Purchasing Power Parity Theory using Panel Data Approach

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Abstract: This paper applied panel data tests in testing for the existence of Purchasing Power Parity (PPP) for a group of asean-5 (Indonesia, Malaysia, Philippines, Singapore and Thailand) countries for the period of 1996-2016. For this purpose, we applied both panel data unit root and cointegration methods to test for Purchasing Power Parity. The paper tested for the stationarity of the variables and found that the variables are non-stationary at levels but stationary at first difference. Furthermore, we applied the cointegration test of Pedroni to see if there is long-run validity of PPP. Results of the cointegration test reject the null hypothesis of no cointegration ASEAN-5 countries, meaning that we have enough evidence to support PPP in the long-run for ASEAN-5 over the period of 1996-2016. We therefore conclude that PPP is valid in ASEAN-5.

Keywords: purchasing power parity, panel data, panel unit root tests, panel cointegration.

1. INTRODUCTION

Panel data consist of a combination of time series data and cross-sectional date. Panel data are increasingly used by researcher various fields of research. It has so many advantages apart from the fact that it gives more information. This paper applies panel data to the testing of purchasing power parity (PPP) theory. The PPP theory is one of the widely researched area in the field of international finance. The theory states that the exchange rate between two countries must be equal to the aggregate price levels between the two countries when converted into the same currency. There are diverse methods used in testing for PPP.

Many researchers have worked on testing for the validity the purchasing power parity theory using different methods to find out if PPP is valid or not in different countries. Among the work done on PPP include those of Carnovale (2001) who re-examined the PPP using Christano and Fitzgeral filter, applied to over a century of data for 10 developed countries. They found strong evidence for PPP while more traditional techniques continue to be unable to find support. Also, Michael (2005), brought innovation into the PPP and panel unit root testing literature by allowing for possible nonlinear deterministic trends in the alternative hypothesis. He found evidence to support the PPP hypothesis and found that stronger evidence for stable long run equilibrium in real exchange rates appears when the German Deutschmark is chosen as a base currency instead of the U.S. dollar. He concluded that a very recent panel unit root test at that time, Pesaran (2005) that takes into account cross-sectional dependencies delivers more consistent and sensible results. Furthermore, Munir and Kok (2015) tested the PPP hypothesis for a collection of ASEAN-5 countries using monthly data from 1968:I-2009:II. They utilised the Langrage Multiplier (LM) cointegration test developed by Westerlund (2006) which is flexible enough to accommodate a large degree of country specific heterogeneity, cross-country dependence as well as multiple structural breaks. The results of the panel cointegration test provides strong evidence in favour of PPP. Moreover, Robertson et al. (2014), examined the long run relationship between the US and Mexican prices using the panel cointegration techniques of Pedroni (1999) which allows for heterogeneous relationship across goods. The results of their analysis provided evidence in favour of the PPP.

This paper applied panel data approaches in testing for the validity of the PPP in ASEAN-5. Our results showed evidence of long-run validity of PPP in ASEAN-5 over the period of 1996-2016.

2. DATA AND METHODOLOGY

Data:

In this paper, we used data collected from *Datastream*, Thomson Reuters. It is a set of monthly data for a group of ASEAN-5 countries starting from January, 1996 to March, 2016. The countries contained in our sample are; Malaysia, Indonesia, Thailand Philippines and Singapore. The data consist of the nominal exchange rate and price levels (local currency per 1USD). Consumer price index (CPI) for each country and CPI for the US. The US was used as the base currency.

Panel Unit Root Tests:

Livin, Lin and Chu (LLC) Test:

LLC argued 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 than performing individual unit root tests for each cross-section. The null hypothesis is that each individual time series contains a unit root against the alternative that each time series is stationary. The maintained hypothesis is that

$$y_{it} = \rho y_{i,t-1} + \sum_{L_1}^{P_i} \theta_{iL} \square y_{i,t-L} + \alpha_{mi} d_{mt} + \varepsilon_{it} \qquad m = 1, 2, 3 \qquad (1)$$

with d_{mt} indicating the vector of deterministic variables and α_{mi} the corresponding vector of coefficients for model $m = 1, 2, 3$. In particular, $d_{1t} = \{\text{empty set}\}, d_{2t} = \{1\}$ and $d_{3t} = \{1, t\}$ Since the lag order p_i is unknown.

Im, Pesaran and Shin (IPS) Test:

Im, Pesaran and Shin (IPS) proposed a test that allows for a heterogeneous coefficient of y_{it-1} and an alternative testing procedure based on averaging individual unit root test statistics. IPS suggest an average of the ADF tests when u_{it} is serially correlated with different serial correlation properties across cross-sectional units. The model is:

$$y_{it} = \alpha_i + \rho y_{i,t-1} + \varepsilon_{it} \qquad t = 1, 2, ..., T \qquad (2)$$

The null and alternative hypotheses are defined as

$$H_0 : \rho_i = 1 \qquad i = 1, 2, ..., N = 1,$$

$$(3)$$

$$H_A : \begin{cases} \rho_i < 1 & \text{for } i = 1, 2, ..., N_1 \\ \rho_i = 1 & \text{for } i = N_1 + 1, ... N \end{cases}$$

The IPS test is a way of combining the evidence on the unit root hypothesis from N unit root tests performed on N cross-section units. The IPS test is applied only for balanced panel data.

Panel Cointergration Test:

Pedroni:

Pedroni (2004) also proposed several tests for the null hypothesis of cointegration in a panel data model that allows for considerable heterogeneity. His tests can be classified into two categories. The first set involves averaging test statistics for cointegration in the time series across cross-sections. For the second set, the averaging is done in pieces so that the limiting distributions are based on limits of piecewise numerator and denominator terms. The first set of statistics includes a form of the average of the Phillips and Ouliaris (1990) statistic:

$$\tilde{z}_\rho = \sum_{i=1}^{N} \frac{\sum_{t=1}^{T}(\hat{e}_{it-1}\,\square\,\hat{e}_{it} - \hat{\lambda}_i)}{\sum_{t=1}^{T}\hat{e}_{it-1}^2} \tag{4}$$

Where $\hat{e}_{it}$ is estimated from $y_{it} = x'_{it}\beta + z'_{it}\gamma + e_{it}$ and $\hat{\lambda}_i = \frac{1}{2}(\hat{\sigma}_i^2 - \hat{s}_i^2)$, with $\hat{\sigma}_i^2$ and $\hat{s}_i^2$ are individual long-run and contemporaneous variances of the residual $\hat{e}_{it}$. For his second set of statistics, Pedroni defines four panel variance ratio statistics. Let $\hat{\Omega}_i$ be a consistent estimate of Ω_i, the long-run variance-covariance matrix. Define $\hat{L}_i$ to be the lower triangular Cholesky composition of $\hat{\Omega}_i$ such that in the scalar case $\hat{L}_{22i} = \hat{\sigma}_\varepsilon$ and $\hat{L}_{11i} = \hat{\sigma}_\mu^2 - \hat{\sigma}_{\mu\varepsilon}^2 / \hat{\sigma}_\varepsilon^2$ is a long-run conditional variance. Here we consider only one of these statistics,

$$z_{t_{\hat{\rho}_{NT}}} = \frac{\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{L}_{11i}^{-2}(\hat{e}_{it-1}\,\square\,\hat{e}_{it} - \hat{\lambda}_i)}{\sqrt{\tilde{\sigma}_{NT}^2 (\sum_{i=1}^{N}\sum_{t=2}^{T}\hat{L}_{11i}^{-2}\hat{e}_{it-1}^2)}} \tag{5}$$

Where $\tilde{\sigma}_{NT} = \frac{1}{2}\sum_{i=1}^{N}(\hat{\sigma}_i^2 / \hat{L}_{11i}^2)$ .It should be noted that Pedroni bases his test on the average of the numerator and denominator terms, respectively, rather than the average for the statistic as a whole.

3. RESULTS

Below are the results of the analyses. Table 1. Presents the results of the panel unit root tests of Levin, Lin and Chu (LLC), and the Im, Pesaran and Shin (IPS). All variables are denoted in log form for exchange rate (Lxrate), consumer price index for each individual ASEAN-5 (Lcpi) and consumer price index for the US (Lcpi_us). The panel unit-root tests are conducted on variables at levels and first differenced (Δ) to see if these variables are integrated of order one, because that is the condition for running a cointegration test.

The results from panel unit-root tests show that all variables are not stationary at levels but become stationary at first differenced, i.e. all variables are integrated of order 1. Since all variables have fulfilled the condition for a cointegration test, we proceed for cointegration test to test for the long-run validity of PPP in ASEAN-5.

Table 2. presents results of the panel cointegration test of pedroni. As observed from the table, 8 out of 11 statistics under Pedroni test reject the hypothesis of no cointegration in ASEAN-5. This provides strong evidence to believe that there is a long-run relationship between the nominal exchange rates and price levels in ASEAN-5.

TABLE 1. Results of Panel Unit Root Tests

Variables	LCC	IPS
Lxrate	1.7460	1.3849
ΔLxrate	-28.4632***	-29.8908***
Lcpi	1.1570	-0.4869
ΔLcpi	-27.2645***	-29.8328***
Lcpi_us	10.9689	1.1960
ΔLcpi_us	-18.8117***	-22.8401***

The table above shows the results of the panel unit root tests. The unit root t-statistics are displayed on the table with *** representing 1% significance level. LLC and IPS are the Levin, Lin and Chu, and the Im, Pesaran and Shin panel unit root test.

TABLE 2. Results of The Pedroni Panel Cointegration Test

	Statistic(Prob.)	Weighted Statistic(Prob.)
Panel v-Statistic	14.1809 (0.0000)	11.3472(0.0000)
Panel rho-Statistic	-27.5960 (0.0000)	-23.449(0.0000)
Panel PP-Statistic	-12.4802 (0.0000)	-11.1514(0.0000)

Panel ADF-Statistic	-1.5179 (0.1053)	-0.6387(0.2615)
Group rho-Statistic	-29.5616 (0.000)	
Group PP-Statistic	-14.1825 (0.0000)	
Group ADF-Statistic	-0.5812 (0.2806)	

The above table shows the important Panel and Group statistics considered in the Pedroni test of cointegration. For each of the Panel and Group statistic, we have the statistic and Probability values in brackets.

4. CONCLUSION

This paper examined the purchasing power parity (PPP) for a group of ASEAN-5 countries by testing for the long-run relationship between the nominal exchange rate and the price levels for the period of 1996-2016. First of all, we conducted panel unit root tests at levels and first difference of the variables to see in the variables are integrated of order one. Results showed that all the variables are integrated of order one which is the requirement for running a cointegration test. Secondly, we went ahead to conduct the cointegration test for ASEAN-5 and found that there is a long-run relationship between the nominal exchange rates and price levels, indicating the presence of cointegration. Because there is a long-run relationship between the nominal exchange rate and the price levels (cointegration) in ASEAN-5, we hereby conclude that purchasing power parity exist in the long-run for ASEAN-5 countries.

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