CHAPTER 2

LITERATURE REVIEW

This chapter provides a broad picture of how empirical studies on PPP were conducted. Major findings of those studies, along with advantages and limitations of each technique, will be summarized and discussed. The first part of this chapter focuses on traditional studies based on a time series approach. Then, the second part concentrates on studies using panel data. Finally, evidence of Thailand and other Asian countries will be shown.

2.1 Traditional Studies: Time Series Approach

Empirical study of PPP based on time series data focuses mainly on testing the stationarity of the real exchange rate and testing for cointegration between the nominal exchange rate and price levels. Stationarity of real exchange rate indicates mean reversion while cointegrated series implies a long run relationship between two or more variables. This section is divided into two subsections, unit root test and cointegration test.

2.1.1 Unit Root Test of Real Exchange Rate

In the first era, studies on PPP mostly relied on the time series properties of real exchange rates. Since the real exchange rate is defined as nominal exchange rate multiplied by the ratio of national price level and the PPP hypothesis postulates a proportional relation between the nominal exchange rate and the relative price ratio, this implies the real exchange rate has to revert to a constant level over time to satisfy PPP. Hence, numerous amonts of literature have attempted to test the mean reversion of PPP by employing a unit root test of real exchange rate for the post-Bretton Woods period of floating exchange rates. If the null hypothesis of unit root or non-stationarity cannot be rejected, then the real exchange rate does not show the reversion toward its own mean, indicating that PPP does not hold in the long run.

There has been limited evidence supporting PPP found in this era. As cited in previous literature[1], Roll (1979), Frankel (1981), Adler and Lehmann (1983), Darby (1983) failed to reject random walk of real exchange rate, implying that long run PPP did not hold. Even in recent studies, results do not tend to have any strong support for PPP. Coakley and Fuertes (1997) examined the real exchange rates of G10 countries and Switzerland between 1973-1996. The results showed that conventional ADF test fails to reject the unit root null hypothesis for all real exchange rates which implies the rejection of PPP. The similar test was also applied to five developing Asian countries by Doganlar (1999). As expected, it led to the same conclusion.

Furthermore, the study of Breitung and Candelon (2005) on Asian countries and South and Latin American during the period of the financial crisis asserted that the ADF test cannot reject the null hypothesis of unit root. Even for the test accounting for structural break (Perron test), the unit root hypothesis still cannot be rejected in all countries, except Thailand. In addition, Darius and Williams (2000), by employing ADF and PP test, found very weak evidence of PPP and suggested the need to search for a model with greater explanation power. A smaller number of studies (Cumby and Obstfeld, 1984; Abuaf and Jorion, 1990), however, confirmed the validity of PPP.

The issue on the low power of test was raised that the failure to reject the random walk might be from a lack of power of standard tests. Frankel (1986, 1990) argued that using post-Bretton Woods data covering just 15 years (since 1973) may not have enough power to reject the existence of unit root even if it is indeed false. Though, over a long period of time, real exchange rate tends to revert to its mean, verification of real exchange rate's behavior in a relatively short time may not have sufficient information to detect its mean reversion. Therefore, he employed over hundred years of data from 1869 to 1984 and was able to find support for PPP. He also estimated the rate of mean reverts by 14 percent per year which meant a half-life for PPP deviation is 4.6 years.

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[1]Rogoff (1996), Flessig and Strauss (2000), Taylor and Taylor (2004) and Wang (2005).

Simulations of Lothian and Taylor (1997) and Sarno and Taylor (2002b), assuming the rate of mean revert of 11 percent per year, showed that the probability to reject unit root of real exchange rate, when it is indeed mean reverting, is around five to eight percent when using 15 years of data. To increase the chance of correctly rejecting the unit root, more data is required.

Unfortunately, Shiller and Perron (1985) have pointed out that increasing the frequency of data in order to increase the sample size will not increase the power of the test. More frequent data can not provide additional long run information but only give more information about short run movement.

Consequently, several studies based on long horizontal data have been conducted. In this era, more evidence in favor of PPP were obtained; for example, Glen (1992) using data for the years 1900-1987 found mean reversion of real exchange rates for nine countries and a half life of 3.3 years. Lothian and Taylor (1996) found strong evidence of mean reversion using two centuries of data on dollar-sterling and franc-sterling real exchange rates. The studies of Diebold, Husted and Rush (1991), Grilli and Kaminsky (1991) and Cheung and Lai (1994) yielded similar results.

In contrast, a smaller number of studies did not obtain confirmation of PPP. Baharumshah and Ariff (1997) and Weliwita (1998) failed to support long run PPP using cointegration tests. In another study, using a shorter period of time, Darius and Williams (2000) also found very little evidence to support PPP.

Besides, Cheung and Lai (1998) argued that post-Bretton Woods period is not too short to reveal any significant parity reversion in individual series of real exchange rates, but it depends very much on the statistical test being used. By employing two modified Dickey-Fuller tests, DF-WS test and DF-GLS test, as the efficient univariate unit root tests, they were able to reject the unit root of real exchange rates.

Another controversy of using long horizontal data, however, is that it has ignored changes in exchange rate regimes. It is unclear whether evidence of PPP based on long time periods data simply confirms the presence of parity reversion in the pre modern floating period or show its presence over the recent float as well (Wang, 2005).

To sum up, the application of conventional unit root test in testing stationarity of the real exchange rate suffers from the low power of test. The existence of PPP was rejected by most literature. The alternative to exploit the long horizontal series yielded stronger results for PPP. This approach, however, confronted a problem of regime change. Therefore, the test with superior power is required.

2.1.2 Time Series Cointegration Test

Aside from investigating the stationarity of the real exchange rate, testing for cointegration between the exchange rate and price levels is another mean to verify the validity of PPP. If cointegration can be found, a long run relationship between the exchange rate and the relative price level exists. This exhibits the co-movement between these variables and, therefore, evidence of PPP.

The cointegration of two variables proposed by Engle and Granger (1987) was used to test for PPP. Cointegration analysis states that any two non-stationary series which are integrated of the same order are cointegrated if a linear combination of the two is stationary. In this case, the non-stationarity of one series offsets that of the other and a long run relationship between these two variables is established. On the other hand, if the no-cointegration hypothesis cannot be rejected, the estimated regression is just a spurious and no economic meaning can be concluded.

Although using Engle and Granger's cointegration testing seems to be a desirable approach, there are still some drawbacks of this method. Firstly, only one cointegration relation can be tested. It seems that this might not be considered as a problem since price levels of two countries can be pooled to one price ratio. Secondly, this method provides no causality between dependent and independent variables. Theoretically, testing for cointegration relationship between y and x or between x and y are equivalent. However, practically, the outcomes can be totally different. Fortunately, for this purpose, there is a prior theory that exchange rate should be determined by price levels. Finally, the symmetry and proportionality conditions of PPP are not imposed and cannot be tested easily by this test (Sarno and Taylor, 2002a). The Johansen (1988) multivariate cointegration allowing for the presence of multiple cointegrating vectors overcomes these problems. Moreover, Johansen also showed how to test for linear restrictions on the coefficients of the cointegrating

vectors which made it possible to test the symmetry and proportionality conditions of PPP[2].

Kargbo (2003) investigated long run PPP in Africa between 1980-1997. Employing Johansen's cointegration technique and error correction models, this study found supportive evidence for PPP. In addition, Allsopp and Zurbruegg (2003) applied a cointegration approach to examine PPP during the crisis period (1990-2002) in Asian countries. The results were generally supportive of PPP with the crisis leading to only shifts in long run trends.

However, the results on this approach were not quite affirmative for PPP. Though some findings favoring of PPP were found, many yielded opposite results. Coakley and Fuertes (1997) and Baharumshah and Ariff (1997) failed to assert cointegration between exchange rate and price ratio. Weliwita (1998) applyed the Engle and Granger two-step cointegration and the Johansen and Jeselius multivariate cointegration to price and exchange rate data of six Asian countries from 1981M1 to 1994M12. No cointegration was found and hence no evidence for PPP. Similar outcomes were found by Doganlar (1999) Darius and Williams (2000). Wrasai (1996) found some cointegrations between exchange rate and price levels of Thailand and trade partners. The symmetry and proportionality conditions of PPP, however, were not satisfied. Consequently, this implies the long run relationship between exchange rate and price levels exists, but does not precisely follow PPP.

2.2 Cross Countries Studies: Panel Data Approach

Apart from expanding the range of years to enhance the power of test, the other choice is to use more countries so that the timeframe can be limited to the post-Bretton Woods period. By increasing the amount of information employed in the tests *across* exchange rates, the power of the test should be increased (Taylor and Taylor, 2004).

[2]As cited by Sarno and Taylor (2002a), it is also possible to circumvent the problem by performing fully modified OLS (FMOLS), instead of OLS, of the nominal exchange rate on the relative price since a correction is made for the problem of the bias in the standard errors (Phillips and Hansen, 1990).

The study of Frankel and Rose (1996) pointed out that even when using only post-1973 floating data, the random walk model can be handily rejected, given that a sufficiently broad cross-section of the countries is included. Moreover, PPP deviations are eroded at a rate of approximately 15 percent annually, i.e., their half-life is around four years which is similar to results using long horizontal data. The panel approach is also adopted by Koedijk, Schotman and Dijk. (1998), Papell and Theodoridis (1998), Flores, Jorion, Preumont and Szafarz (1999), Chiu (2002) and Lopez and Papell (2007). All have reported similar findings, strong evidence in favor of long run PPP.

Moving from time series data to panel data, however, encounters issues of heterogeneity and cross-sectional independence. In the case of time series data, the unit root hypothesis is tested for each individual. Although the test models may differ for each individual, heterogeneity is not a problem as long as the tests are conducted separately. In contrast, when data is pooled in the panel, the panel unit root tests have to account for this heterogeneity. For the case of cross-sectional independence, it is rather restrictive and unrealistic in the majority of macroeconomic applications since co-movements of economies are often observed (Hurlin and Mignon, 2004). Therefore, various tests allowing for cross-sectional correlation have been developed.

According to whether unit root tests allow for potential correlation across residuals of panel units, panel unit root tests can be classified in two generations.

2.2.1 First Generation Panel Unit Root Test

The first generation of the panel unit root test is based mainly on the cross-sectional independence assumption. The panel unit root test (LLC test) proposed by Levin and Lin (1993) and Levin, Lin and Chu (2002) imposes an identical first order autoregressive coefficient on all series in the panel. Rejection of the null hypothesis implies that real exchange rates in all economies adjust at the same rate. They have also analyzed the power of panel unit root tests under the assumption of i.i.d. disturbances, and showed that it is an order of magnitude higher than in a univariate setting.

Later on, Im, Pesaran and Shin (2003) proposed a new panel unit root test (IPS test) allowing for heterogeneous first order coefficients under the alternative

hypothesis so that series may adjust at different rates. This made this test become more realistic than that of the test by Levin and Lin (1993) and Levin *et al.* (2002). While the tests suggested by Levin and Lin (1993), Levin *et al.* (2002) and Im *et al.* (2003) focused on pooled and average statistic, Maddala and Wu (1999) and Choi (2001) proposed Fisher's type test based on combining the significant levels from the individual tests.

Alba and Park (2003) evaluated the existence of PPP on a panel of developing countries with 14 different country classifications based on openness, inflation experience, growth rate and per capita income. The overall period of 1976-1999 was divided into 15 moving periods with ten consecutive years. The unit root hypothesis could not be rejected in closed countries. This is sensible since PPP is applicable to open economies. For panels of developing countries that opened up trade, the unit root hypothesis is only rejected for some periods. In conclusion, this study did not give any assertion for PPP since the evidence of PPP was found in only 14 out of the 210 cases.

Choi (2004) applied six panel unit root tests to twenty real exchange rates of 21 industrial countries over 1973Q1-1998Q4. The results of LLC, IPS and MW tests failed to reject unit root hypothesis in real exchange rates, regardless of using US dollar or deutsche mark as the numeraire. In contrast, the empirical study of Fleissig and Strauss (2000) revealed the confirmation on PPP by applying LLC, IPS and MW tests on the real exchange rate.

All of these tests of the first generation require the absence of contemporaneous and serial correlation across countries. O'Connell (1998), however, referred to Hakkio (1984) that practically the real exchange rates are cross-sectionally dependent. To illustrate this fact, let; denote the real exchange rate between country i and the U.S., q_{it}, by $q_{it} \equiv e_{it} + p_{it} - p_{US,t}$ where e_{it} denotes country's price of dollar in log term and p_{it} is log of local currency price index. Consider the relationship between the French and German real exchange rates, q_{Fr} and q_{GE}. It is quite trivial that q_{Fr} and q_{GE} will absolutely be correlated since they contain two common components, variation in the value of the dollar through e_{it}, and the variation in U.S price index, $p_{US,t}$.

These common components induced by numeraire currency can be massive and this results in such a way that choice of numeraire currency makes a considerable difference. For instance, shocks which originate in Germany may propagate to France, but not to the U.S. As reported by Koedijk *et al.* (1998) and Papell and Theodoridis (1998), when the mark is used as the base currency, the evidence of PPP is uniformly stronger (than dollar). There is further evidence on literature reporting this finding (O'Connell, 1998; Fleissig and Strauss, 2000; Paul, 2004; Cerrato and Sarantis, 2007; Lopez and Papell, 2007).

Furthermore, when the disturbances are not independent, they adversely affect size and power of test. If contemporaneous and serial correlation across countries exists, the limit distributions derived by previous panel unit root tests will be no longer valid. Besides, the power of the test will be diminished, as the total amount of independent information contained in the panel is reduced, and it will also lead to very large sized biases (Maddala and Wu, 1997; Papell, 1997; O'Connell, 1998).

2.2.2 Second Generation Panel Unit Root Test

Since the tests of first generation suffer from size distortion and low power when applied to data with cross-sectional dependencies, the second generation of panel data unit roots tests relaxing the assumption of cross-sectional independence have recently been proposed in literature including Choi's (2006), Bai and Ng's (2004), Moon and Perron's (2004), Pesaran's (2003) and Phillips and Sul's (2003) tests.

Fleissig and Strauss (2000) asserted that accounting for cross correlation[3] positively affects stationarity and the half-life of deviation from PPP. This study evaluated PPP over the floating period (1974Q1-1996Q3) for six different price indices, including 19 economies and used the US as the benchmark. Applying Demeaned-IPS and O'Connell parametric bootstrap procedure, the results confirmed the validity of PPP.

[3]Fleissig and Strauss (2000) found that correcting for both cross correlation and heterogeneity results in quicker mean reversion. In addition, allowing the heterogeneity of real exchange rates in panel positively affects speeds of adjustment and stationarity.

Coakley and Fuertes (1997) adjusted for cross-sectional dependence to analyze the stationarity of real exchange rates for the G10 countries and Switzerland in the post-Bretton Woods period by the Demeaned-IPS test. This study strongly rejected the unit root and hence indicated mean reversion in real exchange rate and also found a half life of under three years for one-off shocks. An empirical study of Paul (2004), also reported results in favor of PPP when demeaned-IPS test was used.

Nevertheless, some investigations did not provide strong affirmation of PPP. For example, Engel *et al.* (1997) verified long run PPP allowing for correlation across equations in their panel and estimated the model using GLS and found no evidence in favor of reversion to PPP. Cerrato and Sarantis (2007) applied bootstrap panel unit root test allowing for heterogeneous serial correlation and different speeds of convergence, along with MW test and CIPS test. No evidence favoring mean reversion in real exchange rate was found for the full panel of OECD countries.

Koedijk, Tims and Dijk (2004) found mixed results in the euro area. Moreover, Drine and Rault (2007) applied unit root tests of Choi (2006) and Moon and Perron (2004) to investigate the PPP. It was reported that the null hypothesis of unit root in real exchange rate can be rejected only in OECD countries. In addition, when countries are classified into two subgroups depending on the exchange rate regimes, the strong version of PPP was also rejected for both fixed and floating exchange rate regimes. They argued that some factors leading to the rejection of PPP exist, such as, obstacles in international exchanges, long run capital movements and interventions on the exchange market.

It is worth noting that the cross-sectional dependence in panel data can be corrected not only by the second generation of panel unit root tests, but also by using bootstrap methodology.

2.2.3 Panel Cointegration Test

The recent approach for testing PPP is panel cointegration test. Due to its difficulty in measuring real exchange rates across countries since countries construct price indices differently, a more appropriate method may be testing for cointegration, a long run relationship, between domestic and foreign price indices and nominal exchange rates (Flessig and Strauss, 2000).

Pedroni (1996) employed a fully modified ordinary least squares (FMOLS) panel cointegration approach and rejected the strong version of PPP, and instead supported the weak version. Later on, Pedroni (2004) examined the properties of residual-based tests for the null of no cointegration for dynamic panels and illustrated the use of these tests in testing for PPP in the post-Bretton Woods period. His results strongly supported that weak PPP holds for at least a significant portion of countries.

Jenkins and Snaith (2005) extended the method of Pedroni (2004) to test for weak PPP among 11 countries and found evidence in support of weak PPP for goods characterized as highly traded, but not for non-traded goods. Thus, they suggested that the failure of PPP can be attributed to inclusion of non-traded goods in the overall index, not from low power of test.

The study of Drine and Rault (2007) confirmed the strong version of PPP for OECD countries and weak PPP for Middle East and North African countries, but no evidence for PPP in African, Asian, Latin American and Central and East European countries. When countries were grouped by the exchange rate regime, fixed exchange rate and floating exchange rate, the cointegration tests of Pedroni confirmed weak PPP for the two exchange rate regimes.

2.3 PPP Evidences of Thailand and Asian Countries

Along with the global trend of studies focusing on PPP, empirical studies based on Thailand and other Asian countries have been conducted overtime employing various approaches and various time periods. Previous studies on individual Asian countries have also found mixed results, as expected.

On one hand, by employing a traditional time series approach, Weliwita (1998) and Baharumshah and Ariff (1997) failed to assert PPP. Baharumshah and Ariff (1997), for example, analyzed quarterly data for five Southeast Asian countries using the unit root and the residual based cointegration developed by Engle and Granger (1987). They obtained weak evidence of long run PPP in Malaysia, Singapore and the Philippines, and somewhat stronger evidence in support of the PPP in Indonesia and Thailand. On the other hand, Allsopp and Zurbruegg (2003) found

general support for PPP with the crisis leading to only shifts in long run trends. Mixed results were found by Tang and Butiong (1994), Doganlar (1999) and Nusair (2003)

Although better techniques, such as panel approach, has been used in examining PPP, the results are still unclear. The studies of Esaka (2003), Paul (2004), and Azali *et al.* (2001) overwhelmingly affirmed long run PPP whereas Basher and Mohsin (2002), Breitung and Candelon (2005) and Drine and Rault (2007) found weak or no evidence asserting PPP.

Azali *et al.* (2001), for example, conducted an empirical analysis of panel unit root, IPS test, and panel cointegration, Pedroni test, tests of long run PPP for seven Asian developing economies (ADE): Indonesia, Korea, Malaysia, Phillipines, Singapore, Taiwan and Thailand. Seasonally unadjusted quarterly data on bilateral exchange rates using Japanese yen as numeraire and consumer price index,1980=100, between 1977Q4-1998Q3 were used in this study. Applying Johansen and Juselius (1990) cointegration test of individual country's series, the PPP was found to hold only in the case of Korea, Taiwan and Thailand at 0.10 level of confidence. Results on the panel cointegration test of Pedroni (1997), however, indicated that PPP does hold in the long run for a group of ADEs with respect to Japan as shown by panel non-parametric (pp-statistic) and parametric (panel-adf) at 0.01 level of confidence.

Paul (2004) studied the validity of PPP for six South East Asian countries: China, India, Korea, Malaysia, Singapore and Thailand, by testing the stationarity of real effective exchange rate constructed using dynamic export, import and trade weights. Employing univariate ADF test and two versions of panel unit root test proposed by Im *et al.* (2003), the study reported that null hypothesis of the failure of PPP cannot be rejected unless the data is demeaned to account for cross-sectional correlation.

Empirical studies concerning Thailand also yielded weak support for PPP. Wrasai (1996) examined the validity of PPP between Thailand and six major trading partners: the United States, the United Kingdom, Germany, Japan, Singapore and Malaysia, on the basis that they were the determinants of Thailand's currency basket at that time. This study employed monthly data of exchange rates, consumer price index and wholesale price index ranging from 1970 to 1995 and divided them into two sub-periods depending on exchange rate system, i.e., fixed exchange rate system

(January 1970 – October 1984) and adjusted pegged system (November 1984 – December 1995). Quarterly gross domestic product and broad money supply of Thailand from 1984Q4 to 1994Q4 was also used to examine the sources of deviation from PPP.

During the fixed exchange rate period, using the Engle and Granger two-step co-integration approach (EG approach), long run PPP relationships were found to hold in cases of Singapore and Malaysia. In addition, PPP was valid for Singapore by testing the stationarity of real exchange rate.

In the period of adjustable pegged exchange rate system, although the long run relationship between the exchange rate and the relative price levels were found in some cases, either symmetry or proportionality conditions of PPP were rejected. Moreover, the cointegration result was sensitive to order of lag selection in some cases. Therefore, the conclusion is that the cointegration relationship may exist, but it does not follow PPP conditions. By employing real exchange rate approach, however, the United Kingdom, Germany and Japan exhibit stationarity. Finally, empirical results from VAR analysis showed that monetary surprise, i.e. broad money supply (M2), have greater effects than real economic shocks, i.e. GDP, in influencing the deviation of the real exchange rates from PPP.

Adithipyangkul (2000) tested PPP and LOP from the end of 1970's to October 1999 using Thai baht as the numeraire currency. The PPP test used aggregate price data while the LOP test used price data disaggregated by commodity group and by individual commodity. Few cases of LOP and PPP were accepted in this study. Furthermore, he also noted that the results were sensitive to the periods of time employed and the sample size.

Sethapramote (2006) examined PPP hypothesis by investigating the relationship between the exchange rate and relative price levels from ten Asia Pacific countries: Australia, Indonesia, Japan, Korea, Malaysia, New Zealand, Phillipines, Singapore, Taiwan and Thailand. Quarterly data of exchange rates (per US Dollar) and CPI between 1980Q1-2002Q4 were tested both by univariate unit root tests and panel unit root tests. In order to control for size distortion due to cross-sectional dependency, Demeaned-IPS, Demeaned-Maddala and Wu (Demeaned-MW) and Cross-sectionally augmented IPS (CIPS) were adopted.

Testing the stationarity of real exchange rates by traditional time series approach could only reject unit root hypothesis of Australia and New Zealand at 0.05 and 0.10 level of confidence, respectively. Employing panel unit root of the first generation, IPS test and MW test (Fisher test), the validity of PPP was found at some level, whereas the second generation test yielded mixed results. Demeaned-IPS asserted for PPP at 0.10 level of confidence, nonetheless, Demeaned-MW and CIPS test could not reject non-stationarity even at 0.10 level.

Though a number of studies were conducted to test the validity of PPP among Asian countries, or at least included Asian countries in their studies, very few of them were focused mainly on Thailand. Moreover, studies based on Thailand were conducted using a traditional approach that might not have sufficient power for PPP to be detected. This study, therefore, intends to apply the recent panel data model to investigate whether long run PPP holds when using Thai baht as the numeraire currency.