International Journal of Economics and Finance; Vol. 7, No. 3; 2015
ISSN 1916-971X E-ISSN 1916-9728
Published by Canadian Center of Science and Education

An Empirical Test of Purchasing Power Parity Theory for Canadian Dollar-US Dollar Exchange Rates

Hussein Al-Zyoud[1]

[1] Faculty of Business, Athabasca University, Athabasca, Canada

Correspondence: Hussein Al-Zyoud, Faculty of Business, Athabasca University, 1 university Drive, Athabasca, AB., T9S 3A3, Canada. Tel: 1-780-457-7534. E-mail: husseina@athabascau.ca

Received: November 21, 2014 Accepted: Decemberber 22, 2014 Online Published: February 25, 2015

doi:10.5539/ijef.v7n3p233 URL: http://dx.doi.org/10.5539/ijef.v7n3p233

Abstract

The paper examines the long run movement between Canadian dollar and US dollar exchange rates. The study uses monthly data for the period 1995:01 to 2008:08 and employs the Engle-Granger cointegration test. Our analysis suggests that the absolute purchasing power parity (PPP) does not hold, indicating no long run relationship between the observed exchange rate and PPP rate. The result shows that there is no cointegration between actual exchange rate and PPP rate, suggesting that there is no long run relationship between Canadian dollar and US dollar exchange rates. A close examination of the data shows that output prices move more slowly, and is evidence against PPP in the short run. We acknowledge that the study period may be small to capture the existence of a long run relationship. However, our regression analysis suggests that the relative price movements are significant in explaining the actual exchange rate between US and Canada.

Keywords: purchasing power parity, Ordinary Least Squares (OLS), Engle-Granger cointegration, Canada and US

1. Introduction

One of the oldest frameworks for assessing the long-term movement of exchange rates is derived from purchasing power parity (PPP) theory. The theory simply asserts that there is an impulse-response relationship between exchange rates and prices (Chortareas & Kapetanios, 2013). The PPP theory states that, in the long run, identical goods and services in different countries should cost the same in those countries. This is based on the belief that the exchange rate will adjust to eliminate the arbitrage opportunity of buying a product or service in one country and selling it in another country. PPP exchange rates are frequently used in the comparison of living standards internationally (Lafrance & Schembri, 2002). Specifically, PPP theory implies that a basket of goods should cost the same in different countries regardless of the country in which the goods are purchased after adjustment has been made for the exchange rate between the countries. Typically, "the basket" will involve many goods; these will be considered and weighted according to their importance within the economy.

There are two variants of this theory: the absolute version and the relative version. The absolute version of PPP states that the exchange rate between the currencies of two countries is equal to the ratio of the price levels in the two countries:

$$E_t = \frac{P_t}{P_t^*} \tag{1}$$

Where E_t, P_t, and P^*_t are the exchange rate, domestic price level, and foreign price level, respectively at time *t*. The PPP theory therefore predicts that when the domestic price level increases or decreases relative to the foreign price, domestic currency depreciates or appreciates proportionally. The basic idea is that goods and markets are integrated and hence if there is a price differential across countries arbitrage will take place until the price levels are equalized.

However, in reality, most of the traded goods are differentiated products rather than substitutable commodities and for this and other reasons consumption baskets across countries differ. This inconsistency in the initial premise challenges the empirical validity of the absolute version of PPP theory at the aggregate level. The problem has been addressed in the relative version of PPP. Relative PPP states that the percentage of change in the exchange rate between two currencies over any time period equals the difference between the percentages of

change in the price levels of goods over that same time period (Lafrance & Schembri, 2002). Relative PPP thus translates absolute PPP from a statement about price and exchange rate levels into one about price and exchange rate change (Lafrance & Schembri, 2002). In the conversion from absolute PPP to relative PPP, the concept of relative PPP affims that both the price level and the exchange rate relative to trading partners will maintain the previous ratio of each of the currrencies' purchasing power both domestically and internationally. To express the relative version of PPP, we present it as shown in the following expression:

$$\frac{E_t - E_{t-1}}{E_{t-1}} = \frac{P_t - P_{t-1}}{P_{t-1}} - \frac{P_t^* - P_{t-1}^*}{P_{t-1}^*} \quad (2)$$

Thus, the exchange rate between two countries is equal to the ratio of the price levels within the two countries. The domestic purchasing power of one's own currency is shown by the price level of one's country (in other words, the overall price of a given basket of goods and services). Therefore, PPP theory assets that a decline in a country's domestic purchasing power will be connected to a proportionate drop in its own currency on the foreign exchange market. In the case of a rise in the domestic purchasing power of one's own currency, there will be a proportionate appreciation of the currency. It should be noted that the validity of the PPP theory has been questioned by some economists, so that the theory is the subject of some debate within the economics profession. Nevertheless, it is generally felt to be valid, and that the theory does indeed demonstrate that there are key underlying reasons for affecting the movement of exchange rates.

Empirically, there has not been any clear-cut evidence to substantiate PPP theory in any of its forms (Ramajo & Ferre, 2010; Shiller, 2013). This is particularly true with respect to the application of PPP to the floating period that followed the Nixon shock and the collapse of Bretton Woods in the early 1970s (Ramajo & Ferre, 2010).

Some of the reasons advanced for the difficulties in applying PPP theory to actual exchange rates involve the difference in inflation rates between countries, impediments to trade, the effect of foreign exchange intervention by central banks, cost of transportation of goods between countries, and the influence of non-tradables on PPP etc. However, in spite of these issues, the increase in free trade between nation states that has resulted from globalization has led to a resurgence of interest in PPP theory. As globalization advances the integration of markets and supports a less restricted flow of goods and services between countries, the potential for PPP to elucidate the relationships between exchange rates and price levels is being re-evaluated.

It is believed that there is an increased likelihood that PPP theory might hold under these less restrictive circumstances. If PPP theory indeed holds, then the determination and prediction of exchange rates may become easier.

2. Contribution to Current Literature

Canada's special economic bond with the US raises intriguing aspects relating to bilateral exchange rates with specific implications for price movements in the two domestic markets. An examination of current economic literature highlights the ongoing debate among researchers regarding the validity of the PPP theory. The long-run PPP between Canada and the US displays mixed experimental evidence (Crowder, 1996; Campbell & Lapham, 2001; Rao et al., 2004; Anderson et al., 2003). The PPP theory continues hold the attention of researchers due to its effects both on theoretical exchange rate determination frameworks (Cerrato et al., 2013) as well as for practical comparative exchange rate policy-making models (Engel et al., 2012). By employing a fractionally integrated process the Engle-Granger two step method of cointegration permits divergence from equilibrium. Moreover, based on the work of Enders and Chumrusphonlert (2004), the method enables the attainment of a broader range of mean-reversion behavior as compared to results provided by standard cointegration studies. Using the Engle-Granger two step method of cointegration, this paper aims to provide important insights into aspects relating to Canada-US bilateral exchange rates with specific implications for price movements in the two domestic markets.

3. Review of Literature

Despite the controversy described above, it is generally accepted that the PPP theory is acceptable as a predictor of long run changes in PPP. In other words, the exchange rate between the two countries in question is expected to be proportionate to the ratio of price levels for these two countries. The literature indicates that there are well known problems with the applicability of PPP theory over short time intervals. Empirical results have shown significant departures from theory over short observation times (Shiller, 2013; Taylor, 2000). The validity of the short run co-movement between exchange rate and relative price level between two countries has been rejected by most empirical studies. However, in the long run, if there are deviations in the exchange rates, market forces may bring them back to their PPP rates. However, analyses of the applicability of PPP theory over extended

periods have also yielded inconsistencies that appear to be related to the currencies under consideration, the price indices that are chosen to measure inflation, price levels, and importantly, the observation period under consideration (Shiller, 2013). In addition, there are also known problems generated when the PPP model is applied to time-series data which has been sampled below the Nyquist-Shannon sampling frequency (Taylor, 2000; Wang & Jones, 2002). Issues of temporal aggregation can arise when data is sampled annually or monthly (Taylor, 2000). Low frequency sampling cannot possibly account for higher frequency parity adjustments (Taylor, 2000; Wang & Jones, 2002).

Despite the fact that some empirical studies are supportive of the PPP theory, most recent studies do not provide evidence that the theory is valid. Supportive studies include the following; Cassel (1916), Keynes (1923), Gaillot (1970), Frankel (1978), and Ohno (1990), have found that PPP theory held. This is important since the respective studies involved data series that covered a range of time periods. The results were contrary to those of Friedman et al (1963), Frankel (1981), Hakkio (1984), Mark (1990), and Rogoff (1996) that found PPP theory did not hold. Some of the important reasons for the failure of PPP theory include the different economic conditions of the countries where parity was being investigated, different economic policies, different price levels for non-traded goods in rich and poor countries, real shocks in the economy, and differences in the time periods over which the studies were done as well as price deviations between international and domestic markets.

Hyrina and Serletis (2010) point out that while the literature indicates that early studies undertaken to verify PPP theory mostly rejected it, later studies employed econometric techniques to evaluate and adjust earlier testing procedures in order to try and mitigate weaknesses in the early testing methodology. Hyrina and Serletis (2010) found that PPP testing methods evolved over time and could be sorted into 6 different categories ranging from early testing methods based on the null hypothesis that PPP holds (Frankel, 1981) to the introduction of the panel-based unit root tests. There is overlap in the different time periods in which the studies took place within this categorization scheme. The time period over which a study takes place is important since there are economic variables that are specific to geographical location that may also be event related and thus temporally dependent. Enders (1988) used the autoregressive integrated moving average (ARIMA) test which resulted in mixed support for the PPP hypothesis over the Bretton Woods period and the flexible exchange rate period following Bretton Woods. The point estimates of the long run real exchange rate for Canada, Japan, and Germany did not significantly differ from unity. Point estimates for all three of these countries indicated that the real exchange rates were convergent over the time period. However, confidence intervals were sufficiently large that the null hypothesis which asserted that the real rate follows a random walk could not be rejected. The test of cointegration also provided mixed evidence that PPP holds. The point estimate of long run real rates is far from unity. However, there is strong support for cointegration of US and Japanese price levels after 1973. This implies that error correcting models are in accord with the intuitive idea that US prices will adjust to any deviation from PPP. Other than an increase in the variability and a decline in the predictability of real rates, there is little evidence to support the claim that PPP collapsed during the 1970s. The point estimates and the test for stationarity indicate that PPP performs equally well or equally poorly over both time periods.

Studies by Meese and Rogoff (1988) and by Mark (1990) did an evaluation of time series data after the cessation of the Bretton-Woods Agreement, and basically determined that there was no support for the PPP theory. Frenkel (1986, 1990) did raise a possible reason for this lack of support. He indicated that the technique used for the study did not involve a sufficient time interval, and that the data collected had insufficient data points to show both evidence of departure from as well as adherence to PPP. Another cause may be the types of tests that have been used. The author suggested two approaches which would increase the power of the tests: (i) use of very long time series data (increase the time interval over which data is collected) and (ii) obtain data for a panel of many countries using only floating data. Frankel (1986) and Abuaf and Jorion (1990) support the use of data from a very long time series; studies may benefit from using time series data that extends over periods as long as a century. The use of long time series data has yielded evidence in favor of PPP. Frankel and Rose (1996) and Papell (1997) have found evidence in favor of PPP using panel analysis involving many countries. However, O'Connell (1998) has found that the evidence for PPP using panel studies disappears if one takes into account the strong cross-sectional dependence in real exchange rates. This argument does not apply if one is looking at the univariate exchange rate. Klaassen (1999) has found evidence in favor of long run relative PPP over the post-Bretton Woods floating period. He attributed the supportive evidence for PPP to a new test involving a regime-switching model in which regime-switching probabilities were dependent on the deviation of exchange rates from PPP. Presently, the literature provides no clear answer regarding the validity of PPP.

4. Methodology of the Study

In order to understand the validity of the purchasing power parity theory of exchange rate determination between

Canada and US, the study empirically examines both relative PPP and absolute PPP. The study uses monthly data and carefully examines the stylised facts with the help of graphs to get a preliminary idea about the relationship between actual exchange rate and the PPP rates. To quantify the relationship to examine the validity of PPP, the study uses the Engle-Granger cointegration test. The study also uses ordinary least square method to understand the influence of the variables used in PPP on the actual exchange rate.

5. Empirical Analysis

We try to understand whether PPP holds in terms of Canada dollar–US dollar exchange rate using monthly data for the study period 1995:01 to 2008:09. The study uses the following variables:

(1) Exchange rates (bilateral exchange rate of Canadian dollar and US dollar)

(2) Domestic price index (Consumer Price Index of Canada)

(3) Foreign price index (Consumer Price Index of US)

The PPP theory of exchange rate determination suggests that the actual exchange rate and the PPP rate should be cointegrated. Visual inspection of series may help to identify cases in which cointegration is possible. For example, the graph of the two exchange rates (see Figure 1) shows that each of the series appears to be I(1) and the spread (the difference between actual and PPP rate) appears to be I(1) and hence, the two series appear to be non-cointegrated.

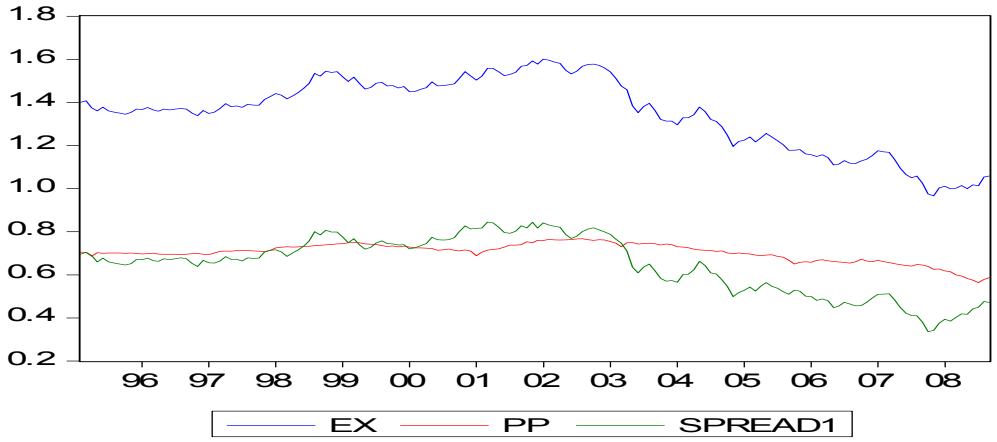

Figure 1. Actual exchange rate, PPP rate and the spread

However, we have examined the plausible cointegration between the two rates using the unit root testing procedure. The insight in which this test is based is that if the two series EX and PPP are cointegrated with cointegrating coefficient θ, then $EX - \theta\ PP$ is stationary; otherwise, $EX - \theta\ PPP$ is non-stationary, that is I(1). Before applying the cointegration test, we need to test the stationarity property of the variables. We apply both ADF and PP test. Both tests consistently suggest that the variables under consideration are non-stationary in the level but stationary in the first difference (see Appendix Table 1). As the variables in the study are I(1) in level, we go for cointegration analysis. As the value of θ is known to us as 1 suggested by economic theory, we need to test the stationarity of the series $u = (EX - \theta\ PPP)$.

The stationarity result of the error series $\boldsymbol{u}$ is given below in Table 1. We applied DF, ADF and PP to check the stationary property in three possible cases, that is, under the assumption of no constant, only constant, and both constant and trend. All the tests consistently suggest that the series $\boldsymbol{u}$ is non-stationary even at 5% level of significance. This indicates that the variables EX and PPP are not cointegrated under the assumption of cointegrating parameter value 1. So there is no long run relationship between actual exchange rate and PPP rate (Engle & Granger, 1987). And hence we can conclude that the absolute PPP does not hold for Canada and US for the period under study.

Table 1. Stationarity of the series u

Assumptions	DF	ADF	PP
No Constant	-0.67	-0.42	-0.62
Constant	-1.21	-1.46	-1.45
Constant and Trend	-1.73	-2.45	-2.07

Note. The ADF and PP Critical values with constant at 1%, 5% and 10% respectively are -3.47, -2.87 and -2.57. The ADF and PP Critical values with trend at 1%, 5% and 10% respectively are -4.01, -3.43 and -3.14.

The economic theory suggests that even if absolute PPP does not hold, there is a possibility that relative PPP may hold. Therefore, we also test the relative PPP for Canada dollar–US dollar exchange rate using monthly data for the same study period. We plot the monthly movement of percentage change in actual exchange rate and the difference between the percentage changes in the price levels of the two countries and their spread in Figure 2. The visual inspection of the figure suggests that the series are stationary. The purchasing power parity theory says that the inflation differential between the two countries will be offset by exchange rate changes. So in a market determined exchange rate regime it is expected that PPP rate and market rate should coincide. However, from Figure 2 it is seen that whereas quite often the two series move in same direction they sometimes move in opposite directions.

We test the stationarity property of the variables under consideration for testing relative PPP. The result is given in Appendix Table A1. We find that all the variables are stationary at 1% level of significance. Therefore we can study the relationship by standard regression analysis. The coefficient of PPP is expected to be 1 if relative PPP is to hold. We estimated the relative PPP model and presented in Appendix Table 2. The result shows that the estimated coefficient is very low–that is, 0.5–, but significant. This indicates that inflation differential between the two countries is an important variable to explain the percentage change in exchange rate but not to the PPP rate. This suggests that relative rates of inflation do not provide a satisfactory explanation for the exchange rate behaviour during the study period.

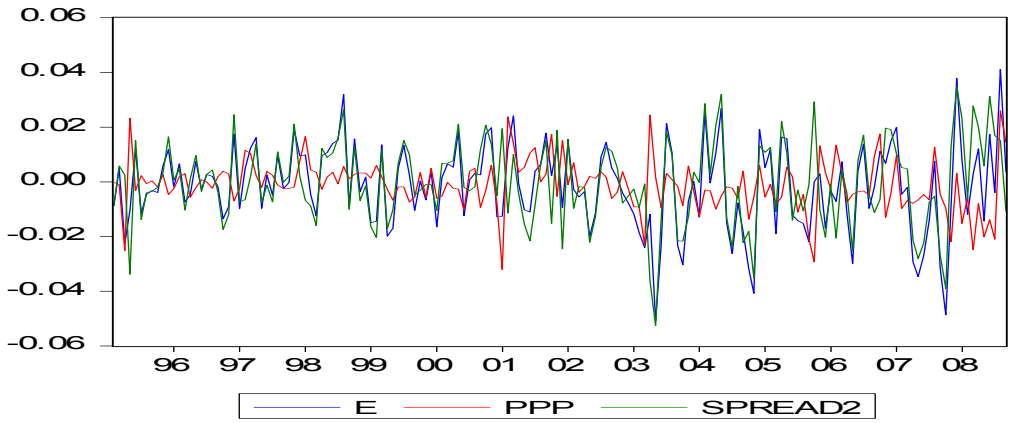

Figure 2. Percentage change in actual exchange rate, PPP rate and the spread

6. Concluding Comments

In this article, we examine both absolute and relative purchasing power parity (PPP) for exchange rate determination for Canada and US. Close examination of the data shows that output prices move more slowly, and suggests against PPP in the short run. Our analysis indicates that the absolute PPP does not hold, yielding no long run relationship between the observed exchange rate and PPP rate. This is evident from our cointegration analysis. The relative PPP also does not hold exactly. However, PPP rate is significant in explaining the actual exchange rate between Canada and US. A more rigorous econometric exercise may be employed to strongly reject the validity of the PPP. A longer period of analysis may also be required to capture the long run relationship between actual exchange rate and PPP rate.

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Appendix

Table A1. Results of unit root test

Variables	ADF(4)		PP(4)	
	With constant	With Trend	With constant	With Trend
EX	-0.36	-1.62	-0.11	-1.23
DP	1.51	-2.83	1.15	-2.48
FP	1.95	-0.20	2.61	0.10
PP	0.20	-0.62	0.94	-0.24
dEX	-4.87	-5.06	-9.90	-9.97
dDP	-7.03	-7.32	-12.92	-13.06
dFP	-5.55	-6.39	-9.95	-10.29
dPP	-4.74	-5.34	-12.29	12.68

e	-4.84	-5.02	-9.90	-9.98
p	-7.12	-7.24	-13.97	-14.02
q	-5.33	-6.05	-10.27	-10.58

Note. (1) The ADF and PP Critical values with constant at 1%, 5% and 10% respectively are -3.47, -2.87 and -2.57. The ADF and PP Critical values with trend at 1%, 5% and 10% respectively are -4.01, -3.43 and -3.14.

(2) e, p and q are respectively the percentage change in exchange rate, the percentage change in domestic price and the percentage change in foreign price.

Table A2. The regression results

Dependent Variable: EX (% change in exchange rate)
Method: Least Squares
Sample(adjusted): 1995:03 2008:09
Included observations: 163 after adjusting endpoints
Convergence achieved after 5 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PPP	0.499632	0.118201	4.226961	0.0000
AR(1)	0.253218	0.076592	3.306062	0.0012
R-squared	0.146998	Mean dependent var		-0.001599
Adjusted R-squared	0.141700	S.D. dependent var		0.015500
S.E. of regression	0.014360	Akaike info criterion		-5.636545
Sum squared resid	0.033200	Schwarz criterion		-5.598585
Log likelihood	461.3784	Durbin-Watson stat		1.959701
Inverted AR Roots		.25		