



**Research Article**

## Statistical Analysis of the Purchasing Power Parity Theory for Five Southeast Asian Countries

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### ABSTRACT

For more than a decade, there has been substantial interest in testing for the validity of the Purchasing Power Parity (PPP) statistically. This paper utilised a series of statistical tests to ascertain if the PPP theory is valid for a group of five Southeast Asian countries from 2000 to 2016 using monthly data. For this purpose, we conducted four different panel unit root (stationarity) tests, two cointegration tests (Pedroni and Westerlund), and also, the vector autoregressive (VAR) model. The stationarity (unit root) tests reveal that the variables tested are non-stationary at levels but stationary at first difference, results of the cointegration tests did not reject the null hypothesis of no cointegration meaning there is no long-run relationship between the variables and results of the VAR model did not reveal a strong short-run relationship. Based on the results, we therefore conclude that PPP is not valid both in the long-run and short-run in the five Southeast Asian countries between 2000 and 2016. This implies that prices of goods are expected to be different in these countries. Meaning that a businessman can make more profits from buying goods that are cheaper in one of these countries and selling at a higher rate in one of these countries where the goods are more expensive.

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## INTRODUCTION

The purchasing power parity (PPP) theory is a vital theory in the field of international finance. The theory says that the nominal exchange rate for a country (local country) with another country (foreign country) should be the same as the proportion of the total price levels (CPIs) between the countries. The theory is very important because it enables us to make comparisons between countries in the sense that we can use PPP to compare the average cost of goods and services between countries.

There are mainly two types of the purchasing power parity; the absolute purchasing power parity and relative purchasing power parity. The absolute PPP holds when the purchasing power of a unit of currency is exactly equal in the domestic economy and a foreign economy, once it is converted into foreign currency at the market exchange rate. This idea suggests that the exchange rate between two countries is identical to the ratio of the price levels for those two countries. While the relative PPP holds that the exchange rate adjusts to the amount of the inflation differential between countries. That is, changes in the exchange rate are equal to changes in the relative national prices (Beirne 2010).

There are several methods used in testing for purchasing power parity that exists in the literature. These methods include the unit root tests, the cointegration tests and regression approaches. The unit root method is used to examine the stationarity of the real exchange rate. If the real exchange rate is stationary, then there exists evidence in favour of PPP, if it is not, the evidence is against PPP. Cointegration holds that the combination of two or more nonstationary series can yield a long-run stationary relationship if the series are integrated of the same order. Essentially the non-stationarity evident in each of

the series is cancelled out and a long-run stationary relationship can be observed. Cointegration tests require only that some linear combination of exchange rates and prices be stationary. If there is evidence of cointegration, then PPP is valid otherwise, PPP is not valid. The regression approach is used to find out the kind of relationship that exists between the exchange rate and the price levels involved ie, how the relative prices affect the exchange rates. Commonly used methods of testing for purchasing power parity are the unit root tests and cointegration methods.

Due to the importance of the purchasing power parity, many empirical analyses have been conducted using either one of those methods mentioned above to determine the validity of PPP theory for different countries. Among the empirical works done are those of Noman and Rahman (2010), used linear and nonlinear unit root tests (Augmented Dickey Fuller (ADF) and Kwiatkowski, Schmidt and Shin (KSS) (2003)) to investigate the validity of the Purchasing Power Parity for four Asian real exchange rates over the period of 1973-2007. Results of the linear unit root test indicate that PPP does not hold in any of the four (Bangladesh, India, Pakistan and Sri Lanka) countries while the results of the nonlinear unit root test found support in only one (Bangladesh) of the four countries. Thereafter, Acaravci and Ozturk (2010), examined the validity of PPP in 8 transition countries for monthly data from 1992:1 to 2009:1. While results from both the ADF and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) unit root tests indicate that PPP does not hold for Bulgaria, Croatia, Czech Republic, Hungary, Macedonia (FYR), Poland, Romania and the Slovak Republic. In the presence of structural breaks, PPP holds only for Bulgaria and Romania but does not hold for the other 6 transition countries. All results emphasised that

there is weak evidence for the long-run PPP hypothesis in transition countries and the validity of PPP remains a controversial and unsettled issue. Furthermore, Al-Zyoud (2015), examined the long run movement between the U.S. dollar and the Canadian dollar exchange rates using the Engle-Granger cointegration test. The analysis suggests that absolute PPP does not hold meaning that there is no long-run relationship between the Canadian Dollar and the U.S. dollar exchange rate. 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. Further, 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.

Recently, Wang *et al* (2019) did not find evidence for the PPP for China when they examined the dynamic link between nominal exchange rate and relative consumer price using a Bootstrap causality test. Furthermore, in a paper titled, "Nonlinear cointegration and asymmetric adjustment in purchasing power parity for USA, Germany and Pakistan", Ali *et al* (2021) found support for the PPP when they used nonlinear cointegration as well as asymmetric adjustment to investigate the long-run PPP. Finally, Liu *et al*

(2021) found evidence to support the PPP when they utilized the panel data KSS unit root test accompanied by a Fourier function and sequential panel selection method in the Belt and Road initiative countries relative to China.

Unlike the papers above which applied basically unit root tests, cointegration tests or both unit root tests and cointegration in one paper, this paper applies several panel data unit root tests, cointegration test and also the VAR (regression) model. The paper applied several panel unit root tests, which differ in their treatment of the null hypothesis. For instance, the Breitung (2000) t-test specify the null as a unit root and assumes common unit root processes. The Im, Pesaran and Shin. (Im et al. 2003) w-test and the ADF-Fisher chi-squared test proposed by Maddala and Wu (1999) specify the null as a unit root but assume individual unit root processes. All these three tests mentioned above assume cross-sectional independence. However, Pesaran (Pesaran 2007), the last panel unit root test considered in this work assumes cross-sectional dependence. Moreover, the paper applies the panel cointegration technique developed by Pedroni (2004) and Westerlund (2007). The Pedroni (2004) allows heterogeneous slope coefficient and for differences in short-run dynamics of the individual members of the panels while the Westerlund (2007) puts the issue of cross-sectional dependence into consideration. In addition, we applied the panel VAR method to see if there is a short-run relationship between the variables. Results of these tests revealed that there is no relationship between the nominal exchange rates and price levels both in the long-run and short-run, implying that PPP is not valid both in the long-run and short-run in the five Southeast Asian countries for the period of 2000-2016 based on the data.

## 1. DATA AND METHODS

### 2.1 Data

The data used was collected from *Datastream*, Thomson Reuters. It is a set of monthly data for a group of ASEAN-5 countries starting from January 2000 to August 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.

### 2.2 Panel Unit Root Tests

#### 2.2.1 ADF-fisher test

The Fisher-type test uses p-values from unit root tests for each cross-section  $i$ . The formula of the test looks as follows

$$p = -2 \sum_{i=1}^N \ln p_i \quad (1)$$

which combines the  $p$ -values from unit root tests for each cross-section  $i$  to test for unit root in panel data. Note that  $-2 \ln p_i$  has a  $\chi^2$  distribution with 2 degrees of freedom. This means that  $P$  is distributed as  $\chi^2$  with  $2N$  degrees of freedom as  $T_i \rightarrow \infty$  for finite  $N$ . Both the IPS and Fisher tests combine information based on individual unit root tests. However, the Fisher test has the advantage over the IPS test in that it does not require a balanced panel. Also, the Fisher test can use different lag lengths in the individual ADF regressions and can be applied to any other unit root tests.

#### 2.2.2 Breitung Test

Breitung studied the local power of LLC and IPS test statistics against a sequence of local alternatives and found that the LLC and IPS tests suffer from a dramatic loss of power if individual-specific trends are included. This is due to the bias correction that also removes the mean under the sequence of local alternatives. Breitung suggests a test statistic that does not employ a bias adjustment whose power is substantially higher than that of LLC or the IPS tests using Monte Carlo experiments. Breitung's test statistic without bias adjustment is obtained as follows.

Step 1 is the same as LLC but only  $\square y_{i,t-j}$  is used in obtaining the residuals  $\hat{e}_{it}$  and  $\hat{v}_{i,t-1}$ . The residuals are then adjusted (as in LLC) to correct for individual-specific variances.

Step 2, the residuals  $\hat{e}_{it}$  are transformed using the forward orthogonalization transformation employed by Arellano and Bover (1995):

$$e_{it}^* = \sqrt{\frac{T-t}{(T-t+1)}} \left( \tilde{e}_{it} - \frac{\tilde{e}_{i,t-1} + \dots + \tilde{e}_{iT}}{T-t} \right) \tag{2}$$

Also,

$$\begin{aligned} v_{i,t-1}^* &= \tilde{v}_{i,t+1} - \tilde{v}_{i,1} - \frac{t-1}{T} \tilde{v}_{i,T} \quad \text{with intercept and trend} \\ &= \tilde{v}_{i,t+1} - \tilde{v}_{i,1} \quad \text{with intercept, no trend.} \\ &= \tilde{v}_{i,t+1} \quad \text{with no intercept or trend} \end{aligned} \tag{3}$$

The last step is to run the pooled regression

$$e_{it}^* = \rho v_{i,t-1}^* + \varepsilon_{it}^* \tag{4}$$

and obtain the  $t$ -statistic for  $H_0 : \rho = 0$  which has in the limit a standard  $N(0, 1)$  distribution.

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### 2.2.3 Im, Pesaran and Shin test

Im *et al.* (IPS) proposed a test that allow 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:

$$y_{it} = \alpha_i + \rho y_{i,t-1} + \varepsilon_{it} \quad t = 1, 2, \dots, T \tag{5}$$

The null and alternative hypotheses are defined as

$$H_0 : \rho_i = 1 \quad i = 1, 2, \dots, N = 1, \tag{6}$$

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

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.

### 2.2.4 Pesaran

Pesaran (2007) suggests a simpler way of getting rid of cross-sectional dependence by augmenting the usual ADF regression with the lagged cross-sectional mean and its first difference to capture the cross-sectional dependence that arises through a single factor model. This is called the cross-sectionally augmented Dickey–Fuller (CADF) test. This simple CADF regression is

$$\Delta y_{it} = \alpha_i + \rho_i^* y_{i,t-1} + d_0 \bar{y}_{t-1} + d_1 \Delta \bar{y}_t + \varepsilon_{it} \tag{7}$$

Where  $\bar{y}_t$  is the average at time  $t$  of all  $N$  observations. The presence of the lagged cross-sectional average and its first difference accounts for the cross-sectional dependence through a factor structure. If there is serial correlation in the error term or the factor, the regression must be augmented as usual in the univariate case but lagged first differences of both  $y_{it}$  and  $\bar{y}_t$  must be added, which leads to

$$\Delta y_{it} = \alpha_i + \rho_i^* y_{i,t-1} + d_0 \bar{y}_{t-1} + \sum_{j=0}^p d_{j+1} \Delta \bar{y}_{t-j} + \sum_{k=1}^p c_{k+1} \Delta y_{i,t-k} + \varepsilon_{it} \tag{8}$$

Where the degree of augmentation can be chosen by an information criterion or sequential testing. After running this CADF regression for each unit  $i$  in the panel, Pesaran’s method averages the  $t$ -statistics on the lagged value (called CADFi ) to obtain the CIPS statistic

$$CIPS = \frac{1}{N} \sum_{i=1}^N CADF_i \tag{9}$$

The joint asymptotic limit of the CIPS statistic is nonstandard and critical values are provided for various choices of  $N$  and  $T$ . The limiting distribution of these tests is different from the Dickey–Fuller distribution, owing to the presence of the cross-sectional average of the lagged level. Pesaran uses a truncated version of the IPS test that avoids the problem of moment calculation.

### 2.3 Tests for cointegration

#### 2.3.1 Pedroni tests

Pedroni (2004) proposed several tests for the null hypothesis of no 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:

$$\tilde{z}_\rho = \sum_{i=1}^N \frac{\sum_{t=1}^T (\hat{e}_{it-1} \Delta \hat{e}_{it} - \hat{\lambda}_i)}{\sum_{t=1}^T \hat{e}_{it-1}^2} \tag{10}$$

Where  $\hat{e}_{it}$  is estimated from  $\hat{e}_{it} = \rho \hat{e}_{it-1} + v_{it}$ , 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, 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,

$$z_{t_{\rho NT}} = \frac{\sum_{i=1}^N \sum_{t=2}^T \widehat{L}_{1li}^{-2} (\widehat{e}_{it-1} - \widehat{\lambda}_i)}{\sqrt{\widetilde{\sigma}_{NT}^2 (\sum_{i=1}^N \sum_{t=2}^T \widehat{L}_{1li}^{-2} \widehat{e}_{it-1}^2)}} \tag{11}$$

Where  $\widetilde{\sigma}_{NT} = \frac{1}{2} \sum_{i=1}^N (\widehat{\sigma}_i^2 / \widehat{L}_{1li}^2)$ .

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. Rejection of the null hypothesis means that enough of the individual cross-sections have statistics “far away” from the means predicted by theory were they to be generated under the null. (Baltagi, 2005).

### 2.3.2 Westerlund (2007)

Following Mehmet et al. (2014), the test of Westerlund (2007) gives strong results in small samples and could be used both in existence and non-existence of cross-sectional dependency. Bootstrap distribution is used when a cross-sectional dependency exists while standard asymptotically normal distribution is used when it does not exist. In addition to that, this test could be used when series are integrated of order one. There are four test types in error correction panel cointegration test. Two of them are panel statistics and the other two are group statistics. Panel statistics give an option to create a deduction for the panel itself while group statistics make a deduction for individual forming panel possible. According to this, panel and group hypotheses are as follows:

For panel statistics we have

$H_0 : \alpha_i = 0,$  Cointegration does not exist for all  $i$ ,

$H_1 : \alpha_i = \alpha < 0,$  Cointegration exist for all  $i$

For the group statistics, we have

$H_0 : \alpha_i = 0,$  Cointegration does not exist for all  $i$ ,

$H_1 : \alpha_i < 0,$  Cointegration exist for some units, but does not exist for some.

Panel error correction cointegration test is parametric in two of these four tests and nonparametric for other two of them. The lag length of series in parametric tests is needed. In addition, when the sample in parametric tests are small and a lot of parameters are estimated, deviation in results could be obtained. Error correction panel cointegration model could be created as follows:

$$\Delta y_{it} = \delta_i' d_t + \alpha_i (y_{i,t-1} - \beta_i' x_{i,t-1}) + \sum_{j=1}^{\rho_i} \alpha_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{\rho_i} \gamma_{ij} \Delta x_{i,t-j} + e_{it} \tag{12}$$

In this equation,  $d_t, \delta', \alpha_i$  show deterministic composition, vector parameters and error correction parameter, respectively. They could be estimated with error correction model  $(y_{i,t-1} - \beta_i' X_{i,t-1})$ .

Equation (20) could be parameterized again and explained as follows:

$$y_{it} = \delta_i' d_t + \alpha_i y_{i,t-1} - \lambda_i' x_{i,t-1} + \sum_{j=1}^{\rho_i} \alpha_{ij} y_{i,t-j} + \sum_{j=0}^{\rho_i} \gamma_{ij} x_{i,t-j} + e_{it} \quad (13)$$

**Group Statistics;**

Group mean statistic is formed by three stages. At the first stage, equation (13) is estimated with OLS for every unit in the panel:

$$y_{it} = \hat{\delta}_i' d_t + \hat{\alpha}_i y_{i,t-1} - \hat{\lambda}_i' x_{i,t-1} + \sum_{j=1}^{\rho_i} \hat{\alpha}_{ij} y_{i,t-j} + \sum_{j=0}^{\rho_i} \hat{\gamma}_{ij} x_{i,t-j} + \hat{e}_{it} \quad (14)$$

In equation (14),  $\rho_i$  which shows lag length, is allowed to differ from unit to unit. At the second stage in group statistic,  $\rho_i$  which is error correction parameter is estimated:

$$\alpha_i(1) = 1 - \sum_{j=1}^{\rho_i} \alpha_{ij} \quad (15)$$

The natural way to do this calculation is to use the parametric method and parametric method is estimated by the formula below:

$$\tilde{\alpha}_i(1) = 1 - \sum_{j=1}^{\rho_i} \hat{\alpha}_{ij} \quad (16)$$

Due to a parametric method which leads deviation in results in small samples, an ambiguity occurs while estimating parameters that are affected by its own deferred values (Autoregressive). Thereby, an alternative way is needed. This alternative approach is called Kernel approach. It is formulated as follows:

$$(\hat{\omega})_{y_i}^2 = \frac{1}{T-1} \sum_{j=-M_i}^{M_i} \left(1 - \frac{j}{M_i + 1}\right) \sum_{t=j+1}^T y_{it} y_{i,t-j} \quad (17)$$

In equation (25),  $M_i$  shows band with parameter expressing covariance number in Kernel the approach  $(\hat{\omega})_{y_i}^2$  shows a long-term variance of  $y_{it}$ .  $y_{it}$  is expressed as  $(\hat{\omega})_{u_i}^2 / (1)^2$ .  $(\hat{\omega})_{u_i}^2$  shows long-term variance of the error term. In this way, alpha (1) could be estimated easily by using  $\alpha_i(1)(\hat{\omega})_{u_i} / \hat{\omega}_{y_i}$ . Equation (18) is obtained by applying  $\hat{\omega}_{u_i}$  together with  $y_{it}$ .

$$\hat{u}_{it} = \sum_{j=0}^{\rho_i} \hat{\gamma}_{ij} x_{i,t-j} + \hat{e}_{it} \quad (18)$$

In this equation  $\hat{\gamma}_{ij}$  and  $\hat{e}_{it}$  are obtained from Equation (13)  $\alpha_i(1)$  which is semi-parametric Kernel estimator becomes  $\hat{\alpha}_i(1)$ .

At the last stage in group statistic, the test statistic is calculated by the formula mentioned below:

$$G_t = \frac{1}{N} \sum_{i=1}^N \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \quad G_\alpha = \frac{1}{N} \sum_{i=1}^N \frac{T \hat{\alpha}_i}{\hat{\alpha}_i(1)} \quad (19)$$

In the equation (19), SE shows conventional standard error of  $\hat{\alpha}_i$ .

**Panel Statistics:**

There are three stages in panel statistics. The first stage is the same with group statistics.



$$\tilde{y}_{it} = \Delta y_{it} - \hat{\delta}'_i d_t + \hat{\lambda}'_i x_{i,t-1} + \sum_{j=1}^{p_i} \hat{\alpha}_{ij} y_{i,t-j} + \sum_{j=0}^{p_i} \hat{\gamma}_{ij} x_{i,t-j} \quad (20)$$

$$\tilde{y}_{it-1} = \Delta y_{it-1} - \tilde{\delta}'_i d_t + \tilde{\lambda}'_i x_{i,t-1} + \sum_{j=1}^{p_i} \tilde{\alpha}_{ij} y_{i,t-j} + \sum_{j=0}^{p_i} \tilde{\gamma}_{ij} x_{i,t-j} \quad (21)$$

The second stage includes common error term parameter  $\alpha$  in  $\tilde{y}_{it}$  and  $\tilde{y}_{it-1}$  which estimates standard error:

$$\hat{\alpha} = \left( \sum_{i=1}^N \sum_{t=2}^T \tilde{y}_{i,t-1}^2 \right)^{-1} \sum_{i=1}^N \sum_{t=2}^T \frac{1}{\hat{\alpha}_i(1)} \tilde{y}_{i,t-1} \tilde{y}_{it} \quad (22)$$

Calculation of standard error of  $\hat{\alpha}$  is expressed below:

$$SE(\hat{\alpha}) = ((\hat{S}_N^2)^{-1} \sum_{i=1}^N \sum_{t=2}^T \tilde{y}_{i,t-1}^2)^{-1/2} \quad (23)$$

$\hat{S}_N^2$  is calculated as follows:

$$\hat{S}_N^2 = \frac{1}{N} \sum_{i=1}^N \hat{S}_i^2 \quad (24)$$

The third stage in panel statistics is the calculation of panel statistics. This calculation is made by the formula given below.

$$p_t = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \text{ and } p_\alpha = T \hat{\alpha} \quad (25)$$

### 2.4 Vector Autoregressive (Var) Model

Following Koop and Korobilis (2016), let  $y_{it}$  denote a vector of  $G$  dependent variables for country  $i$  ( $i = 1, \dots, N$ ) at time  $t$  ( $t = 1, \dots, T$ ) and  $Y_t = (y_{1t}', \dots, y_{Nt}')'$ . A VAR for country  $i$  can be written as

$$y_{it} = A_{1,i} Y_{t-1} + \dots + A_{p,i} Y_{t-p} + \varepsilon_{it} \quad (26)$$

Where,  $A_{p,i}$  are  $G \times NG$  matrices for each lag  $p = 1, \dots, P$ , and  $\varepsilon_{it}$  are uncorrelated over time and are distributed as  $N(0, \Sigma_{ii})$  with  $\Sigma_{ii}$  covariance matrices of dimension  $G \times G$ . Additionally, we define  $\text{cov}(\varepsilon_{it}, \varepsilon_{jt}) = E(\varepsilon_{it}, \varepsilon_{jt}) = \Sigma_{ij}$  to be the covariance matrix between the errors in the VARs of country  $i$  and country  $j$ . We refer to this specification as the unrestricted PVAR.

Note that the unrestricted PVAR is very general and that lagged variables from any country can influence any other country (e.g. lagged values of country 1 variables can impact on current country 2 variables) and the magnitude of such influences are completely unrestricted (e.g. events in country 1 can have different impacts on country 2 than on country 3). Similarly, contemporaneous relationships, modelled through the error covariance matrices, are unrestricted so that, e.g., shocks in country 1 can be strongly correlated with shocks in country 2, but weakly correlated with shocks in country 3.

The panel data VAR methodology combines the traditional VAR approach, which treats all the variables in the system as endogenous, with the panel-data approach, which allows for unobserved individual heterogeneity (Grossmann et al. 2014).

## RESULTS

Below are the results of the analyses. Before the main analyses, preliminary analyses were carried out to examine the properties of the data. Results of the preliminary analyses are displayed on Tables 1-2. Table 1. Show the summary of descriptive statistics of the raw data used. The descriptive statistics for nominal exchange rates for the five Southeast Asian countries (EXRATE), consumer price indices for the five Southeast Asian countries (CPI) and the consumer price indices for the US (CPIUS). Even though we have the same number of observations, all the other statistics differ with the EXRATE having statistics that differ greatly from CPI and CPIUS. The average (mean) of the nominal exchange rate for the five Southeast Asian countries is 2010.07

which is far greater in magnitude than the averages of consumer price indices for the five Southeast Asian countries, 92.48 and the consumer price indices for the US, 208.404. Furthermore, the average of consumer price indices for the US is larger than that of the consumer price indices for the five Southeast Asian countries but the gap between them is not as large as that of the nominal exchange rate which is far off different from them. These apply to all the other statistics. Table 2. Which displays the correlations between the variables clearly shows that there is a correlation between the CPI and the CPIUS, that shows that the gap between them is not so wide as confirmed by the summary of the descriptive statistics. On the other hand, the EXRATE whose values are far different from others has no correlations with CPI and CPIUS.

**Table 1:** Summary of Descriptive Statistics

Statistic	EXRATE	CPI	CPIUS
<b>Mean</b>	2010.07	92.48	208.48
<b>Maximum</b>	14700	91.40	212.59
<b>Minimum</b>	1.20	39.38	169.3
<b>Std. Dev.</b>	4034.83	19.96	22.05
<b>Sum</b>	2010068.95	398087.74	485762.10
<b>No. of Observations</b>	1000	1000	1000

**Table 2:** Correlations

Variables	EXRATE	CPI	CPIUS
<b>EXRATE</b>	1	-0.2382	0.0427
<b>CPI</b>	-0.2382	1	0.7883
<b>CPIUS</b>	0.0427	0.7883	1

Table 3 presents the results of cross-sectional dependence test of Pesaran (2004) to find out if the data have cross-sectional dependence. For all the variables, EXRATE, CPI and CPIUS, the null

hypotheses of no cross-sectional dependence are rejected. Therefore, the data exhibit cross-sectional dependence.

**Table 3:** Cross-sectional dependence test (Pesaran CD)

Test	LEXRATE	LCPI	CPIUS
<b>Pesaran CD</b>	19.7685***	43.6940***	44.7214***

Furthermore, results of panel unit root tests are displayed in Table 4. The table shows results of the ADF-fisher, Breitung IPS and Pesaran panel unit root tests for all the variables at levels and at first difference (LEXRATE and  $\Delta$ LEXRATE, CPI and  $\Delta$ CPI, CPIUS and  $\Delta$ CPIUS). All the tests are consistent with each other, showing that all the variables are not stationary at levels but they are stationary at first difference, indicating that all the variables are integrated of order 1 (all the variables are I(1)). Since all the variables are integrated of order one, we run cointegration tests. Table 5. Displays the results of Pedroni (2004) panel cointegration test. Results clearly show that there is no cointegration between the variables because there was not enough evidence to reject

the null hypothesis of no cointegration for all the group and panel statistics thereby revealing that there are no long-run relationships between the variables. Because there is evidence of cross-sectional dependence in the data we also conduct the cointegration of Westerlund (2007) since this test accounts for cross-sectional dependence when the bootstrap methodology is included. Table 6. Presents results of Westerlund (2007) test for the null hypothesis of no cointegration. Results clearly show that there is not enough evidence to reject the null hypothesis of no cointegration between the variables for all the panel and group statistics thereby indicating the absence of a long-run relationship between the variables.

**Table 4:** Panel Unit Root Tests

Variables/Tests	ADF-Fisher	Breitung	IPS	Pesaran
<b>LEXRATE</b>	6.2244	0.3332	0.3719	-0.1190
<b><math>\Delta</math>LEXRATE</b>	493.792***	-26.5040***	-30.5792***	-9.3290***
<b>LCPI</b>	5.2879	2.0915	1.5672	0.4590
<b><math>\Delta</math>LCPI</b>	305.560***	-16.2046***	-19.6310***	-6.6870***
<b>LCPIUS</b>	8.1450	2.0571	-0.4123	0.3170
<b><math>\Delta</math>LCPIUS</b>	330.496***	-17.9759***	-20.7749***	-10.9380***

Where \*\*\* is significance at 1% level.

**Table 5:** Pedroni (2004) Test of Cointegration

Test Stat.	Panel	Group
<b>V</b>	1.3932	
<b>Rho</b>	-0.4721	0.5384
<b>PP</b>	-0.7527	-0.3429
<b>ADF</b>	-0.6548	-0.3856

**Table 6:** Westerlund (2007) Test of Cointegration

Statistic	Value	Z-value	P-value	Robust P-value
<b>Gt</b>	-1.2780	0.2200	0.5870	0.5900
<b>Ga</b>	-4.5660	0.5140	0.6970	0.6180
<b>Pt</b>	-3.2710	-0.8850	0.1880	0.3580
<b>Pa</b>	-4.6530	-0.9830	0.1680	0.3630

Since there is no evidence of long-run relationships (cointegration) between the variables, as a result, PPP does not hold in the long-run. Therefore, we need to find out if there are short-run relationships between the variables (ie. If PPP exists in the short-run). Table 7. Shows the results of the Vector Autoregressive (VAR) Model for the equation of interest where the nominal exchange rate ( $\Delta\text{LEXRATE}$ ) is the dependent variable. The table displays the

coefficients and t-statistics of the VAR when the exchange rate is the dependent variable (the equation of interest). The results of the VAR reveals the short-run relationship between the exchange rate and itself (as expected) at the 1% level of significance (a strong short-run relationship between exchange rate and itself at lag one). At lag one, we also observe a weak short-run relationship between the foreign price and the exchange rate.

**Table 7:** Coefs, and t-stats of the VAR model

Variables	$\Delta$ LEXRATE
$\Delta$ LEXRATE(-1)	0.1039(3.2406)***
$\Delta$ LEXRATE(-2)	-0.0229(-0.7056)
$\Delta$ LCPI(-1)	0.1453(1.0881)
$\Delta$ LCPI(-2)	0.0406(0.3080)
$\Delta$ LCPIUS(-1)	0.4704(1.8377)*
$\Delta$ LCPIUS(-2)	-0.4143(-1.6243)
C	-0.0002(-0.2659)

Where \*\*\* and \* indicate significance at 1% and 10% levels respectively

## CONCLUSION

This paper examined the purchasing power parity (PPP) theory for a group of five South East Asian countries for the period of 2000-2016 using monthly data. Firstly, apart from the preliminary analysis to check the properties of the data, panel unit root tests were conducted to check the stationarity of the variables. The unit-root tests revealed that all variables (exchange rate, consumer price index for each of the five Southeast Asian countries and U.S.) are not stationary in levels but stationary at first difference, i.e. all variables are integrated of order 1. Since all variables are integrated of the same order, I (1), the cointegration tests were carried out to see if the variables are cointegrated. Both

cointegration tests carried out revealed that the variables are not cointegrated meaning that there is no long-run relationship between the nominal exchange rates and price levels. Therefore, we went further to find out if there is a short-run relationship between our variables by using the VAR model. The results of the VAR model did not reveal any considerable relationship in the short-run only a little short-run relationship between the foreign price and the nominal exchange rate at 10% level of significance which is very weak to be considered. With these results, we hereby conclude that PPP is not valid both in the long-run and short-run in the five Southeast Asian countries for the period of 2000-2016 based on the data.

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