

Asymmetric Co-integration for the MINT in Testing for Purchasing Power Parity Theory

Niri Martha Choji* and Siok Kun Sek

University Sains Malaysia, School of Mathematical Sciences, 11800 Minden, Penang, Malaysia

ABSTRACT

This paper inspects if the purchasing power parity (PPP) exists with asymmetric adjustment in the MINT (Malaysia, Indonesia, Nigeria and Turkey) countries. An asymmetric co-integration approach was conducted to test for the presence of long-run PPP in the MINT nations by utilizing the threshold co-integration tests (TAR and MTAR) of Enders and Siklos. By employing monthly data from 2003 to 2016, results of the threshold co-integration tests (using the TAR model) revealed proof of long-run purchasing power parity accompanied by an asymmetric adjustment in Nigeria and Turkey but not in Mexico and Indonesia. According to the asymmetric error correction model for Nigeria, negative deviations from PPP are terminated more rapidly than positive deviations in attaining the purchasing power parity. However, in Turkey, positive deviations are terminated more quickly than negative deviations. The results of the long-run estimates generally show that most of the coefficients are statistically significant indicating that a unit increase in the domestic price (LCPI) results in a depreciation of some units in the nominal exchange rates, and a unit increase in the foreign price (LCPIUS) brings about an appreciation of some units in nominal exchange rates, for both Nigeria and Turkey. In Nigeria and Turkey, we experience both exchange rate depreciation and appreciation. Consequently, depreciation will cause exports to be cheaper, imports very expensive, and cause inflation to increase in Nigeria and Turkey.

Nonetheless, appreciation of the exchange rate will cause exports to be more expensive, imports cheaper and hence, reduce inflation in Nigeria and Turkey.

Keywords: Asymmetric adjustment, breakdates threshold regression, Momentum Threshold Autoregressive (MTAR) model, purchasing power parity, Threshold Autoregressive (TAR) model

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E-mail addresses:

marthaniri@yahoo.com (Niri Martha Choji)

sksek@usm.my (Siok Kun Sek)

* Corresponding author

INTRODUCTION

The purchasing power parity theory is one of the oldest theories in the area of international finance. It states that the exchange rate between two nations ought to be equivalent to the aggregate price levels between the two nations. Even though substantial empirical studies on the theory of PPP have been carried out, research on the purchasing power parity is still being carried out because of its importance for policy implications in international finance and trade. The importance of PPP is not limited to the fact that it can be utilized to foresee exchange rate to decide if a country's currency is exaggerated or underestimated. PPP is also used in measuring and looking at national pay levels among nations. It is an apparatus utilized for estimating general monetary conditions of nations (Michael, 2005).

Numerous researchers have utilised conventional linear unit root tests for real exchange rates, and co-integration between different measures of local and foreign prices, and spot exchange rates in the investigation of long-run PPP (Su et al., 2010). The conclusions drawn from these investigations depend on linear tests of unit roots as well as/ or co-integration. Since a lot of proof supporting asymmetric reactions in core economic variables have been recognized, there is no motivation to keep accepting that the long-run PPP adjustment process for balance is symmetric (Lu et al., 2011). As shown by Bahmani-Oskooee et al. (2015), economic variables such as the exchange rate may follow an asymmetric

adjustment process. The power of the linear co-integration test is low in an asymmetric change process. It has been shown by Enders and Granger (1998) that the standard tests of stationarity and co-integration have low power when misspecified dynamics are present.

In an effort to finding more powerful tests, a number of researchers have considered tests of nonlinearity or asymmetry in testing economic variables. These include: Cook (2007) who tested for asymmetric adjustment in a co-integrating relationship between stock price and economic activity in the U.K. He found asymmetric co-integration with the use of the MTAR instead of the TAR model (the threshold co-integration method of Enders and Siklos (2001)) with the use of quarterly data from 1975Q1 to 2005Q2. Moreover, Chen et al. (2005) found evidence in support of asymmetric adjustment in the U.S. selling gasoline prices by using the Enders and Siklos (2001) co-integration with weekly data, from January 1991 to March 2003. They found that the asymmetric transmission occurred not simply in the spot markets of raw petroleum and refinery fuel, but also in their future markets. However, Baum et al. (2001) modelled the acts of adjustments to long-run PPP, covering the post-Bretton Wood generation, in a nonlinear framework for a set of U.S. trading partners from August 1973 to December 1995, using the exponential smooth transition autoregressive (ESTAR) model. They found evidence to support a nonlinear dynamic structure with a very slow convergence to long-run

purchasing power parity in the post-Bretton Woods generation. Additionally, Aroui and Fouquau (2009) studied the effect of oil costs and stock market returns in GCC (Gulf Cooperation Council Countries) using monthly data from January 1996-December 2007. Their results found proof for asymmetric co-integration between oil costs and stock market dividends when they combined the Schorderet (2003) with the Lardic and Mignon (2008) methods of asymmetric co-integration.

Furthermore, Chen et al. (2013) found that co-integration adjustment between exchange rate and oil costs in the Philippines, from 1970Q1-2011Q4, appeared to be asymmetric with the use of the momentum threshold autoregressive (MTAR) model. But they got a contrary result when they applied the threshold autoregressive (TAR) model. Moreover, Haughton and Iglesias (2012) analysed asymmetric interest rates and the monetary transmission mechanism on the instability of interest rates, and the monetary transmission mechanism in the countries of Caribbean single market and economy (CSME) by utilizing monthly data from the period 1995 to 2010. The results of TAR and MTAR models showed an asymmetric long-run relationship for Guyana, Jamaica, and St. Lucia (but not for Barbados, Haiti, and Trinidad and Tobago) for both lending and deposit rates. Furthermore, Tiwari and Shahbaz (2014) examined the PPP hypothesis for India with her five main trading associates from 1991M1-2009M2 by utilizing the DF-GLS unit root test, the threshold autoregressive

(TAR) model, and the momentum-TAR (M-TAR) models. Their analysis revealed that the PPP theory did not hold for all the main trading associates of India, indicating that intermediate goods encounter massive obstacles to trade in the countries considered. Finally, Aliyu and Tijjani (2015) found an asymmetric long-run relationship between exchange rate and trade balance in Nigeria with monthly data from 1999-2012 when they applied the threshold co-integration of Enders and Siklos (2001).

To this end, the purpose of this research paper is to investigate if there exists a long-run validity of purchasing power parity alongside the asymmetric adjustment in MINT by utilizing the nonlinear co-integration test of Enders and Siklos (2001). Co-integration holds when the mixture of at least two non-stationary series can form a long-run stationary relationship, if the series have the same order of integration. Basically, the non-stationarity clears out in these series and a long-run stationary relationship is seen. Co-integration tests demand that only some linear blend of exchange rates and prices be stationary. The rejection of the null hypothesis of no co-integration and the null hypothesis of symmetry will lead us to conclude that the PPP is valid with asymmetric adjustment.

MINT stands for Mexico, Indonesia, Nigeria, and Turkey. The acronym was formed by Jim O'Neill of Goldman Sachs who termed these countries as emerging economic giants because of their prospects as the second generation of emerging market pacesetters. They share some common

characteristics such as growing population, youthful workforce, and are located strategically close to large markets. Based on their strategic locations, Mexico is very close to the US, Indonesia is in the middle of Asia, Nigeria is leading Africa's rising, and Turkey combines eastern and western influences. As in 2014, as indicated by the World Bank information on GDP market prices, the MINTs included the world's fifteenth (Mexico), sixteenth (Indonesia), seventeenth (Turkey), and 21st (Nigeria) economy (Kokotović & Kurečić, 2016).

Generally, the characteristics of the exchange rate for the MINT are similar, based on how these countries faced severe challenges with falling exchange rates that made these countries encounter several exchange rate regimes in attempts to finding ways of saving their currencies. They moved from rigid exchange rate regimes to more flexible ones. Despite the efforts put in to save the Mexican peso, it kept falling. The Peso started at 8.65Pesos/USD in 1954, but due to several devaluations of the currency, the exchange rate now stands at 18.752Pesos/USD, as in November 2017. Furthermore, the Indonesian Rupiah is not left behind in terms of fallen currencies. The Rupiah faced severe inflation for most of its existence. Despite the huge effort/intervention invested in the Rupiah, it has not stopped falling. At its inception in 1949, the Rupiah exchanged for Rp.3.8/USD however, it has drastically fallen to Rp. 14185.25/USD, as in November 2017. The case of Nigeria is quite pathetic because its currency was higher in value than the USD. The Naira/USD exchange rate as in 1975

was 0.616Naira/USD, which has drastically fallen to 364Naira/USD as in November 2017. Finally, the Turkish Lira, which was the least valuable currency in the world, based on the Guinness Book of Records, in 1995, 1996, and 1999 to 2004, however, is now the strongest currency in the MINT. In 2001 before the government redominated the currency by removing six zeros, the TL/USD was 1,650,000TL/USD. In the year after the conversion to the new currency, the average yearly exchange rate range, from 2005 to 2015, was 1.29TL/USD to 2.62/USD. Since then the TL has been falling gradually to be at 3.96TL/USD as on 27th November 2017.

This paper significantly contributes to this area of research to the best of our knowledge, in the sense that it is the first to utilise the asymmetric co-integration tests of Enders and Siklos (2001) in testing for purchasing power parity from the period of January 2003 to August 2016 in the MINT. This group of countries is chosen because very little research exists for MINT, and no research has been done in the area of PPP for this group of nations. Based on the threshold co-integration tests, results showed proof of long-run purchasing power parity alongside asymmetric adjustment in Nigeria and Turkey but not for Mexico and Indonesia.

The remaining parts of the paper are organised thus: Section 2 presents the PPP theory, in Section 3, we present some of the few empirical work done on the MINT, the data and methods used are presented in section 4, sections 5 shows our results, and then, we conclude in section 6.

The Theory of PPP

The PPP theory says that the exchange rate between two nations should be the same as the ratio of the total price level between the two currencies so that the unit of currency of one nation will have equal power to purchase goods and services in a foreign nation/country. To understand the concept of PPP, we need to look at the law of one price since PPP theory is built on the variation and expansion of the law of one price applied to the whole economy.

The law of one price states that identical goods in different countries should have the same cost whenever denominated in the same currency. This means that when there is no moving cost or no differential taxes affecting the two different markets, similar products should have the same costs in two different markets. If a price difference exists between two markets, then we experience arbitrage. The success of the law of one price depends on arbitrage between countries. The process of having the same prices in different countries is time consuming, which is why PPP is favoured more as a long-run relationship instead of a short-run relationship. A mathematical representation of the law of one price is given in the equation below:

$$e = \frac{p}{p^*} \quad (1)$$

where, e is the nominal or spot exchange rate, p and p^* are the costs for the similar commodity in the local and foreign countries, successively.

There are basically two types of PPP; the absolute PPP and the relative PPP. The absolute PPP happens when the purchasing power of a unit of money is precisely equivalent in the local economy and in a foreign economy, once it is changed to foreign currency at the market exchange rate. This thought implies that the exchange rate between two nations is the same as the ratio of the price levels for those two nations. Absolute PPP could be represented by the equation $e = \frac{p}{p^*}$. Applying log we have

$$e = p - p^* \quad (2)$$

where e is the log of the exchange rate, p is the log of the local price and p^* is the log of the foreign price. Generally, this form of PPP is unlikely to hold over nations because of obstacles such as mobility costs and tariffs to trade.

On the other hand, relative PPP holds that the exchange rate regulates to the amount of the inflation differential between nations, implying that changes in the exchange rate are equivalent to changes in the corresponding national prices.

The variations between the absolute and the relative PPP is that the former shows that the exchange rate reflects the ratio of the two countries' price levels, which is not simple. In all actuality, there are market defects, for example, non-transferable inputs, transportation costs, taxes, quotas, et cetera. Consequently, relative PPP puts these defects into account and moderates the relationship between the exchange rate and the prices of these two nations. It does

that by considering the connection between the adjustments in the exchange rate and the adjustments in the ratio of the prices. All that the relative PPP needs are the changes in the exchange rate and the changes in the ratio of price levels. Relative PPP could be represented by the equation below

$$\% \Delta e = \% \Delta p - \% \Delta p^* \quad (3)$$

where $\% \Delta e$ is the percentage change in the exchange rate, $\% \Delta p$ is the percentage change in the local rate of inflation and $\% \Delta p^*$ is the percentage change in the foreign rate of inflation (Beirne, 2010).

Empirical Literature on the MINT

Very little empirical work has been done on the MINT. Some of the few empirical works done include the work of Asteriou et al. (2016) who used the GARCH model and the ARDL (Autoregressive Distributed Lag) Bounds testing approach to test for the effect of exchange rate volatility on international trade volumes for the MINT with monthly data from 1995 to 2012. Results indicated that there was no linkage between exchange rate volatility and international trade activities for Mexico, Indonesia, and Nigeria, except for Turkey in the long-run. However, in the short-run, all the variables indicated some form of linkages. Furthermore, Coban et al. (2016) found high correlations between telecom investments and the GDP in the MINT countries when they used three well-known calculations of the correlation coefficient. The results showed high correlations in each

of the four countries. Moreover, Kokotović and Kurečić (2016) examined the basic economic trends in MINT for over 25 years by analysing the linear relationship between GDP, household consumption, foreign direct investment and government consumption using OLS (ordinary least squares). They arrived at the conclusion that the MINT countries might have a significant role in international relations as a regional power. Finally, Ozturk and Yildirim (2015) used annual data from 1967-2010 to examine the Environmental Kuznets Curve (EKC) hypothesis for MINT. They applied the co-integration tests of Pedroni and the fully modified ordinary least squares (FMOLS). Results of the analysis supported the EKC hypothesis only for Nigeria but failed to provide support for other countries of the MINT.

METHODS

Data

Data used was collected from *Datastream*, Thomson Reuters. It is a set of monthly data for MINT (Mexico, Indonesia, Nigeria and Turkey) starting from January 2003 to August 2016. The data consists of the nominal exchange rate (local currency per 1USD), consumer price index (CPI) for Mexico, Indonesia, Nigeria, and Turkey, and CPI for the US since the US is used as the base currency. All the variables (EXRATE, CPI, and CPIus) were transformed into log (LEXRATE, LCPI and LCPIus) forms for consistency before the analyses were carried out.

The data would be analyzed first by the unit root tests in order to check if the variables were stationary. If the variables were integrated of order one, we would go ahead to run several co-integration tests and finally we estimated the long-run relationships with the threshold regression, DOLS, and FMOLS.

Threshold Co-integration Tests (TAR and MTAR)

Following Su et al. (2010), we applied the asymmetric co-integration method of Enders and Siklos (2001) to test for the long-run purchasing power parity alongside asymmetric adjustment in MINT. The test depends on a two-step process. Firstly, we calculate a long-run balanced relationship of the form:

$$e_t = \alpha_0 + \beta_1 p_t^* + \beta_2 p_t + \mu_t \quad (5)$$

where e_t is the log of thenominal exchange rate, p_t^* and p_t are the log of foreign and local prices respectively and μ_t is the stochastic error term. Secondly, we focus on the ordinary least square estimates of ρ_1 and ρ_2 in the regression below,

$$\Delta \mu_t = I_t \rho_1 \mu_{t-1} + (1 - I_t) \rho_2 \mu_{t-1} + \sum_{i=1}^t \gamma_i \Delta \mu_{t-1} + \varepsilon_t \quad (6)$$

where ε_t is a white-noise disturbance term and the residuals, μ_t , in equation (5) are taken to (6) for further estimation. I_t is the Heaviside indicator function thus:

$$I_t = \begin{cases} 1 & \text{if } \mu_{t-1} \geq \tau \\ 0 & \text{if } \mu_{t-1} < \tau \end{cases}$$

where τ is the threshold value. An essential setup for $\{\mu_t\}$ to be stationary is: $-2 < (\rho_1, \rho_2) < 0$. If the variance of ε_t is adequately large, then it is possible for one value of ρ_j to be between -2 and 0 and for the other to be the same as zero. Although there is no convergence in the regime with the unit-root (i.e., when $\rho_j = 0$), large realisation of ε_t will change the system to a convergent regime. Enders and Granger (1998) and, Enders and Siklos (2001) both called attention to the null hypothesis of no convergence, where the F-statistic for the null hypothesis $\rho_1 = \rho_2 = 0$ has a distribution that is not standard. They showed critical values for this non-standard F-statistic in their paper. Enders and Granger (1998) also showed that if there was a stationary sequence, the least square estimates of ρ_1 and ρ_2 had an asymptotic multivariate normal distribution.

The model utilizing equation (6) is known as the threshold autoregressive model (TAR), and the test for threshold characteristics of the equilibrium error is called the threshold co-integration test. Supposing the system is converged, $\mu_t = 0$ is seen as the long-run equilibrium value of the sequence. If μ_t is over its long-run balance, the adjustment is $\rho_1 \mu_{t-1}$ and if μ_t is in its long-run equilibrium, the adjustment is $\rho_2 \mu_{t-1}$. The equilibrium error, therefore, acts as a threshold auto-regression. The null hypothesis of $\rho_1 = \rho_2 = 0$ tests for the long-run relationship and the rejection

of the null tells us that there is existence of co-integration between the variables. In revealing of $\rho_1 = \rho_2 = 0$ hypothesis, it is valuable to further test for symmetric adjustment (i.e., $\rho_1 = \rho_2$) by utilizing a standard F-test. If the adjustment is symmetric as $\rho_1 = \rho_2$, equation (6) converges to the ADF test of Said and Dickey (1984). Rejecting the null hypotheses of $\rho_1 = \rho_2 = 0$ and $\rho_1 = \rho_2$ indicates the reality of threshold co-integration and the asymmetric adjustment.

Based on Enders and Granger (1998), the model is very precious when the adjustment is asymmetric in the sense that the series show more 'momentum' on one side than the other. Rather than calculating (2) with the Heaviside indicator relying on the level of μ_{t-1} , the decay can be made to depend on the preceding period's change in μ_{t-1} . The Heaviside indicator could then be represented as:

$$I_t = \begin{cases} 1 & \text{if } \Delta\mu_{t-1} \geq \tau \\ 0 & \text{if } \Delta\mu_{t-1} < \tau \end{cases}$$

where τ is the threshold value. The model is referred to as momentum-threshold auto-regression model (M-TAR). The TAR model grasps 'deep' cycle process if, for example, positive deviations are sustained more than negative deviations. The M-TAR model makes the auto-regressive decay to be conditioned on $\Delta\mu_{t-1}$. As such, the M-TAR representation can grasp 'sharp' movements in a sequence.

In the broadest case, if the value of τ is not known, it should be evaluated alongside the values of ρ_1 and ρ_2 . By demeaning

the $\{\mu_t\}$ sequence, the Enders and Granger (1998) test strategy utilizes the sample mean of the succession as the threshold estimate of τ . Nonetheless, the sample mean is a biased threshold estimator in the presence of asymmetric adjustments. For example, if auto-regressive decay is slow for positive deviations of μ_{t-1} from τ , than for negative deviations, the sample mean estimator will be biased upwards. A consistent estimate of the threshold τ is gotten by utilizing Chan's (Chan, 1993) methodology of looking for possible threshold values to minimise the residual sum of squares from the fitted model.

Enders and Siklos (2001) used Chan's method in a Monte Carlo study to get the F-statistic for the null hypothesis of $\rho_1 = \rho_2 = 0$ when the threshold τ was approximated using Chan's procedure. The critical values of this non-standard F-statistic for testing the null hypothesis of $\rho_1 = \rho_2 = 0$ are shown in their work. There is no assumption concerning whether to utilize TAR or M-TAR model, for the most part, the suggestion is to choose the adjustment process by a model selection criterion, for example, the AIC or SBC.

Threshold Error-Correction Model (TECM)

If proof in favour of asymmetric adjustment of threshold co-integration is found, then an asymmetric error-correction model will be utilized to examine the adjustment process of variables to the long-run balanced relationship. The traditional error-correction models do not show whether the value of the

threshold is true, over, or below fundamental value τ , that have varying adjustment processes. We calculate the set of equations in (7) for asymmetric error-correction models in Nigeria and Turkey since the asymmetric adjustment of threshold co-integration is found.

$$\Delta e_t = \mu_{10} + \sum_{i=1}^k a_{1i} \Delta e_{t-1} + \sum_{i=1}^k b_{1i} \Delta p_{t-1}^* + \sum_{i=1}^k c_{1i} \Delta p_{t-1} + \lambda_{1e} z_{t-1}^+ + \lambda_{2e} z_{t-1}^- + \varepsilon_t \tag{7}$$

where $z_{t-1}^+ = I_t \mu_{t-1}$ and $z_{t-1}^- = (1 - I_t) \mu_{t-1}$. μ_{t-1} is residual from (7),

$$I_t = \begin{cases} 1 & \text{if } \mu_{t-1} \geq \tau \\ 0 & \text{if } \mu_{t-1} < \tau \end{cases}$$

for the TAR model.

Moreover, z_{t-1}^+ and z_{t-1}^- represent the shock of adjustment for $\mu_{t-1} \geq \tau$ and $\mu_{t-1} < \tau$. The calculated coefficients of z_{t-1}^+ and z_{t-1}^- , λ_2 and λ_2 , measure the speed of adjustment for positive and negative departures from long-run purchasing power parity. The choosing of a suitable lag order is according to the AIC (Su et al., 2010).

Estimation Approaches

The breakdate threshold regression was considered in obtaining the long-run estimates. The equation for breakpoint threshold regression used in searching for breaks in the sample can be written as:

$$e_t = \beta_1 I(t \leq k_1) [c_0 + b_{0,1} p_t^* + b_{0,2} p_t] + \beta_2 I(k_1 + 1 \leq t \leq k_2) [c_1 + b_{1,1} p_t^* + a_{1,2} p_t] + \beta_3 I(k_2 + 1 \leq t \leq T) [c_2 + a_{2,1} p_t^* + a_{2,2} p_t] + u_t \tag{8}$$

for two breakdate models, where k_1 and k_2 are the breakdates. In this study, we used the Bai and Perron (1998) test of L+1 breaks vs. L to sequentially determine two breakdates. The break dates k_1 and k_2 have divided the sample period into three sub-periods, i.e., $(t \leq k)$, $(k_1 + 1 \leq t \leq k_2)$ and $(k_2 + 1 \leq t \leq T)$. Apart from the breakdates threshold regression, we also applied the DOLS and FMOLS for consistency check.

RESULTS AND DISCUSSION

We applied the threshold co-integration tests to test for the PPP hypothesis. Prior to the TAR and MTAR co-integration tests, time series unit root tests were performed to see if the variables are stationary. The time series unit root tests include the ADF (Said & Dickey, 1984) and PP (Phillips & Perron, 1988). The Engle and Granger (1987) and Phillips and Ouliaris (1990) linear co-integration tests were also conducted to check if there were evidence of linear co-integration. Below are results of the analyses.

Table 1 presents the results of the time series unit root tests for Mexico, Indonesia, Nigeria, and Turkey. The table shows results for ADF and PP unit root tests. The results provide evidence for a unit root for the log of the nominal exchange rate (LEXRATE)

and the log of respective price levels for all countries involved in the sample (i.e., the log of consumer price index for MINT countries and the log of the consumer price index for US (LCPI and LCPIUS)). But after first differenced (Δ LEXRATE Δ LCPI and Δ LCPIUS), these variables became stationary, confirming that they are integrated of order one for Mexico, Indonesia, Nigeria, and Turkey. Therefore, we do not reject the null hypothesis of a unit root, meaning that all variables for all countries are not stationary at levels but stationary at first difference. This shows that all our variables are integrated of order one for all the countries. Therefore, we can go ahead with the co-integration tests to see if the combination of these variables will be stationary.

Additionally, Table 2 shows the outcome of linear co-integration tests for Mexico, Indonesia, Nigeria, and Turkey using the linear tests of Engle and Granger (1987) and Phillips and Ouliaris (1990). Both tests results failed to reject the null hypothesis of no co-integration for Mexico and Indonesia but rejected for Nigeria and Turkey. This shows that a long-run relationship exists between the exchange rate and the relative price levels, which means that the PPP theory is valid in Nigeria and Turkey, but not in Mexico and Indonesia.

Moreover, Table 3 presents the outcome of the test for threshold co-integration in all the countries. Here we have the TAR and the MTAR with estimated threshold values, and when the threshold value is zero

(that is when τ has a consistent estimate and when $\tau = 0$). For the TAR model, the null hypothesis of no co-integration and symmetry are rejected for Nigeria and Turkey, indicating the presence of co-integration and asymmetric adjustment in Nigeria and Turkey, but shows the absence of both co-integration and asymmetric adjustment for Mexico, and shows the presence of asymmetric adjustment but not co-integration in Indonesia. However, results of MTAR reject the null hypothesis of no co-integration but not that of symmetry in Nigeria and Turkey, indicating the presence of co-integration and symmetric adjustment in Nigeria and Turkey but shows the absence of both co-integration and asymmetric adjustment in Mexico, and shows only the presence of asymmetric adjustment in Indonesia but no co-integration. Both results show that PPP is valid in Nigeria and Turkey, but only the TAR model indicates the presence of asymmetric adjustment towards equilibrium in Nigeria and Turkey. We have seen from the methodology that the TAR model grasps 'deep' cycle process and the MTAR model is able to grasp 'sharp' movement in a sequence. Consequently, the asymmetric adjustment towards equilibrium in Nigeria and Turkey are 'deep' cycle processes, which is why they are captured by the TAR model. Since there is asymmetric co-integration in Nigeria and Turkey, it implies that PPP exists in these countries with asymmetric adjustments. We, therefore, go ahead with the threshold error correction models for Nigeria and Turkey.

Table 1
Linear unit root tests

Country/Variable	ADF test statistic	PP test statistic
Mexico		
LEXRATE(e_t)	-0.2305(0.9308)	-0.3330(0.9161)
Δ LEXRATE(Δe_t)	-11.3102(0.0000)**	-11.2600(0.0000)**
LCPI(p_t)	-1.6587(0.4501)	-1.1044(0.7136)
Δ LCPI(Δp_t)	-8.4214(0.0000)**	-6.2140(0.0000)**
LCPIus(p_t^*)	-1.8122(0.3736)	-1.8991(0.3322)
Δ LCPIus(Δp_t^*)	-8.4547(0.0000)**	-7.4206(0.0000)**
Indonesia		
LEXRATE(e_t)	-0.6690(0.8503)	-0.8246(0.8091)
Δ LEXRATE(Δe_t)	-11.7438(0.0000)**	-11.7460(0.0000)**
LCPI(p_t)	-1.5862(0.4873)	-1.4884(0.5372)
Δ LCPI(Δp_t)	-10.3052(0.0000)**	-10.2290(0.0000)**
LCPIus(p_t^*)	-1.8122(0.3736)	-1.8991(0.3322)
Δ LCPIus(Δp_t^*)	-8.4547(0.0000)**	-7.4206(0.0000)**
Nigeria		
LEXRATE(e_t)	1.6408(0.9753)	1.7735(0.9816)
Δ LEXRATE(Δe_t)	-9.0938(0.0000)**	-9.1023(0.0000)**
LCPI(p_t)	5.7106(1.0000)	7.7643(1.0000)
Δ LCPI(Δp_t)	-7.2031(0.0000)**	-7.2771(0.0000)**
LCPIus(p_t^*)	4.2913(1.0000)	5.3755(1.0000)
Δ LCPIus(Δp_t^*)	-6.7629(0.0000)**	-6.7629(0.0000)**
Turkey		
LEXRATE(e_t)	0.1609(0.9693)	0.1976(0.9717)
Δ LEXRATE(Δe_t)	-12.0714(0.0000)**	-12.0570(0.0000)**
LCPI(p_t)	-0.8297(0.8076)	-2.4487(0.1302)
Δ LCPI(Δp_t)	-9.7854(0.0000)**	-15.9846(0.0000)**
LCPIus(p_t^*)	-1.8122(0.3736)	-1.8991(0.3322)
Δ LCPIus(Δp_t^*)	-8.4547(0.0000)**	-12.4206(0.0000)**

where ** indicates 5% level of significance

Table 2
Linear cointegration tests

Country	Engle-Granger test	Phillips-Ouliaris test
Mexico	-18.7851(0.1695)	-18.2128(0.1866)
Indonesia	-11.7210(0.4889)	-10.7403(0.5502)
Nigeria	-72.1518(0.0000)***	-30.9705(0.0157)**
Turkey	-34.7993(0.0068)***	-36.3944(0.0047)***

The table shows the z-statistic and probability values for all the countries. *** and ** indicate significance at 1% and 5% levels, respectively.

Table 3
Threshold cointegration test

Country/ Model	τ	ρ_1	ρ_2	No Cointegration	Symmetry
				$\rho_1 = \rho_2 = 0$	$\rho_1 = \rho_2$
Mexico					
TAR	0.0000	-0.0756	-0.0730	1.0210(6.9417)	
	0.0607	-0.1009	-0.0517	1.2008(6.8646)	NA
MTAR	0.0000	-0.0135	-0.1251	18993(7.4397)	
	0.0025	0.0009	-0.1362	2.3482(7.4289)	NA
Indonesia					
TAR	0.0000	-0.0037	-0.0345	0.7437(4.6063)	
	0.0979	-0.2057	-0.0066	6.6073(7.2541)	NA
MTAR	0.0000	-0.1006	-0.0075	3.0538(7.7822)	
	0.0151	-0.1474	-0.0190	3.9235(7.6958)	NA
Nigeria					
TAR	0.0000	-0.1869	-0.3640	9.6801(7.2312)**	2.2253(2.0720)**
	-0.0454	-0.1466	-0.5033	13.2808(7.0902)**	8.7260(2.2691)**
MTAR	0.0000	-0.2454	-0.3101	8.6056(7.7383)**	0.2841(3.7735)
	-0.0135	-0.3513	-0.1502	9.9203(7.7719)**	2.6580(3.9410)
Turkey					
TAR	0.0000	-0.3313	-0.1767	11.5107(7.2906)**	2.6670(2.2551)**
	0.0550	-0.3637	-0.1674	12.3813(7.2189)**	4.2091(2.2326)**
MTAR	0.0000	-0.2438	-0.2344	10.0106(7.7204)**	0.0098(3.7607)
	0.0450	-0.3641	0.2016	11.3044(7.7237)**	2.3016(3.7075)

where ** indicate significance at 5% level

Furthermore, Table 4 shows estimated results of symmetric and asymmetric error correction models for Nigeria and Turkey where we have evidence of cointegration with asymmetric adjustments. The estimated coefficients λ_1 and λ_2 of z_{t-1}^+ and z_{t-1}^- show the speed of adjustment (from short-term positive or negative deviation) to attaining a long-run PPP. For the results of Nigeria, λ_2 the coefficient z_{t-1}^- (the speed of adjustment from short-term negative deviation to long-run equilibrium) is negative and significant, showing long-

run purchasing power parity and also, it has been observed that negative deviation to long-run equilibrium are eliminated more quickly than positive deviations. The symmetric error correction model was also estimated for comparison. The result of the linear error correction model is consistent with that of the asymmetric error correction model. However, for Turkey, results show that λ_1 , the coefficient of z_{t-1}^+ (the speed of adjustment from short-term positive deviation to long-run equilibrium) is negative and significant, showing long-

run purchasing power parity and also, it is seen that positive deviation to long-run equilibrium are eliminated more quickly than negative deviations in Turkey. The result of the symmetric error correction model for Turkey is also consistent with that of asymmetric. Since the speed of adjustment (from short-run positive or negative deviation) to long-run equilibrium are negative and significance for both Nigeria and Turkey, it means that the presence of co-integration (long-run PPP) is confirmed in these countries. However, Nigeria's adjustment was from a negative deviation while Turkey's adjustment was from a positive deviation.

Finally, results of the long-run estimates are displayed in Table 5. The table shows results of coefficients for the breakdate threshold regression, DOLS and FMOLS for Nigeria and Turkey. Looking at the results of the breakdates threshold regression, the sequential determination searching procedure was used to detect two breakdates which break the samples into three different sub-periods for Nigeria and Turkey. The breakdates for Nigeria are; 2003M01-2008M12, 2009M01-2014M08 and 2014M09-2016M08. All the coefficients of the variables for the breakdates threshold regression are statistically significant for 2003M01-2008M12 and 2014M09-2016M08 except for 2009M01-2014M08. It is obvious that the local and foreign prices both have significant impacts on the nominal exchange rates for 2003M01-2008M12 and 2014M09-2016M08 periods. 1 unit increase in the domestic price (LCPI) causes

a depreciation of 0.38 units of the exchange rate, and 1 unit increase in the foreign price (LCPIUS) results in an appreciation of 2.01 units in nominal exchange for 2003M01-2008M12. In the same way, 1 unit increase in the domestic price (LCPI) gives rise to a depreciation of 1.81 units of the nominal exchange rate, and 1 unit increase in the foreign price (LCPIUS) brings about an appreciation of 5.84 units in nominal exchange for 2014M09-2016M08. However, for Turkey, the breakdates are; 2003M01-2007M08, 2007M09-2009M11 and 2009M12-2016M08. Here, the coefficients of the variables for the breakdates threshold regression are statistically significant for 2007M09-2009M11 and 2009M12-2016M08 but not for 2003M01-2007M08. The local and foreign prices both have significant impacts on the nominal exchange rates for 2007M09-2009M11 and 2009M12-2016M08 periods. Consequently, 1 unit increase in the domestic price (LCPI) gives rise to a depreciation of 2.83 units in the nominal exchange rate, and 1 unit increase in the foreign price (LCPIUS) brings about an appreciation of 5.39 units in nominal exchange for 2007M09-2009M11. Moreover, 1 unit increase in the domestic price (LCPI) results in a depreciation of 2.10 units in the nominal exchange rate, and 1 unit increase in the foreign price (LCPIUS) causes an appreciation of 3.23 units in nominal exchange for 2009M12-2016M08. All the variables for DOLS and FMOLS estimators are significant in Nigeria and Turkey. The results of DOLS are consistent with that of FMOLS. For both countries, we

can see that local and foreign prices both have significant impacts on the nominal exchange rates for both countries. We can say that a unit increase in the domestic price (LCPI) results in a depreciation of 1.27 units in the nominal exchange rate, and a unit increase in the foreign price (LCPIUS) gives rise to an appreciation of 4.67 units in the nominal exchange rate for Nigeria. In the same way, the results for Turkey

indicate that a unit increase in the domestic price (LCPI) causes a depreciation of 2.95 units in the nominal exchange rate, and a unit increase in the foreign price (LCPIUS) brings about an appreciation of 8.67 units in the nominal exchange rate. However, the results of DOLS obviously produced better estimates than that of FMOLS because both the R-square and adjusted R-square values are higher than those of FMOLS.

Table 4
Estimated symmetric and asymmetric Error Correction Models (speeds of adjustments)

Country/Variable	Linear ECM	Threshold ECM	
	λ	λ_1	λ_2
Nigeria	-0.1637*** (-2.7256)	-0.0406 (-0.4303)	-0.2789*** (-3.4448)
Turkey	-0.0793* (-1.8402)	-0.1130* (-1.8436)	-0.0917 (-1.5048)

The table presents the estimated coefficients and t-statistics in brackets. *** and * indicate 1% and 10% levels of significance.

Table 5
Long-run estimates

Country/ Variable	Coef. of Threshold regression			Coef. of DOLS	Coef. of FMOLS
	2003M01- 2008M12	2009M01- 2014M09	2014M10- 2016M08		
Nigeria					
C	13.8775***	0.7977	27.8776**	24.2655***	25.8650***
LCPI(p)	0.3846***	0.0225	1.8067***	1.2657***	1.3391***
LCPIu(p*)	-2.0104***	0.7977	-5.8387**	-4.6744***	-5.0333***
R-square	0.9453	0.9453	0.9453	0.9138	0.8770
Adj. R-square	0.9424	0.9424	0.9424	0.9092	0.8754
Turkey					
C	-2.8016	14.9872***	6.9608**	31.9776***	32.4066***
LCPI(p)	-0.6334	2.8262***	2.1009***	2.9475***	2.9556***
LCPIus(p*)	1.1701	-5.3936***	-3.2332***	-8.6720***	-8.7573***
R-square	0.9528	0.9528	0.9528	0.9174	0.8981
Adj. R-square	0.9503	0.9503	0.9503	0.9131	0.8968

The table presents long-run estimates with *** and ** indicating significance at 1% and 5% level.

CONCLUSION

This paper examined if there exist a long-run validity of purchasing power parity and asymmetric adjustment in MINT (Mexico, Indonesia, Nigeria, and Turkey) by utilizing the threshold co-integration test of Enders and Siklos (2001). We applied the threshold co-integration tests to the PPP hypothesis. Prior to the TAR and MTAR co-integration tests, time series unit root tests were carried out to check the stationarity of variables for all the counties involved. The ADF and PP time series unit root tests were used. Results of the time series unit root tests revealed all variables to be integrated of the same order (order one) for all countries, which gave us the confidence to proceed with the co-integrations tests. The Engle and Granger (1987) and Phillips and Ouliaris (1990) tests were conducted to check if there was linear co-integration. Both tests gave evidence of linear co-integration for Nigeria and Turkey but failed to give evidence of co-integration for Mexico and Indonesia. With the application of the threshold co-integration test, we found evidence of asymmetric co-integration in Nigeria and Turkey, meaning that PPP was valid in Nigeria and Turkey with asymmetric adjustment. The results of the linear co-integration tests were consistent with that of the asymmetric co-integration tests, the results confirmed that co-integration and hence PPP was observed in Nigeria and Turkey but not in Mexico and Indonesia. Additionally, the symmetric and asymmetric error correction models were estimated. According to the outcome of the asymmetric error correction model, negative

deviations from the purchasing power parity were terminated more quickly than positive deviations in Nigeria. The result of the symmetric error correction model is consistent with that of the asymmetric error correction model. However, for Turkey, positive deviations were eliminated more quickly than negative deviations. The symmetric error correction model is also consistent with that of the asymmetric error correction model.

Furthermore, we conducted the breakdate threshold regression, DOLS and FMOLS for Nigeria and Turkey respectively, since the evidence of long-run relationship (PPP) was revealed in these countries. Both DOLS and FMOLS confirmed the validity of PPP (long-run relationship) in Nigeria and Turkey as both the domestic (LCPI) and foreign (LCPI) prices are significant determinants of the exchange rate. To be specific, an increase in domestic price (LCPI) leads to exchange rate depreciation while an increase of foreign price (LCPI) causes exchange rate appreciation. The magnitude of the effect of the foreign price (appreciation) on the nominal exchange rate is much larger than the magnitude of the effect of the domestic price (depreciation) on the nominal exchange rate. The results hold for both Nigeria and Turkey. On the other hand, breakdate threshold regression provides deeper results, i.e. provides estimates of the PPP long-run relationship under different time frames due to breakdates. In Nigeria, PPP relationship holds in the periods of 2003M01 – 2008M12 and 2014M10-2016M08 but does not hold

during 2009M01-2014M09. For Turkey, PPP relationship holds for 2007M09-2009M11 and 2009M12-2016M08 but not during 2003M01-2007M08. The results imply that PPP relationship may not necessarily hold for all periods. Basically, our results can be summarised thus: (i) PPP theory does not hold for all countries; (ii) Exchange rate may adjust asymmetrically, where negative deviations from PPP are terminated more quickly than positive deviations; (iii) PPP theory may not hold all the time; (iv) Higher foreign price causes appreciation of exchange rate while higher domestic price leads to depreciation of exchange rate.

Higher foreign prices cause appreciation of the exchange rates while higher domestic prices lead to depreciation of the exchange rates. However, we have observed that in both Nigeria and Turkey, there is a combined effect of appreciation and depreciation of the exchange rates which is good for these countries since the effect of only appreciation or depreciation will not be good as they have their individual advantages and disadvantages. Consequently, appreciation of the exchange rates will cause exports to be more expensive, imports cheaper, and hence reduce inflation. If the economies of these countries become more productive and competitive, appreciation of the exchange rates is beneficial because it can be sustained, and therefore help in the growth of, the economy. However, if the currency appreciates rapidly in difficult economic times, it can be a problem. Depreciation, on the other hand, makes exports to be

cheaper, imports more expensive and thereby cause inflation to increase in Nigeria and Turkey. An exchange rate that is falling can be advantageous to an economy if the economy is not competitive and trapped in a recession. A devaluation/depreciation assists in increasing the demand for exports and the creation of jobs. The standard of living of these countries is reduced by depreciation. In conclusion, the foreign price contributes more to the adjustments in the nominal exchange rates, thereby making the effect of nominal exchange rate appreciation more pronounced than depreciation in both Nigeria and Turkey. Since this is the first research on the PPP in the MINT group, we advise that more research for this group of countries be conducted by researchers and the government of these countries to see how they would strike the balance between appreciation and depreciation of their exchange rates, and also find out why the PPP theory does not hold for some of those countries in the MINT.

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