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THE WON-YEN EXCHANGE RATE AND PURCHASING POWER PARITY DURING THE RECENT FLOAT

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Recent findings on PPP suggest that the deviation from PPP have not been self correcting between countries with large disparities in rates of inflation. Korea has experienced high inflation rates than Japan during 1980s and 1990s and so, under the current exchange rate system, the won-yen exchange rate may be misaligned. In this paper, we test the long-run PPP hypothesis for the won-yen exchange rate in Korea during 1980-1997, and find that the real exchange rate follows a random walk and there exists no cointegration relationship between the exchange rate and prices. The results show that the PPP hypothesis does not hold for the won-yen exchange rate, and suggest that the PPP condition will not hold for countries which experience large disparities in the rates of inflation.

JEL Classification: F3
Keywords: Won-Yen Exchange Rate, PPP

I. INTRODUCTION

The doctrine of Purchasing Power Parity is an important building block in macroeconomic models and a guide in choosing an appropriate long-run exchange rate as reflected in the monetary approach to the exchange rate determination. Numerous empirical studies of the PPP hypothesis have been carried out. However, the evidence obtained so far has been far from conclusive.

Most of earlier empirical studies, however, have been conducted for the major industrial countries with low inflation, and less study has been conducted for inflationary economies or between countries experiencing large disparities in rates of inflation.[1] Recently, several researchers on PPP have found that the choice of

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currencies is crucial for testing the validity of the PPP hypothesis, and argue that there will be persistent deviations from PPP, if the countries examined have large disparities in the rate of inflation and the authorities do not realign the exchange rate. If realignment is not used, the country with high inflation will lose competitiveness to the country with low inflation,[2] and the deviation from PPP will not disappear. The empirical evidence for these countries has been less than conclusive, and this issue has remained as an important topic in PPP research.[3]

Korea has experienced higher inflation rates than Japan during 1980s and 1990s.[4] In order to offset the loss of competitiveness, the Korean won should be realigned by devaluation. However, under the current exchange rate system, the won-yen exchange rate has been determined by the cross rate between the won-dollar exchange rate and the yen-dollar exchange rate. Thus, the won-yen exchange rate might be misaligned, resulting in persistent deviations from PPP. Testing the PPP hypothesis for the won-yen exchange rate is important, because whether PPP holds or not serves as a useful guide for Korean policymakers in implementing exchange rate management. However no earlier studies have been carried out, even though the won-yen exchange rate has played an important role in the Korean economy.

In this paper, we test the long-run PPP hypothesis for the won-yen exchange rate during the recent floating period, using KPSS tests for the stationarity and the cointegration approach developed by Johansen-Juselius(1992).

This paper is organized as follows: Section Ⅱ discusses the PPP theory and provides an overview of the econometric technique used to test the validity of the PPP relationship. Section Ⅲ presents empirical results and section Ⅳ concludes.

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[1] McNown and Wallace(1989) find mixed results in the cases of inflationary economies. Mussa(1979) and Enders(1988) offer some evidence in support of PPP for countries with different inflation rates.

[2] Cheung, Fung, Lai and Lo(1995) test the PPP hypothesis for the EMS countries and find that PPP does hold during the recent float.

[3] Koedijk et.al.(1998) finds that PPP holds for many currencies, although not for all currencies, and argue that the research on PPP should try to explain why it holds for only certain currencies.

[4] Korean CPI based inflation rate of 6.72% was much higher than Japan's inflation rate of 1.92%, during 1980-1997.

Ⅱ. PPP APPROACH TO EXCHANGE RATE DETERMINATION

2.1. Theoretical Background

The equilibrium relationship implied in the absolute version of PPP assumes that perfect commodity arbitrage will ensure that the price of goods produced domestically will be equal to the price of goods abroad. The absolute version of PPP relationship can be expressed as

$$S_t = P_t / P_t^* \qquad (1)$$

where St is defined as the exchange rate of domestic currency per unit of foreign currency and Pt and Pt* are the domestic and foreign price levels.

In the recent literature about PPP, two ways of testing the PPP hypothesis have been used. The first one is based on real exchange rate. Defining the real exchange rate REXt as

$$REX_t = S_t \cdot P_t^* / P_t \qquad (2)$$

If the absolute PPP holds only in the long run, in equation (2), REXt should have a constant mean and the tendency to revert to the mean, i. e., the real exchange rate should be level stationary. If the real exchange rate follows a random walk, then there will be no tendency for the nominal exchange rate and the relative price levels to converge even in the long run. This implies that a departure from PPP will not be self correcting and thus long run PPP does not hold. In terms of the time series property of the data, this implies that the real exchange rate is non-stationary. Therefore, one way to test whether the PPP does hold is to examine whether or not the real exchange rate follows a random walk.

The other traditional way of testing the PPP consists in utilizing aggregate price indices to specify the following equation:

$$s_t = \alpha + \beta p_t - \beta^* p_t^* + u_t \qquad (3)$$

where lower case letters denote the natural logs of the corresponding capital terms.

If PPP holds, the constant term is equal to zero ($\alpha = 0$) and the coefficients of domestic and foreign prices are both unity ($\beta = \beta^* = 1$). Several studies found favorable results by regressing equation (3).

In more recent studies, the cointegration technique proposed by Engle and Granger(1987) has been used to test whether the exchange rate and domestic and foreign prices are cointegrated. If they are cointegrated, these variables have a long-run relationship. Let X_t, which are s_t, p_t and p_t^*, be a multivariate stochastic process. Assuming that X_t is integrated of order one, PPP implies that PPP relationship is stationary. That is

$$\beta' X_t = [1 \quad -1 \quad 1] \begin{pmatrix} s_t \\ p_t \\ p_t^* \end{pmatrix} \sim \text{stationary} \tag{4}$$

Engle and Granger(1987) call the row vector, β', as cointegrating vector for the non-stationary stochastic process X_t corresponding to s_t, p_t, p_t^*. Engle and Granger type cointegration methodology test the null hypothesis of no cointegration against the alternative of cointegration. This approach, however, does not distinguish between the existence of one or more cointegrating vectors. Moreover this approach breaks down when p and p^* cointegrate. Johansen(1988) extends Engle and Granger's cointegration approach to avoid these problems. In this paper, we investigate the PPP hypothesis using the won-yen exchange rate and Johansen's cointegration approach.

2.2. Econometric Methodology

Following Johansen and Juselius(1992), we consider the following VAR mode l.[5]

$$X_t = \sum_{i=1}^{K} \Pi_i X_{t-i} + e_t \tag{5}$$

where $X_t = [s_t, \ p_t, \ p_t^*]$ and et is an independently and identically distributed vector of innovation with zero mean and covariance matrix Λ.

Letting $\Delta = 1 - L$, where L is the lag operator, we can rewrite equation (5) as

$$\Delta X_t = \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \alpha\beta' X_{t-k} + e_t \quad (t = 1, 2, \cdots\cdots T) \tag{6}$$

In (6), matrix Π is restricted as $\Pi = \alpha\beta'$, but the parameter can be eliminated by regressing ΔX_t and X_{t-k} on lagged differences $\Delta X_{t-1}, \cdots\cdots$, ΔX_{t-k+1}. This gives residuals R_{0t}, R_{kt} and residual moment matrices.

$$S_{ij} = T^{-1} \sum_{t=1}^{T} R_{it} R_{jt}' \qquad (i, j = 0, K) \tag{7}$$

[5] See Serletis(1994) for more details.

The cointegration relations are estimated as the eigenvectors corresponding to the r largest eigen values (λ) of equation (8).

$$|\lambda S_{kk} - S_{k0} S_{00}^{-1} S_{ok}| = 0 \tag{8}$$

Johansen suggested two test statistics. One is a maximum eigenvalue test. That is, the null hypothesis, r=0, is tested against the alternative r=1, r=1 against the alternative r=2 etc. The form of the maximum eigenvalue statistics is

$$\lambda_{\max} = -T \ln(\hat{\lambda}_{r+1}). \tag{9}$$

Another test is a trace test. In the trace test, the null hypothesis that there are at most r cointegrating vectors is tested against a general alternative. The trace statistics is computed as

$$Trace = -T \sum_{i=r+1}^{p} \ln(1-\hat{\lambda}_i). \tag{10}$$

Ⅲ. EMPIRICAL TEST OF THE PPP HYPOTHESIS

3.1. Real Exchange Rate Behavior

Traditionally, the stationarity of the real exchange rate is tested by applying standard unit root tests. However, the unit root test is not very powerful against relevant alternatives. Recently, Kwiatkowski, Phillips, Schmidt and Shin(1992) developed the KPSS test in which the null hypothesis is that the real exchange rate is stationary instead of testing the null hypothesis that the real exchange rate is non-stationary.

Within the framework of the KPSS model, we assume that we can decompose the time series into the sum of a deterministic trend, a random walk and a stationary error:

$$z_t = a_t + r_t + w_t \tag{11}$$

Here t is trend variable, r_t is a random walk and ω_t is a stationary error term:

$$r_t = r_{t-1} + u_t \tag{12}$$

where the u_t is iid $(0,\ \sigma_u^2)$. The initial value r_0 is treated as fixed and serves the role of intercept. It is obvious that zt is stationary if $\sigma_u^2 = 0$.

From (11) and (12),

$$z_t = r_0 + a_t + u_t + w_t \tag{13}$$

$$= r_0 + a_t + v_t \tag{14}$$

In equation (14), z_t is stationary if v_t is stationary. The test statistics is

$$\eta_t = T^2 \sum_{t=1}^{T} S^2 / s^2(l). \tag{15}$$

where $S^2 = \sum_{i=1}^{t} v_i$ (16)

and

$$S^2(l) = T^{-1} \sum^{T} e_t^2 + 2T^{-1} \sum^{T} w(s,\ l) \sum^{T} e_t\, e_{t-s} \tag{17}$$

Here e_t is the residual from regression equation (14), and $w(s,\ l)$ is an optional weighting function that corresponds to the choice of a spectral window. For this, the Bartlett window $w(s,\ l) = 1 - s/(l+1)$ is used as in Newey and West(1987). Similarly, the test statistics for level stationary, η_u is calculated with the OLS residual e_t derived from equation (14) with $a = 0$.

The data used in this study are monthly observations on consumer price indices, wholesale price indices and nominal exchange rates for Korea and Japan. The consumer prices, wholesale prices and the won-yen exchange rates are all taken from IFS data tape, and run from January 1980 to July 1997. The choice of sample period is dictated by the implementation of the floating exchange rate system in which the Korean won was unpegged from the U.S. dollar.

Table 1 shows the results for augmented Dickey-Fuller(ADF) and Phillips-Parron(P-P) unit root tests of the won-yen real exchange rate. The results indicates that the null hypothesis for the random walk of real exchange rate can not be rejected for both CPI-based real exchange rate series and WPI-based real exchange rate series. This implies that PPP does not hold in the long-run.

Table 2 reports the KPSS test results for stationarity. The results indicate that the null hypothesis of stationarity is rejected at 5% level in both level and trend cases.[6] Critical values are given in Kwiatkowski et al.(1992). Test results confirm that the PPP hypothesis does not hold for the won-yen exchange rate.

[6] The values of the lag truncation parameter l is used from zero to eight, and is decided by eight. The values of the test statistics are fairly sensitive to the choice of l, and every series of test statistics decrease as l increase. Thus, as l increase, there is less possibility to reject the null hypothesis of stationarity.

[Table 1] Unit Root Test of Real Exchange Rate[7]

	Level		Differenced	
	ADF	P-P	ADF	P-P
CPI - based	−1.8159(1)	−1.6918(4)	−10.0926**(1)	−15.6784**(4)
WPI - based	−1.6674(1)	−1.4508(4)	−10.7388**(1)	−17.2622**(4)

(**) denotes rejection of the hypothesis ar 1% significance level

[Table 2] KPSS Test of Real Exchange Rate

		η_μ	η_τ
rext	CPI-based	1.3638*	0.2101*
	WPI-based	1.6928*	0.1600*

(*) denotes rejection of the hypothesis at 5% significance level

3.2. Cointegration Test

Before proceeding to test whether the exchange rates are cointegrated with the price indices, it is necessary to test the existence of unit root of exchange rate and prices. The unit root test and KPSS test results are reported in Table 3 and Table 4. In Table 3, as indicated by ADF test, the null hypothesis of non-stationary cannot be rejected for the level of the variables, whereas, the hypothesis of the unit root can be rejected for the WPI-based Korean price indices and CPI-based Japanese price index at the 1 percent level and 5 percent level if the P-P test is used. However, when KPSS method is used, test results in Table 4 show that the null hypothesis of stationarity is rejected at 5% level in both level and trend cases. As indicated by ADF and P-P statistics in Table 3, using data in first differences has resulted in the rejection of the null hypothesis of non-stationary for the all series.

Time series properties justify using the won-yen exchange rate, and price indices because there is strong evidence that these variables are nonstationary. Since the most of the data series are integrated of order one, it is legitimate to apply the estimation procedure for testing the existence of the cointegration relationship.[8] In applying the Johansen-Juselius procedure, the lag length should be established for the VAR model.[9]

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[7] Numbers in parenthesis after these statistics indicate the lag length used in the autoregression to ensure residual whiteness.

[8] All the estimations are performed with the use of the software program CATS 1.0 for RATS 4.2 developed by Hansen and Juselius and distributed by Estima Inc.

[Table 3] Unit Root Test

		Level		Differenced	
		ADF	P-P	ADF	P-P
s_t		$-1.7831(1)$	$-1.6229(4)$	$-9.7136^{**}(1)$	$-16.0707^{**}(4)$
p_t	CPI-based WPI-based	$0.6902(13)$ $1.2725(15)$	$-2.8428(6)$ $-5.0735^{**}(4)$	$-3.8754^{**}(12)$ $-6.3025^{**}(14)$	$-9.6276^{**}(4)$ $-18.3682^{**}(4)$
p_t^*	CPI-based WPI-based	$-0.4252(12)$ $-1.3684(4)$	$-3.4104^{*}(4)$ $-0.6022(4)$	$-3.3231^{*}(11)$ $-5.1825^{**}(3)$	$-13.3284^{**}(4)$ $-9.3604^{**}(4)$

(*) denotes rejection of the hypothesis at 5% significance level
(**) denotes rejection of the hypothesis at 1% significance level

[Table 4] KPSS Test

		η_μ	η_τ
s_t		2.2178^{*}	0.1503^{*}
p_t	CPI-based WPI-based	2.4390^{*} 2.2144^{*}	0.1982^{*} 0.1746^{*}
p_t^*	CPI-based WPI-based	2.4091^{*} 1.9930^{*}	0.2203^{*} 0.2044^{*}

(*) denotes rejection of the hypothesis at 5% significance level

The lag order was first estimated using a model selection procedure based on the Akaike's information criterion. The model was also tested for the presence of serial correlation in the residual using a Ljung-Box statistic. If the residual proved to be non-white, a higher lag structure was chosen until they were whitened. Finally it was found that a VAR model of 8 was sufficient. This is done by setting as an upper limit to a model of 12 periods and testing down against the alternative model with shorter lag structure using a likelihood ratio test. The Trace and λmax statistics have non-standard distributions under the null hypothesis, although approximate critical values have been tabulated by Johansen(1988), Johansen, Juselius(1990) and Osterwald & Lenum (1992). The critical values for these tests can be found in Table 1 of Osterwald-Lenum (1992).

[9] Serletis(1994) finds that lower-order VARs reveal litter evidence of cointegration, while higher-order VARs provides much stronger evidence in favor of cointegration.

[Table 5] Cointegration Test

null hypothesis	λmax			Trace		
	CPI-based	WPI-based	critical value	CPI-based	WPI-based	critical value
$r=0$	19.88	19.00	22.00	29.40	26.78	34.91
$r\leq1$	9.06	6.45	15.67	9.52	7.79	19.96
$r\leq2$	0.46	1.33	9.24	0.46	1.33	9.24

(*) 5% significance level

[Table 6] Cointegration Vector

	CPI-based	WPI-based
s_t	1	1
p_t	0.562	-1.053
p_t^*	-5.293	3.340

The results from both the trace and maximum eigenvalue tests are shown in Table 5.[10] It is clear from Table 5 that there is an absence of cointegration between the won-yen exchange rate and prices.

In order to confirm these results, we examine the sign and magnitude of the cointegrating vectors, and the results are reported in Table 6. The estimated coinegration vector using CPI-based data is not correctly signed for both domestic and foreign prices and the magnitudes are not consistent with the hypothesis. In the case of WPI-based cointegration vector, the magnitudes of the cointegration vector are not consistent with the hypothesis even though the coefficients on the price levels are correctly signed. Based on these results, it can be concluded that PPP is a poor description of the behavior of exchange rates and prices.

Ⅳ. CONCLUSION

The empirical studies on long-run PPP have been prolific, yet the issue has remained unsettled. No clear consensus has emerged regarding the hypothesis.

[10] The critical values recorded in Johansen's 1988 paper are for a VAR without an intercept term. Johansen(1990) report critical values for VAR systems without a constant for systems of up to 5 variables. These critical values have been extended by Osterwald-Lenum(1990) for systems of up to 11 variables. We utilize these latter critical values in the present study.

Recent findings on PPP suggest that the exchange rate will deviate from PPP persistently when the countries have experienced large disparities in rates of inflation without frequent exchange rate realignment. In these countries the exchange rate will be misaligned and the countries with high inflation lose competitiveness to the country with low inflation.

The economy of Korea has experienced higher inflation than Japan, and under current Korea's exchange rate system, exchange rates would be misaligned because won-yen exchange rate is determined by the cross rate between won-dollar and yen-dollar exchange rate. Based on this background, it is important to know whether the PPP hypothesis holds or not in the case of won-yen exchange rate.

To increase the power of the PPP test, in addition to the standard unit root test, KPSS test was used. In addition, instead of the Engle and Granger cointegration test, Johansen's multivariate cointegration methodology was used. The results show that the real exchange rate follows a random walk and there exists no cointegration relationship between the exchange rate and prices. Thus, the PPP hypothesis does not hold in the case of the won-yen exchange rate. These results are confirmed when we examine the sign and magnitude of the cointegrating vectors.

The test results implies that PPP condition does not hold between countries which experience large disparities in the rates of inflation. The results also mean that Korea has lost its competitiveness to Japan because the won-yen exchange rate has been misaligned. This suggests that the current exchange rate system should be reconstructed to realign the won-yen exchange rate.

REFERENCES

Cheung, Y., H. Fung, K. Lai, and W. Lo (1995), "Purchasing Power Parity under the European Monetary System," *Journal of International Money and Finance*, Vol. 14, 179-189.

Enders, W. (1988), "ARIMA and Cointegrated Tests of PPP under Fixed and Flexible Exchange Rates Regimes," *Review of Economics and Statistics*, October, 504-508.

Engle, R.F., and C.W.J. Granger (1987), "Co-integration and Error Correction: Representation, Estimation, and Testing," *Econometrica*, 55, 251-276.

Hansen, H., and K. Juselius (1995), *CATS in RATS*, *Cointegration Analysis of Time Series*, Estima Inc., Evanston.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors," *Journal of Economic Dynamics and Control*, June/September, 231-254.

Johansen, S., and K. Juselius (1990), "Maximum Likelihood Estimation and Inference on Cointegration with Application on Demand for Money," *Oxford Bulletin of Economics and Statistics*, Vol. 52, 169-210.

Koedijk, K.G., P. Schotman, M. Van Dijk (1998), "The Re-Emergence of PPP in the 1990s," *Journal of International Money and Finance*, Vol. 17, 51-61.

Kwiatkowski, D., P.C.B. Phillips, P. Schimdt, and Y. Shin (1992), "Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root: How Sure Are We That Economic Time Series have a Unit Root," *Journal of Econometrics*, Vol. 28, 159-178.

McNown, R., and M.S. Wallace (1989), "National Price Levels, Purchasing Power Parity and Cointegration: A Test for a Four High Inflation Economies," *Journal of International Money and Finance*, 533-545.

Mussa, M. (1979), "Empirical Regulations of the Exchange Rate and Theories of Foreign Exchange Market," in *Policies for Employment, Prices and Exchange Rates*, eds. by K. Brunner and A. Meltzer, North-Holland.

Newey, W.K., and K.D. West (1987), "A Simple Positive Semi-Definite, Heteroskedacity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, Vol. 55, 703-708.

Osterwald-Lenum, M. (1992), "A Note with Quantiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics," *Oxford Bulletin of Economics and Statistics*, Vol. 52, 461-472.

Serletis, A. (1994), "Maximum Likelihood Cointegration Tests of Purchasing Power Parity: Evidence from Seventeen OECD Countries," *Weltwirtschft Archiv*, Heft 3, 476-493.