beta_1 ln(p_t^* / p_t) + u_t \tag{7}$$

where

q'_t – the logarithm of the nominal exchange rate.

This is, in essence, the logarithmic transformation of equation (4). For the PPP relationship to hold, it requires that coefficient $\beta_1 = 1$. This also implies $\beta_1 = -\beta_0$, which imposes the joint symmetry/proportionality restriction. Since all unit root tests on the real exchange rate assume implicitly that such a restriction holds, a failure of these tests to find evidence favouring mean reversion in the real exchange rate may be caused by a failure of such a restriction.

3. Data and Methodology

3.1. Data

Data sets used in this study consist of quarterly and end-of-period monthly observations of spot US Dollar – British Pound, US Dollar – Australian Dollar, US Dollar – Canadian Dollar, US Dollar – German Mark, and US Dollar – French Franc real exchange rates. Data sets are obtained from Data Stream, span the time period between January 1965 and January 1995, and are represented in natural logarithms in order to make econometric testing procedures valid.

Table 1

Descriptive Statistics

	USD – UK	USD – GM	USD – FF	USD – AUD	USD – CAD
Mean	–0.049	0.011	–0.048	1.092	0.013
Std. Deviation	0.030	0.018	0.051	0.712	0.042
Skewness	0.126	–0.123	0.506	0.592	–0.345
Kurtosis	3.044	3.585	4.038	3.134	2.975
Jarque-Bera	234.194	74.554	5 431.564	8 017.479	6.448
Probability	0.000	0.000	0.000	0.000	0.041

An examination of the descriptive statistics[1] of the logarithmic transformations of time series data shows that the US Dollar – French Franc, and US Dollar – Australian Dollar exchange rates are the most volatile data sets. The measures of skewness and kurtosis as well as the probabilities of the Jarque-Berra tests statistic provide evidence in favour of the null hypothesis of a normal distribution for all data sets.

3.2. Methodology

To test for long run PPP, the real exchange rate as denoted by q_t has to exhibit mean reversion. If we cannot reject the null hypothesis that the aforementioned log real exchange rate series contain single unit root, then we conclude that it is

[1] Statistics are available from the author upon request.

a non-stationary series. In this case long-run PPP is violated. We perform this using The Augmented Dickey-Fuller (ADF) (1979) unit root test, which consists of running a regression of the first difference of the series against the series lagged once, lagged difference terms, and optionally, a constant and a time trend. This can be expressed as:

$$\Delta y_t = \beta_1 y_{t-1} + \beta_2 \Delta y_{t-1} + \beta_3 \Delta y_{t-2} + \beta_4 + \beta_5 t \qquad (7)$$

The test for a unit root is on the coefficient of $yt - 1$ in the regression. If the coefficient is significantly different from zero then the hypothesis that y contains a unit root is rejected. Rejection of the null hypothesis implies stationarity. If the calculated ADF statistic is higher than McKinnon's critical value then we do not reject the null hypothesis and the considered variable is non-stationary, i.e. has at least one unit root.

4. Empirical Results

Table 2 shows the results of the ADF unit root tests conducted on the five exchange rate sets. Using 5 % McKinnon critical values, it can be concluded that both the quarterly data and monthly data reject the null hypothesis that there is unit root in US Dollar – Canadian Dollar exchange rate. In other words this exchange rate is mean reverting and stationary. In case of US Dollar – Australian Dollar exchange rate, only monthly data rejects the null hypothesis that there is unit root. In the case of the remaining three exchange rate sets, evidence suggests that there exists unit root in the data sets, i.e. these exchange rates are non-stationary.

Table 2

Unit Root Test

	USD – CAN		USD – GM		USD – FF	
	[a] q_t	[b] $D(q_t)$	q_t	$D(q_t)$	q_t	$D(q_t)$
Monthly Data						
Intercept	–4.2354	–4.7072	–2.8324	–2.0985	–2.9393	–2.9983
Intercept + Trend	–4.1630	–4.4953	–2.2533	–2.8372	–2.9482	–2.9239
none	–5.9614	–5.9272	–2.6435	–2.9482	–2.0023	–2.9293
McKinnon at 5 %	–3.0404	–3.0522	–3.0989	–3.1118	–3.1344	–3.6253
Quarterly Data						
Intercept	–3.12483	–3.11571	–1.84720	–1.37919	–1.20448	–1.74873
Intercept + Trend	–4.03723	–3.85931	–1.14649	–1.27301	–1.21115	–1.69293
none	–4.74596	–5.69808	–1.80090	–1.72748	–1.40322	–1.70102
McKinnon at 5 %	–2.49313	–2.50280	–2.54110	–2.55168	–2.57021	–2.97275

[a] log-levels. [b] first differences.

	USD – AUD		USD – GBP	
	q_t	$D(q_t)$	q_t	$D(q_t)$
Monthly Data				
Intercept	–4.8432	–4.3342	–2.1423	–2.9239
Intercept + Trend	–5.8372	–4.6364	–2.5121	–2.9293
none	–4.0234	–5.9493	2.9951	–2.6324
McKinnon at 5 %	–3.0643	–3.0943	–3.9393	–3.5434
Quarterly Data				
Intercept	–1.13240	–1.75065	–2.60673	–2.69293
Intercept + Trend	–1.12790	–1.97730	–2.88408	–2.44698
none	–1.43276	–1.72902	–2.52914	–2.08536
McKinnon at 5 %	–2.51273	–2.53733	–3.23023	–2.90559

Hence, during 1965 : 1 – 1995 : 1, based on the ADF unit root tests, we conclude that there is no mean reversion in the log real exchange rate for US Dollar – French Franc, US Dollar – German Mark, and US Dollar – Great Britain Pound for both monthly and quarterly observations. There is mean reversion, however, in the US Dollar – Australian Dollar exchange rate only for monthly data, and there is mean reversion in US Dollar – Canadian Dollar exchange rate for both monthly and quarterly observations.

Conclusions

This paper sets out to test the PPP hypothesis based on the behaviour of the monthly and quarterly exchange rates between US Dollar and French Franc, German Mark, Australian Dollar, Canadian Dollar and British Pound for the period 1965 : 1 – 1995 : 1. The empirical evidence from ADF unit root tests does not favor mean reversion in the log real exchange rates for the exchange rates US Dollar – French Franc, US Dollar – German Mark, and US Dollar – Great Britain Pound for both monthly and quarterly observations. Hence, the present study fails to verify PPP based on these three exchange rates and corroborates the widely accepted notion that exchange rates deviate from their PPP values. In the case of US Dollar – Canadian Dollar exchange rate, however, results verify PPP based on both quarterly and monthly data, whereas evidence verifies PPP in case of US Dollar – Australian Dollar exchange rate based only on monthly data. These findings suggest the possible impact of geographic factors in influencing the adjustment of relative prices. The fact that the geographic distance between Canada and the United States is shorter than that of between the United States and the other countries might account for the results derived from the present study. There are several other factors such as productivity changes, a natural resource discovery, and changes in consumers' preferences that can account for

changes in the long-run real exchange rate and deviations from PPP. It is important to realize that PPP is an equilibrium relationship between two endogenous variables, i.e. prices and exchange rates are simultaneously determined by exogenous variables that may change independently. It is also worth mentioning here that in high-inflation countries, changes in exchange rates are highly correlated with inflation differentials because the sheer magnitude of inflation overwhelms the relative price effects, whereas in low- or moderate-inflation countries the relative price effects dominate exchange rate movements and lead to discrepancies from PPP. Along with the rate of inflation, the period of time analyzed also has an effect on how well PPP holds. PPP usually holds better for annual data than for monthly data because the longer time frame allows for more inflation. This is an area that requires further research.

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