Purchasing power parity for the MAVINS

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Abstract. This paper utilizes several tests to examine the PPP theory for MAVINS (Mexico, Australia, Vietnam, Indonesia, Nigeria and South Africa) using recent monthly datasets from January 2003 to May 2016. We test for the stationarity of the variables and found that two of the variables are \( I(1) \) while one of the variables is an \( I(0) \). Since the variables are a mixture of \( I(1) \) and \( I(0) \), the paper applied the Mean Group (MG) and the Pooled Mean Group (PMG) ARDL approaches to examine the PPP theory. In choosing between the two estimators, results of the Hausman test indicates that the Mean Group estimator is preferred. Therefore, the results of the Mean Group estimator show that the error correction term which is used to measure the speed of adjustment (from short-run deviation) of the independent variables in converging to long-run equilibrium is negative and significant indicating the presence of cointegration among the variables. This implies that PPP is valid in the long-run in the MAVINS countries. Furthermore, the domestic prices make the nominal exchange rates to appreciate in the long-run and the foreign prices make the nominal exchange rates to appreciate in the short-run. Consequently, appreciation of the nominal exchange rate will cause export to be more expensive, imports cheaper and thereby reducing inflation in the MAVINS based on the data.

1. Introduction

The purchasing power parity theory (PPP) is a very useful theory in the field of international economics. The theory posits that the exchange rate between two countries should be equal (same) as the ratio of the total price levels between the two countries, in order that the unit of currency of one country will have the same ability to buy goods and services in a foreign country. Due to the importance of this theory, research is still being carried out using modern statistical methods. Basically, there are two kinds of PPP; the absolute PPP and the relative PPP. If the ability of money to buy goods is the same in a local/domestic country and foreign country when it is changed to a foreign money at the market conversion rate, then we say that absolute PPP holds. However, if the conversion/exchange rate regulates/adjusts to the rate of inflation differentials among nations/countries, then, the relative PPP takes place or occurs. More specifically, we can say that adjustment or changes in the exchange rates are equal to adjustments in the relative national prices [1].

The most commonly used methods of testing for PPP recently are the use of unit root and cointegration tests. The tests of unit roots need that the real exchange rates be stationary. If the real exchange rates are stationary then PPP is said to hold, otherwise, PPP does not hold. The tests of cointegration, on the other hand, need a combination of two or more series that are not stationary to produce a long-run relationship that is stationary, but the series must be integrated order one. If cointegration holds, then PPP occurs in the long-run since cointegration is all about long-run relationships [1].
Several researchers have utilized different types of unit root and cointegration tests in investigating the PPP theory. Empirical works that utilized several types of unit root and cointegration tests for several countries include; [2], who utilized panel tests of unit root to examine the long-run purchasing power parity in 84 countries using the Dollar as base currency. They found strong proof of PPP in countries with lower inflation, nearer to the U.S and are open to trade. Their discoveries revealed that the characteristics of countries explain deviations from and support to long-run PPP. They also showed that PPP is not valid in Asian and African countries but valid in Latin American and European countries. Also, [3], discovered that PPP does not hold in Bangladesh, India, Pakistan and Sri Lanka when they used the [4] linear unit root, while the results of the nonlinear unit root test of [5] found support in Bangladesh only. They used real exchange rate data over the period of 1973-2007. Thereafter, [6], found that PPP holds for only for two countries when they examined the validity of PPP in 8 transition countries for monthly data from 1992:1 to 2009:1. Testing the stationarity of real exchange rate series by using four types of unit roots tests, the evidence suggests that real effective exchange rate is nonstationary and thus PPP doesn’t hold for 6 out of the 8 transition countries in the long run.

Moreover, [7], discovered that PPP is not valid in Turkey when they analysed data from January 2003 to June 2014 using the nonlinear threshold unit root testing procedure of [8], in contrast to many previous studies in which linear unit root test methods have been employed. Thereafter, [9], generally found evidence of PPP when they used unit root test which accounts for nonlinearity and multiple smooth temporary breaks in 23 developed countries with monthly real effective exchange rate data from 1974:1 to 2012:11. Furthermore, Jiang et al. [10], found support for the PPP theory in 34 OECD countries from January 1994 – August 2013 using a new panel stationarity test with both sharp breaks and smooth shifts, a novel approach to panel unit root testing proposed by [11].

However, studies that applied mainly the method of cointegration include [12] examined if the long-run purchasing power parity hypothesis hold for 17 African countries from the period 1981-1994 using the cointegration method the [13]. He found some evidence for the weak form of PPP in the long-run. Moreover, [14] utilized the [15] test of cointegration which allows for heterogeneous relationship across goods to investigate the weak and strong form of PPP among the US and Mexican prices. Results of the analysis provided strong evidence in favour of the weak form of PPP while the strong form of PPP gained little support. Finally, [16], found concrete evidence in support of purchasing power parity when they utilised the Langrage Multiplier test for cointegration of [17] which puts into consideration cross-sectional dependence, substantial level of country-specific heterogeneity and multiple structural breaks to test the purchasing power parity hypothesis from 1968:1 - 2009:II for a set of ASEAN-5 countries.

This paper utilized the Autoregressive Distributed Lag Model to investigate the theory of purchasing power parity for the MAVINS. The MAVINS is an acronym for Mexico, Australia, Vietnam, Indonesia, Nigeria and South Africa. According to [18], these are the less acknowledged but giant economic growth stories where goods/commodities play an extensive role in their economies. They are exceptionally situated to feed and gain from world economic advancement/growth by means of their relative commodity advantages, still, at the same time, they have huge local market extension openings/opportunities because of an excess of under-used land or individuals. With the correct strategies and policies, these countries are probably going to blow away expectations with time and become leading powers in their areas/regions. The MAVINS economies altogether could quickly equal 60 percent of present America by 2020, more than 200 percent of present-day America by 2050, and then continue to grow strongly after that.

To the best of our knowledge, this paper is the first to do a study for the MAVINS. We used several tests to investigate the theory of PPP for the MAVINS. Results of our analysis revealed that the PPP theory holds for the MAVINS. The domestic price in the long-run and foreign price in the short-run cause the nominal exchange rate to appreciate.

The rest of the paper is arranged as follows; section 2 presents the data and method used for the study, section 3 presents results of our findings and discussions, and section 4 concludes.
2. Data and Methodology

2.1. Data

This paper used a set of monthly data for the MAVINS (Mexico, Vietnam, Indonesia, Nigeria and South Africa) from January 2003 to May 2016 collected from Thomson Reuters Datastream. The data consist of the nominal exchange rate (EXRATE), consumer price index (CPI) for MAVINS, and CPI for the US since the US is used as the base currency. After the descriptive statistics, we converted our data to their log forms (i.e, LEXRATE, LCPI and LCPIUS) for the rest of the analyses.

2.2. The Mean Group, Pooled Mean Group and the Dynamic Fixed Effect Methods

Let the autoregressive distributive lag (ARDL) \((p,q,q)\) of a dynamic panel specification be of the form

\[
LEXRATE_{it} = \sum_{j=1}^{p} \lambda_{ij} LEXRATE_{i,t-j} + \sum_{j=0}^{q} a_{ij} LCPI_{i,t-j} + \sum_{j=0}^{q} b_{ij} LCPIUS_{i,t-j} + \varepsilon_{it} \tag{1}
\]

where \(i = 1,2,...,N\) stand for the number of countries, the \(t = 1,2,...,T\) number of periods \(LEXRATE\) is the dependent variable; \(LCPI\) and \(LCPIUS\) are the independent variables with \(K \times 1\) a vector of explanatory variables; \(a_{ij}\) and \(b_{ij}\) are the \(k \times 1\) coefficient vectors; \(\lambda_{ij}\) are scalars, and \(\varepsilon_{it}\) is the disturbance term.

Assuming that the variables in (1) are cointegrated and integrated of order one, the error term is an I(0) process for all \(i\). However, we can write equation one in an error correction form as;

\[
\Delta LEXRATE_{it} = \phi_i LEXRATE_{i,t-1} + \beta_{ai} LCPI_{it} + \beta_{bi} LCPIUS_{it} + \sum_{j=1}^{q} \lambda_{ij} \Delta LEXRATE_{it-j} + \sum_{j=0}^{q} a_{ij} LCPI_{t-j} + \sum_{j=0}^{q} b_{ij} LCPIUS_{t-j} + \varepsilon_{it} \tag{2}
\]

where \(\phi_i = -1\left(1-\sum_{j=1}^{p} \lambda_{ij}\right)\); \(\beta_{ai} = \sum_{j=0}^{q} a_{ij}\); \(n = a,b; \ell = 1,2 \); \(\lambda_{ij} = \sum_{m=1}^{p} \lambda_{im}, j = 1,...,p-1; n_{ij} = \sum_{m=1}^{q} n_{im}; n = a,b; j=1,..., q\). By regrouping, we can write the error correction equation (2) as;

\[
\Box LEXRATE_{it} = \phi_i (LEXRATE_{i,t-1} - \theta_{ai} LCPI_{it} - \theta_{bi} LCPIUS_{it}) + \sum_{j=1}^{p} \lambda_{ij} \Box LEXRATE_{i,t-j} + \sum_{j=0}^{q} a_{ij} \Box LCPI_{i,t-j} + \sum_{j=0}^{q} b_{ij} \Box LCPIUS_{i,t-j} + \varepsilon_{it} \tag{3}
\]

where \(\theta_i = -\left(\frac{\beta_{ai}}{\phi_i}\right)\); \(n = a,b\) shows the long-run relationship between the dependent and independent variables in (3). \(\lambda_{ij}\) is the short-run coefficient of the independent variable while \(n_{ij} = (a,b)_{ij}\) are the short-run coefficients which show the short-run effects of dependent variables on \(LEXRATE\) in (3). The quantity \(\phi_i\) is the speed of adjustment error correction term. If \(\phi_i = 0\), we do not have long-run
relationship. This quantity is supposed to be negative and significant from a prior assumption that the variables return to a long-run equilibrium. The vector $\theta$, is very important since it contains the long-run relationships between the variables.

In this paper, we estimate equation (3) using the Mean Group (MG) estimator by [19], the Pooled Mean Group (PMG) estimator by [20] and the dynamic fixed effect (DFE) estimator by Anderson and Hsiao as in [20].

The model is fixed independently for every country, and a simple mean of the coefficients is computed with the MG estimator. The slope coefficients, intercepts, and error variances across groups differ. However, the PMG estimator uses a combination of both pooling and averaging. This forces the coefficients of the slope error variances to be the same. The DFE forces all the coefficients of the slope and error variances to be the same.

3. Results and Discussions
The results of the analyses carried out are displayed and discussed here. Table 1. presents the summary of descriptive statistics of the data used. The table shows the mean, median, maximum, minimum, standard deviation, sum and number of observations for the nominal exchange rates for MAVIN (EXRATE), consumer price indexes for MAVIN (CPI) and the consumer price indices for the US (CPIUS). Although we have the same number of observations (966), all the other statistics such differ across the variables. The EXRATE has the highest sum of 4,618,081, followed by the CPIUS with the total of 207756.1, then the CPI with the lowest total of 95,136.31. Moreover, the standard deviation which is a measure of dispersion measures the spread of the data. The lower the standard deviation, the better. CPIUS has the lowest standard deviation of 17.5669, this can be seen from how the maximum value of 239.4100 is not too far away from the minimum value of 182.6000. Next variable with higher standard deviation than CPIUS is the CPI with 28.5109, and lastly, the EXRATE with the highest value of 7235.097 which is also evident by looking at how its maximum value of 22495.00 is far greater/apart from its minimum value of 0.9090. Furthermore, the mean and median are referred to as measures of central tendencies, are used to represent the centre of the data or how the data are arranged in the centre. We decided to use both the mean and the median here because the mean is affected by extreme observations more than the median. Here, the EXRATE has the highest mean of 4780.622 with the median of 67.7645, followed by the CPIUS with the mean of 215.0684 and median of 217.2810, then the CPI with a mean of 98.4848 with the median of 98.4308. Comparing these values, we can see that the EXRATE has much higher mean than median this is because it is affected by extreme observations from the maximum and minimum values. Therefore, the median is a better measure of central tendency in the case of the EXRATE while the mean is a better measure for both CPI AND CPIUS.

Table 2. Shows results for the tests of unit roots by [21], [22] and [23] represented by LLC, IPS and Pesaran respectively. Results for the LLC show that for nominal exchange rates, the variable is not stationary at level ($LEXRATE$) but stationary at first difference ($\Delta LEXRATE$), however, variables are stationary at levels and at first difference for both domestic and foreign prices ($LCPI$ and $\Delta LCPI$, including $LCPIUS$ and $\Delta LCPIUS$). For the IPS test, all the variables ($LEXRATE$ and $\Delta LEXRATE$, $LCPI$ and $\Delta LCPI$, including $LCPIUS$ and $\Delta LCPIUS$) are not stationary at levels but are stationary at first difference. However, the Pesaran test shows the nominal exchange rates and the foreign prices are not stationary at levels but stationary at first difference but the domestic prices are stationary both at levels and at first difference. Generally speaking, we have a mixture of variables of I(1) and I(0) variables as can be seen from the table (RK on the table represents the final remark of the three panel unit root tests). From the results of the panel unit root tests, since the variables are a mixture I(1) and I(0), we estimate the ARDL models for both the long-run and short-run relationships.
Table 1. Summary of Descriptive Statistics

| Statistic    | EXRATE         | CPI           | CPIUS          |
|--------------|----------------|---------------|----------------|
| Mean         | 4780.622       | 98.4848       | 215.0684       |
| Median       | 67.7645        | 98.4308       | 217.2810       |
| Maximum      | 22495.00       | 198.3000      | 239.4100       |
| Minimum      | 0.9090         | 44.1000       | 182.6000       |
| Std. Dev.    | 7235.097       | 28.5109       | 17.5669        |
| Sum          | 4618081        | 95136.31      | 207756.1       |
| No. of Obs.  | 966            | 966           | 966            |

Table 2. Panel Unit Root Tests

| Variables   | LLC            | IPS            | Pesaran        | Rk   |
|-------------|----------------|----------------|----------------|------|
| LEXRATE     | 1.6407         | -28.1274**     | -6.1900***     | I(1) |
| ∆LEXRATE    | -30.7005***    | -18.3580***    | -0.9132        | I(1) |
| LCPI        | -2.3734***     | 1.4259         | -2.9570***     | I(0) |
| ∆LCPI       | -18.9404***    | -19.4363***    | -5.9900***     | I(1) |
| LCPIUS      | -4.9486***     | -0.9132        | -1.9310        | I(1) |
| ∆LCPIUS     | -22.1872***    | -19.4363***    | -5.9900***     | I(1) |

where *** and ** are significance at 1% and 5% levels respectively.

Furthermore, Table 3 shows results of the autoregressive distributed lag (ARDL) models. We have the results of the mean group (MG), pooled mean group (PMG), and the dynamic fixed effect (DFE) estimators displayed on the table. Starting with the mean group estimator, we can see that in the long-run, one unit increase in the domestic price leads to 4.52 unit appreciation of the nominal exchange rate. However, the coefficient of the foreign price is not significant. In the short-run on the other hand, one unit increase in the foreign price leads to an appreciation of 2.15 units of the nominal exchange rate, but the domestic price is not significant in the short-run. Moreover, for the pooled mean group estimator, in the short-run, the domestic price is not significant, but the foreign price is significant and shows that one unit increase in the foreign price causes an appreciation of the nominal exchange rates. For the dynamic fixed effect, however, both the domestic and foreign prices are not significant in the long-run. But in the short-run, the domestic price shows a little level of significance at the 10% while the foreign price is strongly significant. Consequently, in the short-run, the one unit increase in the domestic price causes 0.22 unit depreciation of the nominal exchange rates and one unit increase in the foreign price causes 2.13 appreciation of the nominal exchange rates. Finally, the error correction term (ec) for all the estimators are negative and significant indicating the presence of cointegration. This shows us that there is a long-run relationship between the nominal exchange rates and prices in MAVINS which tells us that the purchasing power parity theory holds for the MAVINS.

In choosing the best estimator, we run the Hausman test between the mean group and the pooled mean group. We do not need to do that for the dynamic fixed effect model since we can see from inspection that it performed poorly. The dynamic fixed effect estimator showed the presence of cointegration however, none of its coefficients is significant in the long-run therefore we do not use it.

Table 4. Presents result of the Hausman test in choosing between the MG and the PMG. The test is significant at 5% level indicating that the mean group estimator is preferred. Since the mean group estimator is the preferred estimator, we make conclusions based on the results of the mean group.
### Table 3. ARDL (2,2,2) models

| Variable | MG | PMG | DFE |
|----------|----|-----|-----|
| LR       | -4.5202(1.8918) ** | 0.2556(0.1891) | 0.0314(0.2638) |
| LCPI     | 1.6980(3.2536)     | -4.3244(0.1409) *** | 1.7931(1.9283) |
| DFE      | 0.2556(0.1891)     | -4.3244(0.1409) *** | 1.7931(1.9283) |
| LCPIUS   | 0.1495(0.2383)     | -2.1522(0.9581) ** | 0.2230(0.1357) * |
| SR       | 0.1590(0.02942)    | -1.9133(0.8807) ** | 2.1311(0.3134) *** |
| ∆LCPI    | -0.1008(0.0277) *** | -0.0887(0.0299) *** | 0.0332(0.0099) *** |

The table shows coefficients and standard errors in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels.

### Table 4. Hausman test

| Hausman test | MG versus PMG |
|--------------|---------------|
| Chi-square   | 6.2100        |
| p-value      | 0.0448        |
| Decision     | MG            |

## 4. Conclusion

This paper does not only test for the existence of the purchasing power parity but also estimated the relationship between the nominal exchange rates, the domestic and foreign prices in the MAVINS (Mexico, Australia, Vietnam, Nigeria and South Africa) using monthly data from 2003 to 2016. Firstly, we test for the stationarity of the variables and found that two of the variables are I(1) while one of the variables is I(0). Since the variables are a mixture of I(1) and I(0), the paper applied the dynamic fixed effect (DFE) model in addition to the Mean Group (MG) and the Pooled Mean Group (PMG) ARDL approaches to investigate the PPP theory. The results of the analysis showed that the DFE performed poorly in the sense that none of its coefficients is significant in the long-run even though there exists the evidence of a long-run relationship (cointegration) among the variables. Therefore, we are left with the choice of choosing between the MG and the PMG. In choosing between the MG and PMG estimators, results of the Hausman test indicates that the Mean Group estimator is preferred. Therefore, the results of the Mean Group estimator show that the error correction term which is used to measure the speed of adjustment (from short-run deviation) of the independent variables in converging to long-run equilibrium is negative and significant indicating the presence of cointegration among the variables. This implies that PPP is valid in the long-run in the MAVINS countries. Furthermore, the domestic prices make the nominal exchange rates to appreciate in the long-run and the foreign prices make the nominal exchange rates to appreciate in the short-run. Basically, in the MAVINS, we experience the effect of exchange rate appreciation solely. Consequently, appreciation of the nominal exchange rate will cause export to be more expensive, imports cheaper and thereby reducing inflation in the MAVINS for this period based on the data.

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