The Real Exchange Rate Behavior in the Pacific Rim Since 1974

Jin-Ock Kim*

목 차

Introduction

The real exchange rate behavior has been the most popular subject of study for a long time in international finance. The mean reverting behavior of real exchange rate implies that Purchasing Power Parity(PPP) holds in the long run. Given PPP holds in the long run, it has a merit of both as a theoretical building block of standard monetary model and as an empirical rule of thumb, such as in establishing the target zones. In resource allocation perspectives, the fluctuations of the real exchange rates can have important effects on the resource allocation. For example, a persistent real appreciation may hurt country's competitiveness while a prolonged real depreciation can have a positive effect on the country's exportable sectors.

The empirical results of the real exchange rate movements are that the real exchange rate movements are more stable under fixed exchange rate than under flexible rate regime. Within traditional univariate unit root test frame work, early studies(e.g. Roll(1979), Darby(1983), and Enders(1988)) have shown that the real exchange rates follow a random walks under a float rate period. Kim and Enders(1991) also has shown that US based real exchange rates in the pacific rim follows a unit root process during a floating rate period. During the floating rate period, one of the stylized facts of the real exchange rate behavior is that it reflects the fluctuations of the nominal exchange rate, which implies that the relative price ratio changes do not offset the movements in nominal exchange rate to keep the real exchange rate in the long-run level.

* Associate Professor, Department of Economics, College of Economics and Commerce, Cheju National University.

The weak evidence against a unit root may be caused by the intrinsic low power when small samples are employed in estimation. The time span of floating rate period is so short that these unit root tests are unlikely to be powerful in distinguishing a unit root process from a near unit root process. To circumvent this problem of low power in unit root test, researchers have employed the longer-term historical data to show the mean reverting behavior of the real exchange rate(e.g. Lothian(1990), and Lothian and Taylor(1996)). The problem in employing the longer-term data is that the exchange rate regime has changed during this time span, which results in the very different pattern of the real exchange rate movements. In this regard, Mussa(1986) has shown that the movements of the real exchange rates of the major industrialized countries is eight to eighty times more volatile under floating rate period than under fixed rate period. One alternative way in avoiding this problem is to employ the panel data which are generated in the same exchange rate regime. Fortunately, the panel unit root test proposed by Levin-Lin(1992) yields more power than the standard univariate unit root tests. Using the panel unit root test, researchers have shown that the real exchange rate tends to revert to the long-run level(e.g. Yangru Wu(1996), Lothian(1997), Frankel and Rose(1996)). Most of the empirical studies on PPP concerns the developed economies. But, there is no reason to confine the study of PPP to the developed economies. In this paper, we investigated the real exchange rate behavior in the pacific rim. To preview our results, a unit root process of the real exchange rate in the panel data was rejected when considering only a drift term in the test equation regardless of the base country(US or Japan) in this region. Within this econometric specification, the real exchange rate shows the mean reverting behavior in this region

This paper is organized in the following way. In section 1, we introduce the empirical implementation of the real exchange rate behavior, especially in the methodology of the panel unit root test proposed by Levin and Lin(1992). The empirical results of univariate or panel unit root test are presented in section 2. Finally we summarize the results.

Empirical Implementation

Let's define the real exchange rate q_t as follows:

$$q_t = e_t + p_t^* - p_t. \qquad (1)$$

where e_t = the base(home) country's currency price of a unit of foreign currency, p_t = the base country's price level, p_t^* = the foreign price level: all variables are expressed in natural logarithms.

The absolute version of PPP says that the nominal exchange rate(e_t) is proportional to the relative price level difference(p_t - p_t^*), which implies that the log real exchange rate is constant over time(specifically, q_t = 0). If q_t changes over time, we can specify $\{q_t\}$ as a stochastic process. If

PPP does hold, q_t follows a stationary ARMA(p,q) process: then any deviations from PPP will be temporary and disappear as time goes on. On the contrary, if q_t has a unit root, q_t is represented as an ARIMA(p,q) process so that it does not have an unconditional mean. Then if deviations from PPP occurs, the real exchange rate will not revert to the long-run level, which implies that PPP does not hold in the long run.

To investigate the theory of PPP, researchers have employed the time series technique called the Dickey-Fuller(1979) Unit Root Test on the real exchange rate. More advanced technique is to do the cointegration test developed by Granger and Engle(1986) and Johansen(1987). The basic idea of cointegration test for PPP is to examine the equilibrium relationships between the base country's price level and foreign country's price level in common currency unit. The pitfalls of these approaches are that they have the intrinsic low power and give the imprecise estimates when using the small sample sizes. There are two ways to avoid these econometric problems. One way is to use the longer-term time series data set. The other way is to use a panel data set. The problem with longer-term time series in real exchange rate study is that the longer -term sample period includes serious structural shifts of exchange rate regime. As Mussa(1986) has shown, real exchange rate moves very differently under different exchange rate regime. To circumvent this kind of problems, researchers in international economics employ the panel unit root test on the real exchange rate. The panel unit root tests have been recently proposed by Levin and Lin(1992), Im, Pesaren and Shin(1997). We introduce the popular Levin-Lin test.

Let $\{q_{it}\}$ be a balanced panel of real exchange rate, for $i=1,...,N$, and $t=1,...,T$. Assume that the stochastic process q_{it} is generated by the following model.

$$\Delta q_{it} = \alpha_{0i} + \alpha_{1i}t + \delta_i q_{it-1} + \zeta_{it}, \tag{2}$$

where $-2 < \delta_i \leq 0$ for all $i = 1,....,N$. If $\delta_i = 0$, $\alpha_{1i} = 0$. ζ_{it} is the idiosyncratic disturbance term.

The existence of unit root in the panel assumes the null hypothesis that $\delta_i = 0$ for all $i=1,....,N$ against the alternative hypothesis that $\delta_i < 0$.[1] The testing procedures of unit root in the panel data requires that the data are generated independently across individuals. The dependent movements across individuals may be caused by the common time-specific aggregate effects v_t. We can remove these aggregate time-specific effects by subtracting the cross section averages $q_t = (1/N)(\Sigma_{i=1}^{N} q_{it})$

1) Im et al.(1997) extend the Levin and Lin framework by allowing for heterogeneity in the value of δ_i under the alternative hypothesis. Let:

$$\Delta q_{it} = \alpha_{0i} + \alpha_{1i}t + \delta_i q_{it-1} + \zeta_{it}, \; i = 1, 2, ..., N; t=1, 2, ..., T.$$

The null and alternative hypothesis are defined as H_0 $\delta_i = 0$ for all i against the alternatives H_a: $\delta_i < 0$, $i = 1, 2, ..., N_1$, $\delta_i = 0$, $i = N_1 + 1, N_1 + 2, ..., N$. In a Monte Carlo Study, they demonstrate better finite sample performance of the test statistic.

from the observed data. In the remainder of this paper, we will follow the notation q_{it} referring to the adjusted data.

The ADF method for testing for a unit root in the individual series $\{q_{it}\}$ is to estimate the following equation.

$$\Delta q_{it} = \alpha_{0i} + \alpha_{1i}t + \delta_i q_{it-1} + \Sigma_{L=1}^{p_i} \theta_{iL} \Delta q_{it} + \epsilon_{it.} \quad (3)$$

This is equivalent to estimating the following equations.

$$e_{it} = \delta_i v_{it-1} + \epsilon_{it.} \quad (4)$$

Where e_{it} is the residuals of regressing Δq_{it} with respect to p_i lagged first differences of q_{it} and the deterministic variables {1, t}. v_{it-1} is the residuals of regressing q_{it-1} with respect to the same regressors of $e_{it.}$

The ADF method is to test the null hypothesis of $\delta_i = 0$ using the t-statistic for $\delta_{i.}$ The panel unit root test considers the analogue of equation (4) under the cross equation restriction that δ_i = 0 for all individuals i=1,...N. To avoid heterogeneity problems across individuals, We normalize the estimated innovation e_{it} and orthogonalized lagged level v_{it-1} using the regression standard error in equation (4):

$$\sigma_{ei}^2 = [1/(T-p_i -1)] \ \Sigma_{t=pi+2}^{N}(\ e_{it} - \delta_i v_{it-1})^2 \quad (5)$$

In the remainder of this paper, we will use the notation e_{it} and v_{it-1} as the adjusted ones in the above way. Using the adjusted data for e_{it} and v_{it-1}, we regress e_{it} with respect to v_{it-1} under the cross equation restriction of $\delta_i = \delta$:

$$e_{it} = \delta \ v_{it-1} + \epsilon_{it.} \quad (6)$$

By using the OLS(ordinary least square) estimator δ_e of δ , we calculate the regression t-statistic for the null hypothesis that $\delta = 0$ as follows:

$$\tau = [\delta_e/RSE(\delta_e)] \quad (7)$$

Where $RSE(\delta_e)$ is the standard error of above panel OLS estimation.

Levin and Lin showed that the regression t-statistic τ has a standard normal limiting distribution when we do not include the deterministic variables {1,t} in equation 3. If we do include deterministic variables either {1} or {t} or both, it diverges. However the following adjusted t-statistic τ^* has a standard normal distribution:

$$\tau^* = [(\tau - {}_N\tau^0 S_e \sigma_\epsilon^{-2} RSE(\delta_e)\mu_m^*)/\sigma_m^*] \quad (8)$$

Where $\sigma_\epsilon = [(1/N\tau^0)\Sigma_{i=1}^N \Sigma_{2+Pi}^T(e_{it} - \delta_e v_{it-1})^2]^{1/2}$, $\tau^0 = \{T-[(1/N)\Sigma p_i]\}$, μ_m^* and σ_m^* are the mean adjustment and standard deviation adjustment respectively, which can be found in Table 1 of Levin-Lin(1992).

Given the unit root process in each individual real exchange rate $\{q_{it}\}$ in the panel, the Monte Carlo distribution of Levin and Lin's τ and τ^* is different from the asymptotic distribution when there is a drift or time trend in the test equation. That is, the finite sample size distortion of the test occurs. To correct for the size distortion, we make the bootstrap distribution(parametric or non-parametric) for τ and τ^* respectively.

Empirical Results

Univariate Unit Root Test Results

All data are taken from Korea Statistical Office's Monthly Bulletin of International Statistics. We have constructed real exchange rate using the consumer price index(CPI). all data are quarterly. For the CPI real exchange rates, we have considered 12 countries in the pacific rim: Malaysia, Singapore, India, Japan, Thailand, Philippines, Korea, U.S., Chile, Canada, Mexico, Colombia. We have constructed real exchange rate from 1974.1 to 2001.1 in two types: one is real exchange rate using U.S. as a base country, the other one is real exchange rate such that Japan is a base country.

Table 1 ADF and PP Tests for a Unit Root in Real Exchange Rate Using Japan as a base country (sample period; 1974.1-2001.1)

	ADF Test				PP Test			
Country	τ_c	δ	τ_{ct}	δ	τ_c	δ	τ_{ct}	δ
Malaysia	-1.670	0.977	-2.810	0.894	-1.308	0.983	-2.360	0.936
Singapore	-2.782	0.944	-3.140	0.903	-2.146	0.961	-2.284	0.948
India	-1.682	0.981	-1.824	0.942	-1.198	0.987	-1.711	0.961
Thailand	-1.306	0.974	-2.898	0.869	-1.194	0.980	-2.627	0.907
Philippines	-1.745	0.956	-2.663	0.883	-1.680	0.964	-2.498	0.917
Korea	-1.435	0.959	-3.495	0.804	-1.596	0.960	-3.153	0.864
U.S.	-2.214	0.945	-2.573	0.903	-1.940	0.959	-2.104	0.945
Chile	-1.225	0.981	-1.868	0.954	-2.338	0.958	-2.338	-2.197
Canada	-2.019	0.959	-3.390	0.862	-1.696	0.971	-2.569	0.926
Mexico	-2.814	0.914	-2.344	0.944	-2.344	0.944	-2.286	0.940
Colombia	-1.462	0.977	-1.879	0.956	-1.280	0.983	-1.280	0.983

Notes:

1. τ_c indicates the test statistic in case constant(drift term) is only included in test equation.
2. τ_{ct} indicates the test statistic of including additionally time trend in test equation.
3. The lag length chosen in ADF test is 4.
4. Significance at the 10% level is indicated in bold face. The critical values of 10% significance level for τ_c and τ_{ct} are -2.59 and -3.15 respectively.

Unit Root tests for Japan based real exchange rate are reported in Table 1. When a drift term is only allowed in ADF test equation, Singapore-Japan and Mexico-Japan real exchange rate rejects the unit root at 10% significance level. Korea-Japan and Canada-Japan real exchange rates reject the unit root process at 10% significance level when a drift and time trend terms are included in test equation. Singapore-Japan real exchange rate rejects the unit root process at almost 10% significance level in the test equation of including a drift and a time trend. Phillips-Perron(PP) test shows that Korea-Japan real exchange rate rejects the unit root when a drift and a time trend terms are included in the test equation. Using Japan as a base country in the pacific rim, we found the mean reverting behavior of real exchange rates of Singapore, Canada, Mexico, and Korea.

In Table 2, unit root tests of U.S. based real exchange rates in the pacific rim are reportd.

Table 2 ADF and PP Tests for a Unit Root in Real Exchange Rate Using US as a base country (sample period;1974.1-2001.1)

	ADF Test				PP Test			
Country	τ_c	δ	τ_{ct}	δ	τ_c	δ	τ_{ct}	δ
Malaysia	-0.960	0.984	-2.170	0.884	-0.618	0.994	-2.541	0.920
Singapore	**-2.797**	0.930	-2.741	0.931	-1.829	0.961	-1.809	0.961
India	-1.284	0.985	-2.674	0.878	-0.651	0.994	-2.911	0.897
Japan	-2.214	0.945	-2.573	0.903	-1.940	0.959	-2.104	0.945
Thailand	-0.600	0.983	-2.121	0.901	-0.567	0.993	-2.149	0.928
Philippines	-1.508	0.956	-2.091	0.927	-1.424	0.973	-2.005	0.950
Korea	-1.713	0.939	-2.141	0.923	-1.664	0.957	-1.959	0.944
Chile	-1.031	0.982	-1.787	0.959	-2.497	0.945	-2.469	0.933
Canada	-0.739	0.989	-1.656	0.965	-0.515	1	-1.360	0.982
Mexico	**-3.185**	0.862	-3.075	0.863	-2.582	0.919	-2.491	0.922
Colombia	-1.392	0.982	-2.182	0.966	-0.941	0.992	-1.447	0.980

Notes: Significance at the 10% level is indicated in bold face. The chosen lag length in ADF test equation is 4.

Using US as a base country in the pacific rim, Singapore-US and Mexico-US real exchange rates rejected the unit root when only a drift term is included as a deterministic one in the test equation. In Phillips-Perron test, all US based real exchane rates in the pacific rim have shown the unit root process.

Overall Impression of this univariate unit root test is that real exchange rate shows the mean reverting behavior in small set of countries in the pacific rim: the evidence against a unit root is more strong in case Japan is a base country than in case of U.S. being a base country.

The weak evidence against a unit root may be due to the lack of power of the test in small finite samples(only 109 quarterly observations in the study). One way to circumvent this kind of problem is to get more observations by going back in time. Using longer term annual data, Lothian and Taylor(1996) constructed real exchange rate and support the mean reverting behavior of it. The other way of enhancing the power of the test is to employ the panel data, and do the panel unit root test on the real exchange rate.

Panel Unit Root Test Results

Table 3 Levin-Lin Test of a Unit Root in the Real Exchange Rate

Numeraire	Time Effect	τ_c[1]	δ	τ_{ct}[2]	δ	τ_c^*[3]	τ_{ct}^*
U.S.	yes	-5.295[4]	0.967	-7.432	0.933	-0.701	-0.188
		[0.052][5]		[0.064]		[0.000]	[0.140]
		(0.082)[6]		(0.057)		(0.000)	(0.135)
	no	-4.285	0.978	-6.976	0.942	0.352	0.543
		[0.148]		[0.111]		[0.413]	[0.298]
		(0.281)		(0.100)		(0.437)	(0.311)
Japan	yes	-5.160	0.968	-7.272	0.936	-0.485	-0.137
		[0.063]		[0.082]		[0.288]	[0.128]
		(0.102)		(0.088)		(0.216)	(0.139)
	no	-5.282	0.975	-7.481	0.928	-1.476	1.038
		[0.184]		[0.209]		[0.197]	[0.511]
		(0.240)		(0.202)		(0.167)	(0.510)

Notes:

1. τ_c indicates only a constant included in test equation.
2. τ_{ct} indicates linear time trend in test equation.
3. τ_c^* and τ_{ct}^* are the adjusted studentized coefficients.
4. Bold face indicates significance at the 10% level.
5. Nonparametric bootstrap p-values are in square brackets
6. Parametric p-values are in parentheses.

We have done the popular Levin-Lin's panel unit root test. The test results are presented in Table 3. Above result says that the unit root is rejected at the 10% level when we account for the common time effect regardless of the base country chosen. Here, the evidence against the unit root is weak when the common time effect is omitted. In contrast to the univariate unit root test, the mean reverting behavior of the real exchange rate is strengthened. This result confirms the recent overall consensus that PPP holds when using the panel data.

Conclusion

We have investigated the time series behavior of real exchange rates in the pacific rim. In the pacific rim, there are two giant countries such as US and Japan which make a big influence on the economies in this region. In this regard, we constructed two types of real exchange rates depending on the base country chosen. That is, US based real exchange rate and Japan based real exchange rate are constructed. Using these real exchange rate data, we have done both the univariate unit root test and the panel unit root test proposed by Levin and Lin. For the case that US is a base country in the pacific rim, the univariate unit root test is that Singapore-US and Mexico-US real exchange rates show the mean reverting behavior when tests equations include only a constant. Slighty different results occurred when Japan is chosen as a base country in this region. When only a constant is included in tests equation, Singapore-Japan and Mexico-Japan real exchange rates rejects the unit root process. The unit root process in real exchange rates of Korea-Japan and Canada-Japan are rejected when including the linear time trend in tests equation. Compared to the real exchange rate behavior with US being a base country, the mean reverting behavior of real exchange rate works in the larger set of countries with Japan being a base country. However, the pitfall of univariate unit root test with small samples is that it may give imprecise estimates due to the lack power of test.

To avoid this kind of problem, we have implemented the popular Levin Lin's panel unit root test. The unit root is rejected at the 10% level when we account for the common time effect regardless of the base country chosen. But, the evidence against the unit root is weak when the common time effect is omitted. This result is in sharp contrast with the univariate unit root test. That is, Supporting the hypothesis of PPP, the panel unit root test is more strong than the univariate unit root test. Given the panel unit root tests results, we would say PPP may work in the pacific rim.

References

Darby, M. R.(1983) "Movements in Purchasing Power Parity: The Short and Long Runs.", in The international transmission of inflation. Eds.: Michael R. Darby and James R. Lothian ET AL. Chicago: U., of Chicago Press, Chicago, 1983, 462-77.

Dickey, D. A. and Fuller, W. A.(1979) "Distribution of the Estimators for Autoregressive Time Series with a Unit Root.", Journal of the American Statistical Association 74, 427-431.

Enders, W.(1988) "ARIMA and Cointegration Tests of PPP under Fixed and Flexible Exchange rates.", Review of Economics and Statistics 70, 504-508.

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

Frankel, J. and Rose, A. (1996) "Mean Reversion within and between Countries: a Panel Project on Purchasing Power Parity.", Journal of International Economics 40, 209-224.

Im, K. S., Pesaran, M, H. and Shin, Y. (1997). "Testing for Unit Roots in Heterogeneous Panels.", Mimeo, Department of Applies Economics, University of Cambridge.

Johansen, Soren(1988), "Statistical Analysis of Cointegrating Vectors.", Journal of Economic Dynamics and Control 12, 231-54.

Kim, J. O. and Enders, W.(1991) "Real and Monetary Causes of Real Exchange Rate Movements in the Pacific Rim.", Southern Economic Journal 57, 1061-1070.

Levin, Andrew, and Chien-Fu Lin.(1992) "Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties.", Mimeo, University of California, Sand Diego, June 1992.

Lothian, J. R.(1990) "A Century plus of Japanese Exchange Rate Behavior.", Japan and The World Economy 2, 47-70.

Lothian, J. R.(1997) "Multi-country Evidence on the Behavior of Purchasing Power Parity under the Current Float.", Journal of International Money and Finance, Vol. 16, No.1, 19-35.

Lothian, J. R. and Taylor, M. P.(1996) "Real Exchange Rate Behavior: the Recent Float from the Perspective of the Past Two Centuries.", Journal of Political Economy 104, 488-509.

Mussa, M.(1986) "Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates: Evidence and Implications.", In Real Business Cycles, Real Exchange Rates and Actual Policies, eds K. Brunner and A. H. Meltzer, Carnegie Rochester Conference Series on Public Policy, XXV, PP. 117-214, North-Holland, Amsterdam.

Roll, R.(1979) "Violations of Purchasing Power Parity and Their Implications for Efficient International Commodity Markets.", in International finance and trade. Eds.: Marshall Sarnat abd Giorgio P. Szego. Cambridge, MA: Ballinger, 1979, PP. 133-76.

Yangru Wu.(1996) "Are Real Exchange Rates Nonstationary? Evidence from a Panel-Data Test.", Journal of International Money and Finance Vol. 28, No. 1, 54-63.