A Test Of Purchasing Power Parity (PPP) Theory And The International Fisher Effect: A Case Of The U.S. Dollar And The Japanese Yen

Dr. Kishore G. Kulkarni, Economics, Metropolitan State College of Denver

Abstract

The present paper discusses the theories of Purchasing Power Parity (PPP) and the International Fisher Effect dating back to the early years of the twentieth century, and tests their evidence for the recent time period data for the U.S. dollar - Yen exchange rate. The results show that both these theories provide a satisfactory explanation of the behavior of exchange rates. One of the main reasons why these theories lost their explanatory power in recent years was the inflexibility of exchange rates in the Bretton Woods System. However, as the exchange rates became flexible again in recent years, the theories have become more applicable. It is further observed that the quarterly data are more relevant for these theories than the monthly data.

Introduction

A simple but enduring explanation of exchange rate determination is found in Gustov Cassels' Purchasing Power Parity (PPP) theory, laid down first in Cassel (1922), in the aftermath of the first World War. Over the years, the view that PPP holds in the long-run has not been seriously challenged. It needs to be mentioned, however, that the tests of the theory have been generally carried out for the years around 1930 only.

The present paper conducts an empirical test of Purchasing Power Parity (PPP hereafter) for the recent time trend 1980-1981, for the Dollar-Yen exchange rate. Of course, ever since the advent of the flexible exchange rate system in 1973, various tests have been carried out for the various theories of exchange rate determinants including the portfolio balance approach and the monetary approach, which has been coincided by some to be the "sharpest" formulation. However, even the monetary approach in the simplest form is eventually an evaluation of the price and most relevant only under fixed exchange rates. In general, there are other theories including the expectations-augmented approaches that address the short-run fluctuations and do not really compete with the PPP theory as long-run explanations. Indeed PPP may or may not coincide in the long-run tendency in these models.

In this paper, we also test another theory of exchange rate determination based on the International Fisher effect, which was also put forth in the early 1900s. At the domestic level, the International Fisher effect concerns the relationship between nominal and real interest rates. When applied internationally, it implies that differences in national interest rates will affect the exchange rate given the free arbitrage activities. This effect may be either tested for directly or serve as the underpinning of a model to test for deviations from PPP. We adopt the former of the two approaches.

The paper is organized as follows: Section 1 reviews briefly the relevant research on PPP and the International Fisher Effect in recent years; Section 2 formulates a simple model of exchange rate determination based on Cassel's absolute and relative PPP specifications, also formulating a testable equation for the International Fisher Effect; and Section 3 uses monthly and quarterly data of the U.S. Dollar-Yen exchange rate to examine the validity of the models specified in the earlier section. There is a final concluding and summary section.

Section 1: A Review of Relevant Research on the PPP Theory and the International Fisher Effect

One of the most extensive reviews of earlier studies related to PPP was undertaken by Officer (1977).

Hence, in this paper we will concentrate only on recent studies. As can be seen in Broadberry (1987), the arguments for and against flexible exchange rates can be reconciled by appealing to PPP. Using data for the dollar/pound exchange rate, he shows that although exchange rates moved to preserve purchasing power parity in the long run, there were significant deviations from it in the short run. The source of the major deviation from PPP between 1931 to 1933 appears to lie in the asymmetric response of foreign exchange markets to fluctuations in economic variables in the U.K. and the U.S. while the latter adhered to the gold standard.(1) The study is useful for our purposes to make a point, that even in controversies concerning fluctuations in exchange rates as early as the 1930s, the PPP theory figured prominently.

In Taylor and McMahon (1988) one finds use of the PPP theory in providing explanations for the exchange rate fluctuations of the 1920s. Their results are strongly supportive of the PPP hypothesis as a long-run equilibrium condition on which actual exchange rates tended to converge over the period. However, the main focus of the paper is on the econometric techniques that are used by Frenkel (1980) and Edison (1985). A more recent study of PPP is carried out by Edison (1987), who tested the dollar/pound exchange rate for a very long period (between 1890 to 1978). It uses the "error correction mechanism" that was made popular and was used for consumption and demand for money by Davidson et.al. (1978) and Rose (1985) respectively. It concludes that a naive version of the PPP relationship does not adequately represent the dollar/pound exchange rate. This result was reinforced when the sample was divided into two sub-samples and the fixed exchange rate assumption was exploited. The conclusion supports the qualified interpretation of the PPP doctrine: the proportionality between the exchange rates and relative price level emerges in the long run, after taking into account the effects of changes in structural factors. In general, the consensus among economists is that PPP explanation does not provide a guide for short-run movements of exchange rate. However, one of the major reasons for deterioration in the explanatory power of PPP in the 1970s was the barrage of real shocks to economies in that period that resulted in relative price changes.

Dryden, Reut and Slater (1987) use the U.S. and Canadian dollars to test the importance of PPP doctrine. They formulate in conventional hypothesis and test it for data spanning 1960 to 1987. Considering specific consumption patterns in the U.S. and Canada they conclude that PPP theory is justified in its argument that the price ratios approximately equal the real exchange rate. David Bigman (1983) summarizes the main theoretical points of PPP theory in comparison to the related theoretical arguments like the monetary models. Similarly the International Fisher Effect has become the primary focus of study for some researchers. Giddy and Dufey (1975) showed that interest differentials have the ability to properly anticipate currency changes. Essentially, what the International Fisher Effect advocates is that arbitrage between financial markets, in the form of capital inflows and outflows, ensure that the interest rate differential between two countries is an unbiased predictor of the future change in spot-exchange rate. In other words, currencies with low interest rates are expected to devalue relative to the currencies with high interest rates.

In the next section we lay down the models to be used in testing the PPP hypothesis and the International Fisher Effect on exchange rates, after briefly noting the theoretical arguments.

Section 2: Exchange Rate Determination with the PPP Theory and the International Fisher Effect

Essentially, PPP theory postulates that exchange rates adjust over time to offset divergent movements in national price levels. In its absolute version, the exchange rate between two currencies is approximately equal to absolute purchasing power parity given by the ratio of price levels in the two countries. This is because adherents to the theory of the 'law of one price' hold that goods produced in the two countries are perfect substitutes, and market arbitrage will bring about price equality in freely interacting markets. The efficient function of the gold standard rested on such arbitrage. However, one does not have to subscribe to the extreme view of the 'law of one price' to establish PPP. Even with product differentiation, substitution in demand would work to bring about uniformity in price levels, but then the process would take longer and would entitle deviations from PPP for extended time periods.

At any rate, in the absolute version of the PPP theory, the exchange rate in time period t, e_t is defined as the ratio of the price level in the home country for time period t, $P_h(t)$, the price level in the foreign country in time period t, $P_f(t)$. This will hold with the additional assumption of no transportation costs, tariffs, quotas, or other restrictions. In general,

$$e_t = PPP_{absolute} = P_h(t)/P_f(t) \tag{1}$$

The relationship in (1) is consistent with intuition. The value of a currency is based on the purchasing power of a unit, which may be defined as the inverse of the general price level. Hence, the rates of the values of the two currencies or the equilibrium exchange rate is given by absolute PPP, i.e. the rates of the two price levels in its relative version, the PPP theory relates the absolute version at time periods t+1 to that at base period 0. Then the relative version of PPP states that,

$$e(t) = PPP_{relative} = \frac{P_h(t+1)/P_h(t)*e(t)}{P_f(t+1)/P_f(t)} \tag{2}$$

Now, let us define the inflation rate in the home country, ih, as the $\frac{P_h(t+1) - P_h(t)}{P_h(t)}$, so that $P_h(t+1)/P_h(t) = 1+i_h$.

Expressing the inflation rate, i_f, in the foreign country in a similar fashion and substituting in equation 2, we get

$$\frac{e(t+1)}{e(t)} = \frac{1 + i_h}{1 + i_f} \tag{3}$$

It is further possible to express a percentage change in exchange rate from time period t to t+1 as approximately equal to the difference between two inflation rates divided by $(1 + i_f)$. Thus the determination, as well as the forecasting of exchange rates, is possible by using the PPP arguments. Nonetheless, if we consider that PPP expresses the exchange rate as a price ratio, it is perfectly possible that exchange rate's real value is unchanged even though nominal value changes. For example, consider a case of increase in domestic inflation that is more than the foreign inflation. This would, according to PPP, devalue the local currency in relation to foreign currency. Still from the perspective of the local firm, it is possible that its competitive position in the world market is unchanged, because the devaluation and domestic inflation can have offsetting effects. This is a case of having a change in the nominal exchange rates without a change in the real exchange rate. Therefore, with concern about currency changes affecting relative competitiveness, the focus must be on the changes in the real rather than the nominal exchange rate. For the sake of generality, the real exchange rate is defined as follows:

$$e_{rt} = e_t \frac{(1 + i_{ft})}{(1 + i_{ht})} \tag{4}$$

For estimation purposes a modified version of equation (4) that uses prior (lagged) values of dependent and independent variables can be specified as follows:

$$\log e_t = bo + b1 \log e_{t-1} + b2 \log(P^*/P)t + b3 \log (P^*/P)t-2 + b4[\log e_{t-1} - \log(P^*/P)t-1] \tag{5}$$

Equation (5) is similar to the equation used for testing PPP by Broadberry (1987). E_t is the exchange rate defined in the European way meaning the number of units of foreign currency per unit of the home currency. When the change in the domestic inflation rate relative to the foreign inflation rate is substantial, so that even the real exchange rate is changed, there is a deviation from PPP. As can be seen in equation (5), deviations from the PPP is the main reason for the change in the exchange rate between the currencies. An increase in the foreign inflation rate relative to the domestic (P*/P), creates appreciation of domestic currency (and depreciation of foreign currency) and vice versa. Hence, the expected sign of (P*/P) is negative. As mentioned in the last section, it is not very possible that a change in the real exchange rate can occur in the short-run. Therefore, the studies that use short-run data (say monthly, ranging from only 5 to 10 years) generally do not testify the validity of the PPP theory. Our belief is that, since exchange rates in the Bretton Woods system were not truly flexible, the circumstances have not been satisfactory enough to test the PPP theory either for the short-run or long-run data. It is, therefore, important to test the PPP relationship in the form of equation (5) by using data from recent years, when exchange rates are relatively more flexible.

The International Fisher Effect is another simple concept that is very relevant in international finance. It relates the real interest rates of two economies and claims that the exchange rate between the two currencies would be determined by the difference between two interest rates. In equation form, a test of the International Fisher Effect is represented by,

$$\log e(t) = d_o + d_1(r - r^*) + d_2(r_{t-1} - r^*_{t-1}) + d_3e_{t-1} \tag{6}$$

Since the exchange rate is defined as the number of foreign currency units per unit of domestic currency, a higher domestic interest rate creates higher capital inflows, hence, leads to appreciation of domestic currency, and an increase in exchange rate value as it is defined here. Hence, the expected sign of d_1 is positive according to the International Fisher Effect.

The next section is devoted to an empirical evaluation of equation (5) and (6) for the dollar-yen rate, using time series data from very recent years.

Section 3: Testing Theories: A Case of the Dollar/Yen Exchange Rate

To test the PPP theory and the International Fisher Effect, we decided to initially use monthly data of the U.S. and Japanese economies for the time period between 1980 to 1988. The data points were collected from data disk series for the U.S. economy and from the International Financial Statistics (IFS) series of the International Monetary Fund. The exchange rate is defined as the number of yens available per dollar so that the exchange rate is the ratio of foreign currency per domestic currency unit. Consumer price index series serves as a proxy for general price levels. The U.S. economy is located as the home country, hence, number of yens per dollar is the exchange. (The estimated results of equation (5) were as follows):

$$\log e_t = \underset{(1.800)}{.114} + \underset{(3.488)}{.326} \log e_{t-1} - \underset{(-2.2903)}{.9905} \log (P^*/P)_t + \underset{(.7156)}{.305} \log(P^*/P)_{t-2} - \underset{(-1.8196)}{.02442}[\log e_{t-1} - \log(P^*/P)_{t-1}]$$

$R^2 = .2155$, Standard Error of Regression = .02246, Durbin-Watson Statistic = 2.008, F Statistic = 6.3197.

Figures within parenthesis under the estimated coefficients represent the t statistic values.

As can be observed, the R^2 value is small (.2155), but the standard error of the regression is satisfactory. The Durbin Watson statistic is excellent, and altogether the regression form works as expected by theory. The satisfactory Durbin-Watson statistic may be primarily because of the lagged value of dependent variable on the right-hand side. The relative price ratio shows a significant negative (as expected by PPP theory) coefficient. The lagged relative price ratio has a positive non-significant coefficient. In general, except for the small value of R^2, the regression results are not very disappointing. All the results are tested with 95% confidence interval by using the estimated t statistic. For the estimation of the International Fisher Effect, using the same time period and monthly data, we received the following results:

$$e_t = \underset{(-.6279)}{-1.1644} + \underset{(2.771)}{.7842}(r_t - r^*_t) - \underset{(-1.68)}{.4728}(r_t - r^*_t) - \underset{(-.3122)}{.0045} e_{t-1}$$

$R^2 = .1475$, Standard Error of Regression = 2.7897, Durbin Watson Statistic = 1.552, F Statistic = 5.4813.

The results of International Fisher Effect are more encouraging than the ones for PPP, even though the R^2 value is smaller for the latter. The higher interest rates differential without lag depreciates the exchange rate (as expected from the International Fisher Effect). Moreover, the lagged values of the independent variable are not as significant as the current period values. Also the lagged value of the dependent variable is not significant, as tested by the t statistic.

Nonetheless, to test whether quarterly data could yield any better R^2, we decided to run the PPP regression one more time. Our results for the quarterly data are as follows:

$$\log e_t = \underset{(1.21)}{.292} + \underset{(3.483)}{.525} \log e_{t-1} - \underset{(-.203)}{.258} \log(P^*/P)_t - \underset{(-1.049)}{1.273} \log(P^*/P)_{t-2} - \underset{(-1.184)}{.0635}[\log e_{t-1} - \log(P^*/P)_{t-1}]$$

$R^2 = .4261$, Standard Error of Regression = .0404, Durbin Watson Statistic = 1.9974, F Statistic = 4.6408.

The above results show a significant improvement in R^2 value without changing the sign of any estimated coefficient. All the estimated coefficients are more or less as significant as in the earlier estimation. As explained in Kennedy (1985) or any other econometrics textbook, a higher R^2 does not necessarily mean a better specification (or estimation) of the relationship. However, compared to monthly, quarterly data estimation shows: (1) a higher R^2, (2) a low but small increase in Standard Error of Regression, and (3) an equally satisfactory Durbin-Watson Statistic. Hence, we conclude that 'ceteris paribus', relative PPP theory explains quarterly fluctuations in exchange rates better than it explains the monthly fluctuations in exchange rates. Similarly, we used the quarterly data to test the International Fisher Effect to get the following results:

$$e_t = -6.5908 + 1.1482(r_t - r^*_{t-1}) - .02712(r_{t-1} - r^*_{t-1})$$
$$(-.9989) \quad (2.1904) \qquad (-.0544) \quad (.0479)$$

R^2 = .3199, Standard Error of Regression = 5.0413, Durbin Watson Statistic = 1.172, F Statistic = 4.3903.

From the results above the quarterly data estimation once again shows the following facts when compared to monthly data estimation: (1) R^2 value is much more improved, (2) F Statistic is lower than in case of monthly data, (3) Standard Error of Regression is higher, but by a very small increase, and (4) the Durbin-Watson Statistics is comparable. Thus, there is some evidence that the International Fisher Effect is more applicable to the quarterly data than to the monthly data, as far as the U.S. dollar and Japanese yen are concerned. It seems that both theories can be used to effectively forecast the behavior of the exchange rate. The R^2 values for both estimations are better for the quarterly data. The expected signs of all coefficients are observed, and, in general, the results are quite satisfactory and seem to validate the theoretical postures.

Section 4: Summary and Conclusions

The present paper discusses the theories of Purchasing Power Parity (PPP) and the International Fisher Effect dating back to the early years of the twentieth century, and tests their evidence for the recent time period data for the U.S. dollar - Yen exchange rate. The results show that both these theories provide a satisfactory explanation of the behavior of exchange rates. One of the main reasons why these theories lost their explanatory power in recent years was the inflexibility of exchange rates in the Bretton Woods System. However, as the exchange rates became flexible again in recent years, the theories have become more applicable. It is further observed that the quarterly data are more relevant for these theories than the monthly data.

I am indebted to Mr. Lam for the helpful research assistance on this paper, Mrs. Dianna Dovenmuehle for efficient typing, to Dr. Nandakumar, and an anonymous reference of this journal for valuable comments on the earlier version.

Footnotes

1 Frenkel, J. A. (1978), Purchasing Power Parity: Doctrinal Perspective and Evidence from the 1920s', Journal of International Economics Vol. 8, pp. 169-81.

Bibliography

1 Bigman, David, "Exchange Rate Determination: Some Old Myths and New Paradigms" Chapter 4 in *Exchange Rate and Trade Instability*, Bigman and Taya Editors, Ballinger Publishing Co. 1983, pp. 73-102.

2 Branson, William H., "Comment: The Collapse of Purchasing Power Parity During the 1970s", *European Economic Review*, Vol.16, pp.167-171, May 1981.

3 Broadberry, S. N., "Purchasing Power Parity and the Pound-Dollar Rate in the 1930s", *Economica*, Vol. 54, pp. 69-78, February 1987.

4 Cassel, Gustav, *Money and Foreign Exchange Rate After 1914*, New York: Constable and Company Ltd., 1922.

5 Davidson, James E.H., Hendry, David F., Srba, Frank and Yeo, Stephen, "Econometric Modelling of the Aggregate Time Series Relationship Between Consumers' Expenditures and Income in the U.K.", *Economic Journal*, Vol. 88, pp. 661-692, December 1978.

6 Dryden , John, Reut, Katrina, an Slater, Barbara, "Comparison of Purchasing Power Parity Between the U.S. and Canada", *Monthly Labor Review*, pp. 7-24, December 1987.

7 Edison, Hali J., "Purchasing Power Parity in the Long-run: A Test of the Dollar/Pound Exchange Rate (1890-1978)", *Journal of Money, Credit and Banking*, Vol. 19, No. 3, pp. 376-387, August 1987.

8 Frenkel, J. A., "The Collapse of Purchasing Power Parity During the 1970s", *European Economic Review*, Vol 16, pp 146-165, 1981.

9 Giddy, Ian H. and Dufey, Gunter, "The Random Behavior of Flexible Exchange Rates" *Journal of International Business Studies*, Spring 1975 pp. 1-32.

10 Kennedy, Peter, *A Guide to Econometrics*, Second Edition, The MIT Press, Cambridge, MA, 1985.

11 Officer, Lawrence H. "The Purchasing Power Parity Theory of Exchange Rates: A Review Article", *International Monetary Fund (IMF) Staff Papers*, Vol. 83, pp. 1-60, 1976.

12 Rose, Andrew K., "An Alternative Approach to the American Demand for Money", *Journal of Money, Credit and Banking*, Vol. 17, pp. 439-455, Nov. 1985.

13 Taylor, Mark and McMahon, Patrick C., "Long-Run Purchasing Power Parity in the 1920s", *European Economic Review*, Vol 32, pp 179-197, 1988.