

The Purchasing Power Parity Hypothesis:

Is there evidence from the Bilateral Real Exchange Rate between Mexico and the United States of America?

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Abstract

The hypothesis that national price levels should be equal when expressed in a common currency has been widely studied. However, evidence from empirical literature is mixed on the validity of purchasing power parity (PPP) in the long run. This paper examined the long run validity of PPP using the bilateral real exchange rate between Mexico and the United States of America (USA). It tests for the relative version of the PPP hypothesis using univariate unit root technique. It discusses evidence in favor of PPP for the bilateral real exchange rate between Mexico and USA. It also finds a half-life of 1-2 years for the real exchange rate adjustment to its mean. Consequently, it suggests that there is mean reversion in the bilateral real exchange rate between Mexico and USA.

Keywords: Exchange Rate Variability, Inflationary Differentials, Purchasing Power Parity, Unit Root, Mean Reversion.

Introduction

Purchasing Power Parity (PPP) postulates that national price levels should be equal when expressed in a common currency. It implies the proposition that nominal exchange rates, do not affect the relative price of goods or that changes in the nominal exchange rate will be proportional to relative inflation. It is commonly used as a long-run concept in relative terms. It states that in the long-run the exchange rate between any two countries is proportional to the ratio of the price levels of the two countries. The PPP implies that pure monetary disturbances have no effect on real exchange rates. It presupposes that the price of a commodity is the same in different countries, irrespective of the unit of account in which it is expressed.

Rogoff (1996) notes that many economists intuitively believe that PPP is an anchor for long-run real exchange rates. PPP is essential for open-economy macroeconomics; it serves as an anchor for the long-run equilibrium real exchange rate (Horne, 2004). The underlying argument of PPP is that goods price arbitrage will equalize prices in the same currency across countries. However, the existing empirical literature remains mixed on the validity of the PPP hypothesis. While many studies recognize the failure of PPP in the short run, there exists no consensus on the validity of PPP in the long run. The validity of the PPP hypothesis is not only of theoretical importance but it also has policy implications since the long-term behavior of exchange rates relative to prices affects many economic decisions. The validity of PPP is fundamental to macro-economic theory (Sjolander, 2007). The PPP relationship is the cornerstone of exchange rate models and also provides a benchmark exchange rate which makes it practically appealing to policymakers and exchange rate arbitragers (Hyrina & Serletis, 2010). If the PPP hypothesis should hold it would become a predictive model for exchange rates and a basis for determining currency over and under-valuation. The notion of PPP is employed in the modeling of many exchange rate theories. Thus, Liu and Burkett (1995) note that the quality of policy advice based on these theories may depend on the validity of PPP. Similarly, PPP is important for determining nominal exchange rate misalignment and for appropriate policy response (Sarno & Taylor, 2001), exchange rate parity setting, and the international comparison of national income levels. These practical applications of the PPP hypothesis would obviously be affected if the unit root null hypothesis holds for the real exchange rate. Sarno (2001) notes that the implications of open economy dynamic models depend sensitively on the presence or absence of a unit root in the real exchange rate.

This paper has sought to find out whether the PPP hypothesis holds and whether there is any evidence to support the validity of PPP. This is accomplished by examining for empirical evidence on the PPP hypothesis from the literature. The paper obtained data from the International Monetary Fund's (IMF's) International Finance Statistics. Univariate unit root technique was used to test the PPP hypothesis.

The paper is organized as follows: Section 2 deals with the convergence to PPP. It reviews literature on PPP convergence in the long-run. Section 3 discusses the methodology employed. Section 4 describes the data used in the study. Section 5 presents the results of the study. The conclusion is presented in section 6.

Convergence to Long-Run Purchasing Power Parity

Earlier empirical studies generally rejected the PPP hypothesis. Most of these studies used aggregate price indices and found evidence against PPP as a short-run concept. This is however, not surprising due to the failure of the law of one price (LOP) in microeconomic data. Apart from hyperinflationary economies, PPP tends to be strongly rejected. Studies such as Frenkel (1981) and Krugman (1978) rejected PPP in a more stable environment. Rogoff (1996) notes the difficulty in reconciling perplexedly high persistence of real

exchange rates with their immense short-term volatility. Chen and Lai (2000) note that the slow reversion to PPP can be rationalized if real shocks are predominant, but real shocks are not volatile enough over the short term to account for the vast exchange rate volatility.

The inability to reject the random walk hypothesis of the real exchange rate in the short run may be attributed to short horizon data. Several studies have suggested that convergence to PPP occurs slowly and over a longer period of time. It has been argued that real exchange rates are mean reverting in the long run. Alba and Park (2003) observe that real exchange rates move towards PPP in the long but the rate of movement is extremely slow. Researchers have focused on long-run PPP because the large variation in the nominal spot rate in relation to the variation in inflation rates makes it improbable that international inflation differentials will elucidate changes in the short run exchange rates (Sjolander, 2007). Frenkel and Rose (1996) note that there is some tendency towards long run PPP.

Many economists believe that the non-stationarity hypothesis has not been rejected because of short spans of data (Hyrina and Serletis, 2010). Frenkel (1986) argues that PPP disequilibria may be removed slowly, therefore, it may take several decades of data for one to be able to reject the existence of unit roots in real exchange rate series. Froot and Rogoff (1995) show that it may take about 72 years of data to reject the unit root null at the 5% level using the Dickey-Fuller test. Lothian and Taylor (1996) contend that the failure to reject the unit root hypothesis in real exchange rates may simply be due to the shortness of the sample. If the real exchange rate reverts towards its mean over long periods of time, then an examination of just one real exchange rate over a short period of time may not yield enough information to be able to detect slow mean reversion towards PPP. It is thus imperative for longer data sets to be employed. Alba and Park (2003) note that the power of the test increases when longer data sets are employed.

Evidence against Long-Run Purchasing Power Parity

Some empirical studies using long-horizon data upheld the random walk hypothesis for the real exchange rates; suggesting that deviations from PPP are permanent (see Taylor, 1988; Mark, 1990). Roll (1979), Alder and Lehman (1983) and MacDonald (1985) have all upheld the unit root null hypothesis. Alder and Lehman (1983) investigated data spanning from 1901 to 1972 and found no evidence to reject the random walk model. On their part, Taylor (1988), Mark (1990) and Patel (1990) employed the co-integration methodology and their results suggest that there is no tendency in the long run for the exchange rate and relative prices to settle on an equilibrium path. Acaravci and Acaravci (2007) found evidence that rejected the empirical validity of PPP for both developed countries and emerging market economies. The real exchange rates among Pacific Basin countries were also found to be non-stationary by Wu, Tsai and Chen (2004). It has been difficult for researchers to support empirically that real exchange rates in the long-run converge to PPP.

The inability to reject the random walk hypothesis of the real exchange rate may be attributed to the lack of power of the statistical tests. Frenkel (1986) suggests that the statistical tests commonly used to investigate PPP may lack power. The non-stationarity hypothesis has not been rejected because of the lack of power in the standard unit root and co-integration tests (Hyrina and Serletis, 2010). Abuaf and Jorion (1990) suggest that the negative results in the empirical studies are a reflection of the poor power of the test rather than evidence against PPP. The power problems in unit root tests are frequently cited for being responsible for the feeble empirical support for PPP (Sjolander, 2007).

Alba and Park (2003) note that the power of the test increases when panel data analysis is employed. Some studies have therefore attempted to improve the power and reliability of tests by increasing the number of countries under consideration. Hakkio (1984), for instance, carried out a joint test of four industrialized-countries' exchange rates against the dollar. Even though the power of the test improved, Hakkio found no evidence to reject the random walk model. Drine and Rault (2008) using panel unit root test found no evidence for PPP for African, Asian, Latin American and Central and Eastern European (CEE) countries.

Evidence for Long-Run Purchasing Power Parity

Some studies on long horizon data series have reported evidence of mean reversion in real exchange rates. Galliot (1970), Lee (1976) and Friedman (1980) found evidence in support of long-horizon mean reversion in PPP. Huizinga (1987), and Chowdhury and Sdogati (1993) found support for long-run PPP. Abuaf and Jorion (1990) show evidence of mean reversion in the real exchange rate by modeling the time-series properties of the real exchange rate. Corbae and Ouliaris (1988) and Kim (1990) provide evidence to support the long-run PPP hypothesis. Frenkel (1986) using annual data from 1869 to 1984 is able to reject the random walk hypothesis of the real exchange rate. Edison (1987) using data for the period 1890–1978 provided evidence to support the PPP hypothesis. Glen (1992) finds mean-reversion in the real exchange rates over the sample period from the years 1900 to 1987. Moosa (1994) found evidence for long-run PPP. Lothian and Taylor (1996) using two centuries of data provided evidence that supports PPP.

Abuaf and Jorion (1990) used data from 1901-1972 and noted mean reversion in real exchange rates. Similar results have been reported by Glen (1992) using bilateral data for the period 1900-1987. Diebold, Husted, and Rush (1991) also found evidence to reject the random walk model. They used data spanning between 74 and 123 years from the gold standard era. Chen and Kon Lai (1994) also note mean reversion in real rates across several countries for the period 1900-1992. Frenkel and Rose (1995) find evidence to reject the random walk model after examining data for 150 countries from 1948-1992. Drine and Rault (2008) using panel unit root test found evidence for strong PPP for OECD countries and weak PPP for Middle East and North African (MENA) countries. Hadri (2000) carried out panel data analysis and noticed mean reversion in the real exchange rate for the OECD

countries. Murray and Papell (2005), Papell (2002), Papell and Theodoridis (2001) all found evidence to support the validity of PPP.

It is worth noting the suggestion by O'Connell (1998) that the panel evidence disappears if one takes into account the strong cross-sectional dependence in real exchange rates. Maddala (1998) also notes that panel data analysis creates cross-sectional heterogeneity problems which may be worse than time homogeneity or structural breaks. Sjolander (2007) argues that panel tests of PPP are questionable on statistical grounds. It is also important noting that both fixed and flexible rates data are used together in most of these studies. Mussa (1986) notes that the behavior of real exchange rates under different exchange rate regimes are very different. Drine and Rault (2008), however, observe that the nature of the exchange rate regime does not condition the validity of PPP.

Half-Life for the Real Exchange Rate Reversion to its Mean

Studies that supported the PPP hypothesis suggest a long half-life of PPP reversion. The consensus in the literature on the half-life of deviations to PPP is 3-5 years (Rogoff, 1996). Moosa (1994) suggests a half-life of 2 to 3 years. Edison (1987) argues that shocks affecting real exchange rates are very persistent, and the half-life is about 7.3 years. Abuaf and Jorion (1990) suggest 3.3 years half-life of PPP deviations. Diebold and associates (1991) suggest an average half-life of 2.8 years for exchange rate. Glen (1992) suggests a half-life of 3.3 years. Frenkel and Rose (1995) note an estimated half-life of four years for deviations from PPP which is in agreement with what is suggested by the long-horizon data. Lothian (1997) also obtained similar estimates of convergence to PPP. Hegwood and Pappel (1998) note that the half-life of PPP deviations in long horizon data is much reduced once the effects of occasional permanent disturbances to real exchange rates are accounted for. Wei and Parsley (1995) estimated the half-life for deviations in PPP for non-European Monetary System and European Monetary System (EMS) areas respectively as 4.75 and 4.25 after examining post 1973 data for 14 OECD countries. They also found out that there is a faster convergence to PPP when initial deviations are large. Taylor and Peel (2000) investigated nonlinear mean reversion. They note that the speed of adjustment to real exchange rates shock may be much greater than what is found in linear models once allowance is made for non-linearities. Despite the limitations of the long horizon and cross section results, deviations in PPP in general disappear slowly at about 15 percent per annum (Rogoff, 1996).

Methodology

A test of the PPP hypothesis involves either a test of the relative or absolute versions of the hypothesis. The paper tested the relative PPP hypothesis; it postulates that exchange rates will adjust by the amount of inflation differentials between two economies. This can be represented as;

$$\Delta r = \Delta \rho^d - \Delta \rho^f \quad (1)$$

where Δ represents a proportionate change in the variables with respect to time, and, and are the logs of the nominal exchange rate R (R is expressed as the domestic currency's price of one unit of the foreign currency), the price of the good in terms domestic currency P^d , and the price of the good in terms of foreign currency P^f respectively. Most researchers have tested the PPP hypothesis by applying unit root tests to the real exchange rate (S). The PPP hypothesis holds if only there is a tendency for the real exchange rate to revert to its equilibrium value. That is, the time series process of the real exchange rate is stationary if PPP holds. This is the approach used in this paper.

The null hypothesis that s (the natural log of S) has a unit root is tested against the alternative that s is stationary. The ADF test, in this case involves regressing the first difference of the logarithm of the real exchange rate (s_t) on a constant (α), the lagged level of s_t (s_{t-1}), and k lagged first differences (see Papell (1997), Papell (1998) and OH (1996)). That is;

$$\Delta s_t = \alpha + \beta s_{t-1} + \sum_{i=1}^k b \Delta s_{t-1} + \omega_t \quad (2)$$

Evidence of PPP is found if the unit root null hypothesis can be rejected in favor of the alternative hypothesis of stationarity of the real exchange rate. The question, however, is whether the alternative hypothesis should be level or trend stationarity, that is, whether a time trend should be included in equation (2) or not. An included trend means that there is increased divergence in inflation rates and not just price levels in the case of relative PPP. These issues are of central importance in studying long-horizon real exchange rates. This paper, tests the PPP hypothesis with the alternative hypothesis first as a level stationarity and second as a trend stationarity.

If β is significantly different from zero, the null hypothesis of a unit root is rejected in favor of the alternative hypothesis of stationarity. A rejection of the null hypothesis is viewed as evidence in favor of PPP. Several lag cases are investigated since a lag selection problem may occur. The number of lags is chosen by using recursive t-statistic procedure suggested by Campbell and Perron (1991) and Ng and Perron (1995). The maximum value of k is set equal to 8 and the 10% value of the asymptotic normal distribution used to determine significance. The choice of the maximum value of k is somewhat arbitrary. A large value of k would allow unrestricted procedure as possible. However, a large maximum value of k could lead to multicollinearity problems in the data and also a substantial loss of power.

Data Series

Quarterly data (from the first quarter of 1957 to the fourth quarter of 2010) obtained from the International Monetary Fund's (IMF) International Finance Statistics (IFS) online database were used. The price measure used was the CPI. The price of a unit of US dollar was used as the exchange rate. These variables are standard choices in the literature. Mexico is treated as the home country for prices and exchange rate.

Presentation of Results

The relative PPP hypothesis suggests that exchange rates will adjust to compensate for the inflation differential between two economies. The inflation rates in this study are estimated from the consumer price indices (CPI), and of the home and foreign economies respectively at a given time t . Let R be the nominal exchange rate (home currency price for a unit of foreign currency), S the real exchange rate, and Δ the change in the variables (Δ is either a proportionate or a percentage change in the variables over a period of time). The inflation differential (π) between the two economies would be given by;

$$\pi = \Delta\rho^{dt} - \Delta\rho^{ft} \quad (3)$$

Where, is the rate of inflation in the home country and is the inflation rate in the foreign economy all measured at time t .

The relative PPP hypothesis could then be formulated as;

or

$$\Delta S = \pi - \Delta R = 0 \text{ or } \pi = \Delta R \quad (4)$$

Table 1: Univariate Unit Root Test for the Whole Period (1957:1 – 2010:4)

No. of Lags	B	ADF test Statistic	Critical Values			P-value
			1%	5%	10%	
1	-1.258024	-9.959042	-3.478186*	-2.882433*	-2.577990*	0.0000
2	-0.949565	-5.866556	-3.478187*	-2.882435*	-2.577991*	0.0000
3	-0.939764	-5.158389	-3.478188*	-2.882436*	-2.577993*	0.0000
4	-0.969343	-4.838803	-3.478189*	-2.882438*	-2.577995*	0.0001
5	-1.157783	-5.408384	-3.478192*	-2.882439*	-2.577996*	0.0000
6	-1.264532	-5.337283	-3.478195*	-2.882440*	-2.577998*	0.0000
7	-1.385684	-5.299742	-3.478199*	-2.882443*	-2.577999*	0.0000

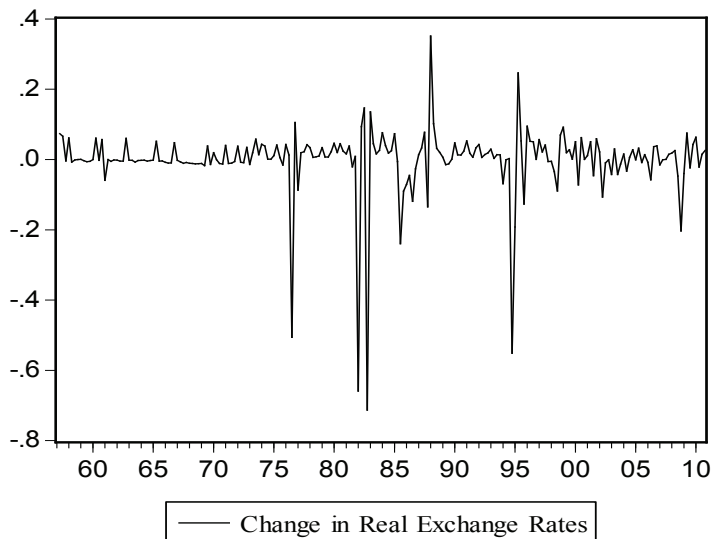
* Indicates a rejection of the null hypothesis of unit root at each level of significance.

The results of the ADF tests of the real exchange rate are presented in Table 1. The tests employed the CPI and the data used were for the whole period (1957:1 to 2010:4). The reported ADF tests are without trend. The critical values for the 1%, 5% and 10% significance levels are reported. The null hypothesis was rejected for all cases. By

incorporating a time trend, similar results were found. The trend coefficient was also found to be insignificant in the testing equation.

An inspection of Figure 1 suggests mean reversion in the real exchange rate for the period 1957:1 to 2010:4. This conforms to the ADF test results presented in Table 1.

Figure 1: Real Exchange Rates for the Whole Period



The paper investigates the PPP problem further; by testing the PPP hypothesis for the floating rate period (1976:3 to 2010:4). The results are reported in Table 2 (the experiment was performed without trend in equation 2).

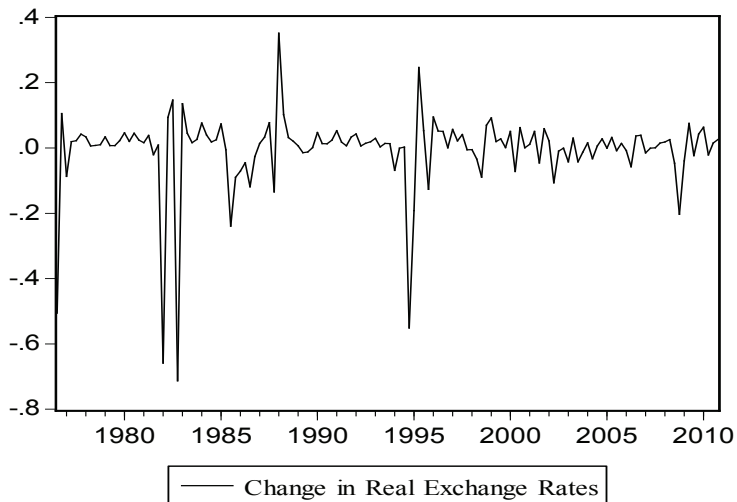
Table 2: Univariate Unit Root Test for the Floating Rate Period (1976:3 – 2010:4)

No. of Lags	B	ADF test Statistic	Critical Values			P-value
			1%	5%	10%	
1	-1.240476	-10.41072	-3.4788547*	-2.882590*	-2.578074*	0.0000
2	-0.914190	-5.871292	-3.478911*	-2.882748*	-2.578158*	0.0000
3	-0.940894	-5.369539	-3.479281*	-2.882910*	-2.578244*	0.0000
4	-0.899548	-4.643265	-3.479656*	-2.883073*	-2.578331*	0.0002
5	-1.088716	-5.278619	-3.480038*	-2.883239*	-2.578420*	0.0000

6	-1.161886	-5.076937	-3.480425*	-2.883408*	-2.578510*	0.0000
7	-1.309884	-5.206321	-3.480818*	-2.883579*	-2.578601*	0.0000

* Indicates that we reject the null hypothesis of unit root at the given level of significance

Figure 2: Real Exchange Rates for the Floating Rate Period



As Table 2 shows, the unit root null hypothesis was rejected for all cases over the floating rate period. Also, an inspection of Figure 2 suggests mean reversion in the real exchange rate for the floating rate period. Further tests were performed but with a trend in equation 2. The result of the tests for the floating rate period with or without trend is consistent with that of the whole period; except in one case when the test with trend could not reject the unit root null hypothesis but that without trend rejected it. The trend coefficient is not significant in this case.

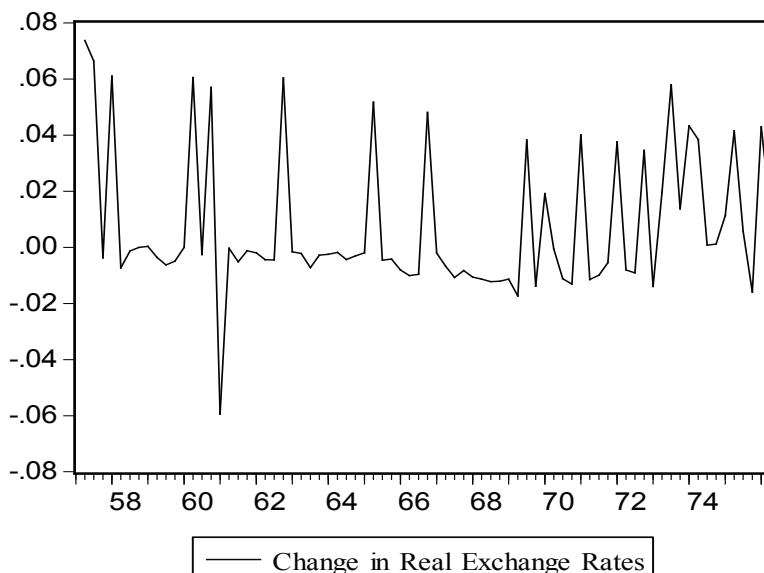
Table 3: Univariate Unit Root Test for the Fixed Rate Period (1957:1 – 1976:2)

No. of Lags	B	ADF test Statistic	Critical Values			P-value
			1%	5%	10%	
1	-1.010363	-6.398098	-3.520307*	-2.900670*	-2.587691*	0.0000
2	-0.901175	-4.501186	-3.521579*	-2.901217*	-2.587981*	0.0005
3	-1.029628	-4.571736	-3.522887*	-2.901779*	-2.588280*	0.0004
4	-1.047207	-3.994394	-3.524233*	-2.902358*	-2.588587*	0.0025
5	-0.939815	-3.148021	-3.525618	-2.902953*	-2.588902*	0.0275
6	-0.945408	-2.883927	-3.527045	-2.903566	-2.589227*	0.0523
7	-0.904956	-2.537435	-3.528515	-2.904198	-2.589562	0.1112

* Indicates that we reject the null hypothesis of unit root at the given level of significance

Table 3 indicates that the unit root null hypothesis was rejected for some but not all cases for the fixed exchange rate period (1957:1 – 1976:2). A visual inspection of Figure 3 is indicative enough of the existence of mean reversion for some cases but not all cases in the real exchange rate over the fixed rate period. It cannot therefore be said that PPP holds in all cases for the data over the fixed rate period.

Figure 3: Real Exchange Rates for the Fixed Rate Period



The result as discussed above provides strong evidence for PPP either as level or trend stationarity. The change in the real exchange rate (ΔS_t) is regressed on a constant to further analyze the PPP hypothesis. The coefficient of α was found to be -0.001350 , -0.006097 , and 0.007156 respectively for the whole period, floating rate period and the fixed rate period which are not significantly different from 0. This is consistent with the theory which postulates that should have a value of 0.

If follows a first order autoregressive (AR(1)) process, then we have;

$$\Delta S_t = \alpha + \beta \Delta S_{t-1} + \omega_t \quad (5)$$

Where $\beta = 1$ corresponds to a unit root and hence a rejection of the PPP hypothesis. α and β are constants with the error term being independently distributed over time. The constant in the stationary AR(1) process satisfies $\alpha = (1-\beta)\mu$, where μ is the mean of the series. It follows that the null hypothesis of a unit root also implies $\alpha = 0$. It is therefore possible to jointly test the restrictions $\beta = 1$ and $\alpha = 0$. However, it is easier and common to test only the restriction $\beta = 1$. The null hypothesis of a unit root; $H_0: |\beta| = 1$ is tested against the alternative hypothesis of no unit root; $H_1: |\beta| < 1$. A rejection of H_0 is viewed as evidence in favor of PPP.

Table 4: AR(1) Estimation

Coefficients	Whole period (1957:1 – 2010:4)	Floating rate period 1976:3-2010:4	Fixed rate period (1957:1-1976:2)
α	-0.001841	-0.006717	0.006551
β	-0.094615	-0.100100	-0.038241

Table 4 presents the results of estimating equation 5. The result of the AR(1) estimations confirms the stationarity of the series for all periods. H_0 is therefore rejected in favor of H_1 . This is consistent with the ADF tests reported above. The estimate of β is about -0.094615 (hence first order autocorrelation is about 0.9054) for the whole period which implies a half-life of 7 quarters (1-2 years) for the real exchange rate adjustment. However, the estimate for the floating rate period is -0.100100 (first order autocorrelation is about 0.8999) which means the half-life is 6-7 quarters (1-2 years). The strong rejection of the unit root null hypothesis in this paper may be due to the long horizon data set used.

Conclusion

A survey of the PPP literature suggests a consensual rejection of the PPP hypothesis over the short run; however there is no consensus on mean reversion in the real exchange rate over the long run period. While some studies have provided evidence in support of the PPP hypothesis over the long run, other studies have rejected it. Various techniques (including

univariate unit root tests, cointegration tests and panel unit root test) aimed at improving the power of their tests have been used by researchers to test the PPP hypothesis.

This paper employed univariate unit root technique to test for mean reversion in the bilateral real exchange rate between Mexico and USA. A unit root in the real exchange rate is strongly rejected. Long-run equilibrium tendencies are thus evident. The PPP has widely been used as the basis of the equilibrium exchange rate; the result indicates that this may not be completely inadequate.

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