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Trade Relations and Long-run Purchasing Power Parity (PPP) between the Selected East Asian Countries and Iran*

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In this paper, we have examined the long-run currency relationship, based on purchasing power parity (PPP), between the five major ASEAN countries (Malaysia, Indonesia, the Philippines, Singapore and Thailand) plus China, South Korea and Japan (as the East Asian side) and Iran (as the West Asian side) by using panel data methods to test for unit roots over the period 2000-2009. If the test rejects the unit root hypothesis, the long-run PPP holds. We six thus used five panel unit roots tests: Levin, Lin, and Chu (2002), Breitung (2000), Im, Pesaran and Shin (2003), Maddala and Wu (1999) and Hadri (2000). By the use of real effective exchange rates, such methods test the PPP hypothesis showing whether real exchange rates among East Asian countries and also between two Asian sides (East and West) are stationary. Of these tests, only the LLC (Levin, Lin, and Chu method) holds the hypothesis in which the PPP holds. The results are consistent with those obtained by O'Connell (1998).

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1. INTRODUCTION

Purchasing Power Parity (PPP) has been one of the most enduring concepts in international economics. In its strongest form, absolute PPP implies that one could buy the same basket of goods in any country for the same value when prices are denominated in a common currency. This concept is based on the law of one price, which presumes that arbitrage in a wide range of goods equalizes prices across countries. After the collapse of the gold standard during World War I, Cassel (1922) proposed the use of PPP to restore relative gold parities. He suggested that countries set their post-war exchange rates according to PPP by setting the change in their post-war and pre-war exchange rates equal to the difference between their post-war and pre-war inflation rates. Since that time, economists have used PPP in setting and forecasting exchange rates, in adjusting for cross-country incomes to account for differences in prices and as a foundation of models in international macroeconomics.

Despite a vast empirical literature on PPP, many questions remain unanswered regarding the validity. Since a short-run PPP is almost never an economically relevant proposition, empirical investigation has focused on the long-run PPP. This usually involves testing for unit roots in real exchange rates. If the test rejects the unit root hypothesis, the real exchange rate reverts to its mean and the long-run PPP holds. In addition, because price indexes are used to construct real exchange rates, these methods are necessarily tests of a weaker, relative, form of PPP. Since the price indexes are equalized in an arbitrary base year, what can be tested is whether relative prices denominated in the same currency revert to a constant long-run mean, not whether one could ever buy the same basket of goods for the same prices in different countries (Amara and Papell, 2006).

This paper investigates long-run PPP by testing for unit roots in real effective exchange rates of 8 selected Asian countries (China, Japan, South Korea, Indonesia, Malaysia, Singapore, Thailand and the Philippines) and Iran during the period 2000-2009, regarding the availability of data. This

may address the question whether there is a stationary trade relationship between West and East Asia.

In the following, the paper reviews briefly the related literature in section 2. Then, it focuses on methodology applying several panel unit-root methods in section 3 to test for PPP in the sampling countries. Section 4 analyzes the empirical results on the PPP approach, which have been obtained by the selected panel unit root tests. Finally, section 4 concludes the important remarks and then gives an implication.

2. THE RELATED LITERATURE

The primary studies on PPP in developed countries use univariate Augmented Dickey–Fuller (ADF) tests with post-1973 flexible (nominal) exchange rate data and often do not find evidence for long-run PPP. A common explanation implies why these studies mostly failed to find evidence of PPP is the lack of power of unit root tests in small samples. To address the small sample problem, researchers use long horizon (up to 200 years) data of developed countries and generally show stronger rejections of the unit root hypothesis. However, long horizon data combine fixed and floating exchange rate periods and cannot determine whether PPP would hold over a century (or more) of a stable exchange rate regime

To address the low power of the univariate unit-root tests with post-1973 data, researchers have turned to panel methods that allow for cross-section variation, as developed by Levin *et al*. (2002) and Im *et al*. (2003). The empirical evidence has been, overall, supportive of PPP. While early studies such as Frankel and Rose (1996) and Jorion and Sweeney (1996) find strong support for PPP, work incorporating serial correlation in Papell (1997) and contemporaneous correlation in O'Connell (1998) find much weaker evidence. More recently, panel unit root tests that extend post-1973 quarterly real exchange rate data with the US dollar as numeraire currency through 1997 or 1998 tend to provide strong support of PPP for developed countries.

Examples of this work include Higgins and Zakrajšek (2000), and Papell (2006). Papell and Theodoridis (2001) show stronger rejections of the unit root hypothesis with European rather than non-European numeraire currencies.

For less developed countries, panel unit root tests have not provided much support of PPP. Using real exchange rates constructed from price indexes and black market quotations of nominal exchange rates, Phylaktis and Kassimatis (1994) reject the unit root hypothesis for eight Pacific Basin countries. Oh (1996) uses data from Summers and Heston's (1991) Penn World Table and mostly fails to reject the unit root hypothesis in real exchange rates of less developed countries during the flexible rate period. Both studies use Levin *et al*. (2002) tests. Holmes (2001) uses panel unit root tests, as developed by Im *et al*. (2003), and fails to reject the unit root hypothesis in panels of countries with high inflation and of countries located outside Africa. Hence, while panel methods have significantly increased the power of unit root tests, studies using these methods fail to show convincing evidence of PPP.

There are a number of reasons why PPP might vary systematically with country characteristics. PPP may hold better for countries more open to trade because trade barriers hinder international arbitrage and among countries that are geographically closer because high transportation costs associated with greater distance could hinder trade and arbitrage. PPP may also hold improved between countries with similar inflation rates because, with differences in inflation, countries can prevent their nominal exchange rates from adjusting to parity. The relation between PPP and nominal exchange rate volatility is more nuanced. For developed countries, PPP may hold better among countries with low nominal exchange rate volatility because rigidities may prevent prices from adjusting to parity. For developing countries, however, low nominal exchange rate volatility may hint restrictions on exchange rate movements that prevent PPP from holding. Accordingly, in the literature, Balassa (1964) and Samuelson (1964) posit that countries with high productivity growth in traded goods will have appreciating real

exchange rates. In that case, PPP will not hold between high-growth and low-growth countries.

3. METHODOLOGY: PANEL UNIT ROOT TESTS

Due to our analysis, which is being concerned with changes in real exchange rate, the following equation specifies the calculation of the variable as:

$$q = e + p^* - p, \tag{1}$$

where q denotes the real exchange rate, e is the nominal US dollar exchange rate, p is the domestic price index and p^* is the price index of the United States. q, e, p, and p^* are all in logarithms.

The univariate ADF tests involve running regressions on the following equation:

$$\Delta q_t = \mu + \alpha q_{t-1} + \sum_{i=1}^{k} c_i \Delta q_{t-i} + \varepsilon_t, \tag{2}$$

where Δq_t is the first difference of the real exchange rate and k is the number of lagged first differences. k is determined following the recursive t-statistic procedure proposed by Hall (1994). We choose a maximum value of k equal to 24, with the significance determined at the 10% level of the asymptotic normal distribution. The test is specified without a time trend for consistency with long-run mean reversion implied by PPP. The null hypothesis is a unit root and the alternative is the stationary level of q, and the null hypothesis is rejected in favor of the alternative hypothesis if α is significantly less than zero.

The failure to reject unit roots in real exchange rates could be due to the low power of univariate ADF tests in small samples. In order to increase

power, we use panel methods that allow for variation across countries as well as across time. The panel unit root tests are conducted by running regressions on the following equations:

$$\Delta q_{it} = \mu_j + \alpha q_{jt-1} + \sum_{i=1}^{k} c_{ji} \Delta q_{jt-1} + \varepsilon_{jt}, \tag{3}$$

where μ_j represents heterogeneous intercept and the subscript j is the country index. The lag length k and the coefficient c_{ij} are heterogeneous across countries. Equation (3) is estimated by using feasible GLS (SUR), with the values of k taken from the results of univariate ADF tests. The coefficient of lagged real exchange rate, α, is the same in all countries. The restriction on α follows the panel unit root tests developed by Levin *et al*. (2002). The *t*-statistic on α is the test statistic. If this coefficient is negative and significantly different from zero, the null hypothesis that all the real exchange rates in the panel have unit roots is rejected in favor of the alternative hypothesis that all the real exchange rates in the panel are level stationary.

To improve the power of the univariate Dickey-Fuller procedure, Jorion and Sweeney (1996) estimate a SUR system of equations. A univariate regression is defined as follows:

$$\Delta q_{it} = \alpha_i + \rho_i q_{i,\, t-1} + e_{it}, \qquad t = 1, \ \ldots, \ T. \tag{4}$$

Since the regression has a null hypothesis that $\rho_i = 0$ for all i, Jorion and Sweeney (1996) impose an identical first order autoregressive coefficient on all series, $\rho_1 =$, …, $\rho_n = \rho$ and estimate the following system of equations using SUR, that is:

$$\Delta q_{it} = \alpha_i + \rho q_{i,\, t-1} + e_{it}, \qquad t = 1, \ \ldots, \ T. \tag{5}$$

Jorion and Sweeney (1996) show that the SUR procedure can lead tests to

be more powerful rather than others. The critical values are obtained from Monte Carlo simulations under the null with $\alpha_i = 0$, $\rho = 0$ and T=87 observations and the corresponding number of countries in each panel using 10,000 trials. The error terms e_{it} are generated jointly T=87 times from a multivariate normal distribution with mean zero and the covariance matrix from the data set.

O'Connell (1998) extends the GLS approach using a parametric bootstrap method and shows that cross serial correlation can considerably change the critical values. He assumes that the vector of disturbance terms e_t are generated by the following restricted VAR (p) process:

$$e_t = \Phi_1 I_n e_{t-2} + \cdots + \Phi_p I_n e_{t-p} + v_t, \tag{6}$$

where Φ_i and I_n are parameter and identity matrices, $\varphi(L)e_t = v_t$ and $E(v_t v_t') = \Omega$. The coefficients on the VAR matrices are restricted to be diagonal so that Ω is estimated unrestricted using maximum likelihood estimates of the VAR process to estimate Ω and ρ_{FGLS}. The critical values are derived from a parametric bootstrap by generating 10,000 panels of real exchange rates under the null and matching the moments of the real exchange rate innovations to the estimates of $\{\varphi_i\}$ and the estimated Ω from the restricted VAR. O'Connell (1998) achieves parsimony by constraining the VAR coefficient matrices to be diagonal. An additional 50 observations are generated but discarded to avoid initial value bias. The null and alternative hypotheses have the same interpretation as in the LLC test.

The Im *et al*. (2003) test (IPS) relaxes the assumption of identical first order autoregressive coefficients of the SUR and Levin and Lin (2002) approaches. The method pools N separate cross-section ADF unit root tests to evaluate $H_0 : \rho_i = \rho = 0$ *for* i=1, ..., N and the alternative, $H_1 : \rho_i < 0$. Rejecting the null implies that real exchange rate series in the panel are stationary, but can mean revert at different rates. However, if there are 1, 2, or 4 stationary real exchange rate series in a panel of N=25 with T=50, Maddala and Wu (1999) show that the power of the IPS test is only 0.08,

0.13 or 0.18, respectively. Thus the IPS test, like the LLC procedure, also appears sensitive to the time series properties of the variables in the panel.

Following Maddala and Wu (1999), we choose the *t*-bar test version of the *IPS* technique which averages *N* univariate ADF regression from equation (3) to calculate $\bar{t} = \sum_{i=1}^{N} t_i$ where the estimated *t*-ratio for each series, $t_i = (\rho_i / \sqrt{Var(\rho_i)})$, is from *T* observations. IPS shows that:

$$\bar{Z} = \sqrt{N}(\bar{t} - \mu) / \sigma, \quad N(0, 1), \tag{7}$$

where $E(t_i) = \mu$, $\text{var}(t_i) = \sigma^2$. Since μ and σ^2 are unknown, they use Monte Carlo methods and give critical values.

The IPS test is derived assuming that the series are independently generated, and they suggest subtracting cross-sectional means to remove common time specific effects. This assumes the error term from equation (3) consists of two random components, $e_{it} = \theta_t + \zeta_{it}$ where ζ_{it} the idiosyncratic random component, and θ_t is a stationary time-specific effect that accounts for correlation in the errors across economies.

The Fisher P_λ test of Maddala and Wu (1999) pools the *P*-values of ρ_i from the ADF regression for each of the *N* independent ADF regressions from equation (3) for ρ_i. The test is nonparametric and is based on the work of Fisher (1932). Similar to the IPS method, this test allows for different first order autoregressive coefficients and has the same null and alternative hypotheses. Assuming that the test statistics are continuous, the *P* values (P_i) from the ADF regression are independent uniform *U*(0,1) variables so that $-2Log_e P_i$ is distributed as χ^2 with 2 degrees of freedom. The χ^2 variables are additive and thus $\lambda = -2\sum_{i=1}^{N} \log_e P_i$ has a χ^2 with $2N$ degrees of freedom. Similar to the LLC and IPS, the Fisher P_λ test gives unbiased test statistics when the series are independent. Maddala and Wu (1999) employ a nonparametric bootstrap method to remove more general forms of contemporaneous correlation than the common time specific method.

The bootstrap procedure requires estimating the parameters of equation (3) using iterative SUR and saving the fitted residual $\hat{e}_{it}$. To preserve the

contemporaneous correlation among the countries, the fitted residuals $\hat{e}_{it}$ are re-sampled over time with a fixed cross-section

$$\Delta q_{it}^{*} = \hat{\alpha}_i + \sum_{j=1}^{p} \hat{\theta}_{ij} \Delta q_{i,\, t-j} + e_{it}^{*}. \tag{8}$$

The bootstrap sample q_{it}^{*} for q_{it} is generated from the following equation: where $\hat{\alpha}_i$ and $\hat{\theta}_{ij}$ are the SUR estimates from equation (3). The initial values for $q_{i.0}^{*}$ are obtained by randomly re-sampling a block with replacement after dividing q_{it} into *T-p* overlapping blocks of length $p+1$.

4. EMPIRICAL RESULTS: TESTING THE PPP HYPOTHESIS

Using panel data and Eviwes-6 computer software, we investigate the PPP approach by testing for unit roots in the real effective exchange rates of the selected countries. Our hypothesis is that if real effective exchange rates are stationary, PPP holds when tested in panel data (Banerjee *et al*., 2005). The required data are obtained from the Bank for International Settlements (http://www.bis.org/statistics/eer/index.htm). Table 1 reports panel unit root tests for real effective exchange rates (Iran and 8 selected Asian countries), based on individual effects. Although the calculated statistic by the LLC method is only significant at 10%, the overall results confirm non-stationary exchange rates, that is, PPP does not hold between the countries in the sample.

Levin *et al*. (2002) argue that individual unit root tests have limited power against alternative hypotheses with highly persistent deviations from equilibrium. This is particularly severe in small samples. LLC suggest a more powerful panel unit root test including both individual effects and individual linear trends than performing individual unit root tests for each cross-section. This supports O'Connell (1998) that discussed previously in section 3. Table 2 summarizes panel unit root tests for real effective exchange rates of Iran and 8 selected Asian countries. The results have been

Table 1 Panel Unit Root Tests for Real Effective Exchange Rates (Iran and 8 Selected Asian Countries), based on Individual Effects, Sample: 2000-2009

Method	Statistic	Prob.
Lin, Lu, and Chu (LLC)	–1.287*	0.099
Breitung (B)	–0.281	0.389
Im, Pesaran, and Shin (IPS)	0.220	0.587
Maddala and Wu (ADF-Fisher)	15.282	0.643
Hadri (H)	4.707	0.000

Note: * Significant at 10%.

Table 2 Panel Unit Root Tests for Real Effective Exchange Rates (Iran and 8 Selected Asian Countries), based on Individual Effects and Individual Linear Trends, Sample: 2000-2009

Method	Statistic	Prob.
Lin, Lu and Chu (LLC)	–6.469*	0.000
Breitung (B)	–1.369**	0.085
Im, Pesaran, and Shin (IPS)	–0.567	0.286
Maddala and Wu (ADF-Fisher)	27.091**	0.077
Hadri (H)	7.417	0.000

Notes: * Significant at 5%. ** Significant at 10%.

obtained on the basis of individual effects and individual linear trends. Of the used tests, LLC, ADF-Fisher and B methods apply significantly for a long-run PPP between the sampling countries in which PPP holds for them in the long-run. However, the results obtained by ADF-Fisher and B methods could be critical as stationarity is accepted at the 10% significance level, while the result obtained by the LLC technique is accepted at the 5%. More specifically, we accept the hypothesis that PPP holds between Iran and the Asian countries just through the LLC method, which its process is based on individual effects and individual linear trends. This leads Iran to expand trade relations with such countries through an appropriated price mechanism.

5. CONCLUSION

Purchasing power parity (PPP) is usually studied as an "all or nothing" proposition. Either the unit root hypothesis is rejected and evidence of PPP is found, or the unit root hypothesis is not rejected and evidence of PPP is not found. In this paper, we used panel unit root tests with the real effective exchange rate to investigate PPP for 8 selected East Asian countries and Iran. Accordingly, we did run several panel unit-root tests, which were based on individual unit root process holding for the PPP hypothesis for such countries. Basically, on one hand, we concluded that PPP holds depending only on the result obtained by the LLC method, which is consistent with O'Connell (1998). On the other hand, we may conclude that PPP for all countries depends on the country characteristics in ways that are consistent with economic theory. The evidence of PPP is thus stronger for countries that are more open to trade. The evidence of PPP is thus stronger for countries that are more open to trade. The existence of a long-run interaction between currencies thus implies expansion in trade relations between Iran and the selected East Asia countries.

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