

# Testing the PPP in the non-linear STAR Framework: Evidence from MENA Countries\*

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## Abstract

*Most previous studies that used standard ADF test to validate the purchasing power parity theory failed to find linear stationarity in the real exchange rates. Since its introduction in 2003, a new unit-root test that incorporates non-linearity in mean reverting process of a time series variable has gained momentum in testing the theory. This new test rejects the null of unit root in real exchange rates more often than the standard ADF test, helping solve the PPP puzzle. In this paper we apply the new test as well as the standard ADF test to the real effective exchange rates of 14 MENA countries and show that indeed, the PPP is validated in 8 out of 14 countries by the new test.*

**Key words:** Non-linear Unit Root, PPP, MENA

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## 1. Introduction

Many developing countries have been struggling to decide on the appropriate exchange rate policy. Several options range from a free floating to a fixed exchange rate peg. Along the spectrum, there are several options that can be identified as managed floating with a varying degree of intervention in the foreign exchange rate market in order to avoid the severe consequences of over-appreciation or over-depreciation of the exchange rate. The polar choices of free floating or a fixed exchange rate have the advantage of transparency, which may be a necessary requirement to guide agents' expectations. Nonetheless, each option may carry a huge risk, depending on the type of shocks the economy is facing. For example, a small open economy that is highly dependent of imported goods may opt to a fixed exchange rate policy to stabilize inflationary expectations and insulate the economy from nominal shocks. In contrast, where the domestic economy is subject to real shocks, a flexible exchange rate policy provides flexibility to absorb real shocks and minimize their adverse effects on the economy.<sup>1</sup>

As countries face a wide range of choices to manage the exchange rate, the tradeoff often hinges on stability versus flexibility. While a fixed exchange rate policy provides stability and confidence to hold the domestic currency, it carries the risk of realizing an overvalued real exchange rate that adversely affects competitiveness and export growth. In contrast, a flexible exchange rate policy adjusts to fluctuations in relative prices, ensuring the right balance of the real relative price of tradables and non-tradables.<sup>2</sup>

Many developing countries have been gradually opting to abandon a fixed exchange rate policy in favor of a managed floating. The advantage of such a policy is to manage the nominal exchange rate within a band to achieve stability of the real effective exchange rate. As many developing

countries have large shares of exports and imports, managing a stable real effective exchange rate strikes the right balance between stability and flexibility. Each country determines the appropriate weights to manage its real effective exchange rate based on the relative importance of exports and imports in its total trade. A weighted average of bilateral exchange rates measures the nominal effective exchange rate. Stability of the nominal effective exchange rate indicates stable relative prices, on average, for exports and imports based on the relative importance of bilateral exchange rates in the trade basket.

Nonetheless, relative inflation may be another important factor that determines the relative prices of tradables and non-tradables. To offset the effects of inflationary differentials between the domestic economy and major trading partners, managing a real effective exchange rate may provide the right balance. By doing so, countries adjust the nominal exchange rate to ensure a stable real exchange rates, on average, based on the relative weights of major trading partners, while taking into account movements in bilateral exchange rates and relative prices with each trading partner.

To what extent have MENA countries managed a stable real effective exchange rate over time? This question is the focus of our research in this paper. We calculate the real effective exchange rate for a sample of MENA countries as the weighted average of real bilateral exchange rates with major trading partners for each country. We then test the stationarity of the real effective exchange rate over time. A stationary real effective exchange rate indicates cointegration between relative prices and bilateral exchange rates, in support of purchasing power parity. That is, nominal exchange rates adjust to offset movements in relative prices and stabilize the real effective exchange rate over time. More importantly, we study short-term adjustments in the real effective

exchange rate to reflect on the success of the exchange rate policy to strike the right balance between flexibility and stability that would satisfy the objectives of maintaining confidence in the domestic currency. If such a policy is to be successful and effective, the real effective exchange rate has to revert to its mean or it should be stationary. Testing stationarity of the real exchange rate amounts to testing the validity of the well-known theory of Purchasing Power Parity (PPP).<sup>3</sup>

Earlier studies that tried to test stationarity of the real exchange rates mostly relied on the standard Augmented Dickey-Fuller (ADF) test and provided little support for the PPP. Examples include Taylor (1988), Layton and Stark (1990), Kim (1990), Kearney and MacDonald (1990), Corbae and Ouliaris (1991), Bahmani-Oskooee and Rhee (1992), Bahmani-Oskooee (1993a, 1993b, 1995a, 1995b, 1998), Lothian and Taylor (1997), Mark and Choi (1997), Zhou (1997), Bahmani-Oskooee and Barry (1997), and Bahmani-Oskooee and Goswami (2005).

The main assumption behind the standard ADF test is that it assumes the movement in a time series variable is linear. Recently, Kapetanios, Shin and Snell (2003) have introduced a new test that accounts for non-linearity in the mean-reversion process of a time series variable. Measurement problems and problems in modeling complex nonlinearities warrant an attempt to introduce testable non-linearity. Several studies have applied the new test (hereafter KSS test) to determine whether the real bilateral exchange rates are non-linear but stationary so that they can validate the PPP. Examples in this group include Michael, Nobay and Peel (1997); Baum, Barkoulas and Caglayan (2001); Parsley and Popper (2001); Taylor (2001); Taylor, Peel and Sarno (2001) and Sarno, Taylor and Chowdhury (2004), Chortareas and Kapetanios (2004), Erlat (2004), Hasan (2004) and Liew *et. al* (2004). A common feature of these studies is that they provide some support for nonlinear mean reversion in some real bilateral exchange rates.

In this paper we consider the non-linear behavior of the real effective exchange rates in 14 MENA countries which have received little attention in the literature. Since a country's currency may gain against the currency of one partner and lose against the currency of another partner, a better measure to capture movement in the overall value of a currency is the *real effective exchange rate*. Thus, unlike the studies mentioned above, in this paper we try to apply the KSS test to the real effective exchange rates of 14 MENA countries to determine whether we can provide some support for the PPP in the MENA region. To that end, we briefly explain the KSS test in section 2. In section 3 we introduce the method of constructing the real effective exchange rate and report the results. Section 4 concludes

## 2. The KSS Test

The test introduced by Kapetanios, Shin and Snell (2003) is an extension of the standard ADF test in that the null hypothesis is still unit root but the alternative hypothesis is nonlinear stationary smooth transition autoregressive (STAR) process. This new test, as they show, is more powerful than the standard ADF test. For a time-series variable  $X_t$ , it is based on the following exponential smooth transition autoregressive (ESTAR) specification:<sup>4</sup>

Where  $X_t$  is de-meaned or de-trended series of interest and  $\mu$  is an error term with usual properties. Kapetanios *et al.* (2003) demonstrate that testing the null hypothesis of  $\theta = 0$  against the alternative of  $\theta > 0$  is not feasible because  $\lambda$  is not identifiable under the null. They then use Taylor series to approximate specification (1) by (2):

$$\Delta X_t = \alpha X_{t-1}^3 + e_t \quad (2)$$

or its augmented form by (3):

$$\Delta X_t = \alpha X_{t-1}^3 + \sum_{k=1}^n r_k \Delta X_{t-k} + e_t \quad (3)$$

As can be seen, (3) is similar to the standard ADF test with the difference that the lagged value of the time-series variable under consideration is raised to power three rather than to power one. In (3) the null of unit root, i.e.,  $\delta = 0$  is tested against the alternative of  $\delta > 0$  by familiar t ratio obtained for  $\delta$  with new critical values tabulated by Kapetanios *et al.* (2003). Since this t ratio is for a non-linear model, it is denoted by  $t_{NL}$ . As for selecting the lag order in (3), Kapetanios *et al.* (2003, p. 365) recommend a procedure that relies upon significance of augmented terms.

### 3. The Results

As indicated in the introduction, unlike most previous research that relied upon bilateral real exchange rates to test the PPP, we use the real effective exchange rate to test for its mean reverting properties or the PPP. The exchange rate fluctuates bilaterally with respect to the various currencies of major trading partners. Equally important, inflationary differentials between trading partners further contribute to the real effective exchange rate. Unfortunately, real effective exchange rates are not readily available for MENA countries over a sufficiently long time horizon. Thus, our first task is to construct them for each of the 14 MENA countries. In constructing the *real effective exchange rate* for country  $j$  we follow the method in Bahmani-Oskooee (1998). Assuming country  $j$  has  $i$  trading partners, the *real effective exchange rate* ( $RE_j$ ) is constructed using the following formula:

In (4)  $P_j$  is the price level in country  $j$ ,  $P_i$  is the price level in trading partner  $i$ , and  $E_{ij}$  is the nominal bilateral exchange rate defined as the number of units of  $i$ 's currency per unit of  $j$ 's currency.<sup>5</sup> The numerator in (4) is the real bilateral exchange rate which is set in an index form by dividing it by its own value in a base year (2000 in our case). The weighted average of these indices is then taken to arrive at the real

effective exchange rate. The weights identified by  $\lambda_{ij}$  are measured by the sum of import and export shares of country  $j$  for each of her trading partners such that  $\sum \lambda_{ij} = 1$ .<sup>6</sup> The real effective exchange rates are constructed for each of the 14 MENA countries using annual data over the 1970-2004 period.<sup>7</sup> Note that the bilateral nominal exchange rate between two non-dollar currencies was generated using the rates against the US dollar. All exchange rates against the U.S. dollar and price levels are collected from the International Financial Statistics of the IMF and the trade shares (imports plus exports) come from the Direction of Trade Statistics (June 2005 issue), also from the IMF.

The results of the unit-root tests applied to the real effective exchange rates are reported in Table 1.

Table 1. Unit root test results of real effective exchange rates for 14 MENA countries.

Country	$ADF_c$	$ADF_t$	$t_{M1}$	$t_{M2}$	$t_{M3}$
Bahrain	-1.40 [1]	-2.60 [1]	0.98[2]	-2.06 [1]	-1.96 [1]
Egypt	-2.27 [1]	-2.65 [1]	-2.97 [1]*	-3.76 [1]*	-3.38 [1]*
Jordan	-1.28 [1]	-2.78 [1]	-1.18 [1]	-2.51 [1]	-4.27 [1]*
Kuwait	-2.46 [4]	-1.54 [4]	-0.61 [8]	-1.30 [8]	-1.74 [8]
Lebanon	-1.79 [1]	-2.43 [1]	-0.77 [1]	-2.11 [1]	-2.26 [1]
Libya	-2.01 [8]	-0.76 [1]	-0.99 [5]	-2.61 [6]	-2.32 [6]
Morocco	-0.92 [1]	-2.54 [1]	-1.09 [1]	-0.89 [1]	-4.20 [1]*
Oman	-2.60 [5]*	-2.20 [5]	-3.26 [5]*	-1.68 [1]	-2.40 [1]
Qatar	-3.22 [8]*	-3.16 [8]*	-0.72 [8]	-2.81 [8]*	-2.78 [8]
Saudi Arabia	-1.03 [1]	-2.73 [1]	-0.88 [1]	-0.90 [1]	-1.60 [1]
Syria	-2.22 [1]	-2.38 [1]	-4.87 [1]*	-7.29 [1]*	-7.26 [1]*
Tunisia	-2.31 [1]	-0.71 [1]	-3.00 [1]*	-2.92 [7]*	-1.11 [7]
Turkey	-4.98 [8]*	-5.92 [8]*	-3.43 [8]*	-3.42 [8]*	-2.88 [8]
U.A.E.	-2.37 [1]	-2.34 [1]	0.16 [1]	-1.96 [1]	-2.45 [1]
<b>10% Critical Value</b>	<b>-2.57</b>	<b>-3.12</b>	<b>-1.92</b>	<b>-2.66</b>	<b>-3.13</b>

There are total of five t ratios reported.  $ADF_C$  is the t ratio from the standard ADF test that includes only a constant term.  $ADF_t$  is the t-ratio from, again, the standard ADF test that includes a constant and a trend. These two statistics are reported to compare the results from linear ADF to those from non-linear ADF. For non-linear ADF test, following Kapetanios *et al.* (2003) we report three statistics. First, we use the raw data of the real effective exchange rate and apply the non-linear ADF test outlined by equation (3) to the raw data and report the t ratio as  $t_{NL1}$ . Next, we subtract the mean of the real effective rate from the raw data and apply (3) to de-meanded data and report the t ratio as  $t_{NL2}$ . Finally, we de trend the raw data following the procedure in Kapetanios *et al.* (2003, p. 364) and apply (3) to de-trended data and report the t ratio as  $t_{NL3}$ .

Concentrating on the standard ADF test (with or without trend) we gather from Table 1 that the null of unit root is rejected in favor of stationarity of the real effective exchange rate in three countries. This is due to the fact that the absolute value of our calculated t statistic is greater than the absolute value of its critical value. These three countries are Oman, Qatar, and Turkey. Thus, the PPP is validated in these three countries. However, when we shift to non-linear ADF test results, the number of cases in which the null of unit root is rejected, at least by one of three t ratios, increases to eight. These eight countries are Egypt, Jordan, Morocco, Oman, Qatar, Syria, Tunisia, and Turkey. Consistent with previous studies, non-linear stationarity of the real effective exchange rate is present in more cases than the linear stationarity, providing relatively more support for the PPP in MENA countries.

#### 4. Summary and conclusion

In an attempt to fight inflation and coordinate their macro policies, developing countries try to manage their nominal exchange rate. If such

policies are to be successful, relative prices should adjust to changes in the nominal exchange rate, implying that real exchange rates in these countries should revert to their means or they should be stationary. Testing for stationarity of real exchange rates amounts to testing the well-known theory of purchasing power parity. The introduction of a unit root test that accounts for non-linearity in a time series variable by Kapetanios *et al.* (2003) has renewed interest in testing unit root in real exchange rates as a way of validating the purchasing power parity (PPP). Most studies have used the real bilateral exchange rates to show that the new test rejects the null of a unit root and supports non-linear stationarity, thus, the PPP more often than the standard ADF test.

Given bilateral movements in the nominal exchange rate and differential inflation relative to each major trading partner, policy makers have become more interested in managing their real effective exchange rate to strike an appropriate balance between flexibility and stability. In this paper we apply the standard ADF test, as well as the new ADF test that accounts for non-linearity in a time-series variable, to the *real effective exchange rates* of 14 MENA countries. To that end, we first construct the real effective exchange rates using annual data over 1970-2004 period and then apply the tests. The results reveal that the standard ADF test supports the PPP only in three countries. However, when non-linearity in the real effective exchange rates are incorporated into the testing procedure, number of countries in which the PPP is validated, increases to eight. The eight countries are Egypt, Jordan, Morocco, Oman, Qatar, Syria, Tunisia, and Turkey. Such evidence reflects the success of exchange rate policy in these countries to stabilize the real effective exchange rate over time. As the exchange rate policy varies substantially across this sample of countries, the evidence indicates that stability of the real effective exchange rate can be achieved under both flexible and fixed exchange rate systems.

For countries where PPP does not hold, it is possible to envision multiple equilibria as the price level adjusts fully to changes in the exchange rate with a lag. Subsequently, a new shock hits and forces a new adjustment in the exchange rate, departing from the previous equilibrium. PPP is an equilibrium concept and, at least implicitly, it requires sequentially optimal decisions in a frictionless trading environment. There is no guarantee that such optimally unique equilibria would hold in the long-run with shocks and regime changes. Hence, a stable REER can be achieved in more than one way, which makes it difficult to determine empirically.

For policy implications, countries should evaluate the success of the exchange rate system to maintain the equilibrium real effective exchange rate. Failure to minimize deviations around this target equilibrium, may exacerbate the adverse effects on output growth and economic stability in the short-run.<sup>8</sup>

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Note: Critical values come from Kapetanios et al. (2003, p. 364).

**(Footnotes)**

<sup>1</sup> For a survey of choices for the exchange rate system and the appropriate exchange rate policy in the West Bank and Gaza see Beidas and Kandil (2005).

<sup>2</sup> For empirical evidence of the inflationary and output cost, attributed to demand and supply channels, in the face of exchange rate fluctuations, see Kandil (2006) and (2004) and Kandil and Mirzaie (2005), (2003) and (2002).

<sup>3</sup> For a recent survey see Sarno (2005).

<sup>4</sup> This section closely follows Bahmani-Oskooee *et al.* (2006).

<sup>5</sup> Unit labor costs are not available to replace the price level in the formula.

<sup>6</sup> Trading partners for each country were mostly OECD countries. The composition differed somewhat for some countries, dropping minor partners and adding major ones from the region. A table is available upon request from the authors showing exact partners for each country.

<sup>7</sup> Data limitation has prevented the inclusion of other countries in MENA.

<sup>8</sup> For empirical evidence, see Kandil (2004, 2006) and Kandil and Mirzaie (2005). Shocks to the exchange rate may create positive or negative effects on output growth depending on supply and demand channels, i.e., the cost of imports relative to competitiveness. The specifics of each country determines whether the adverse effects are more dominant. Regardless, shocks are deviations around stable equilibrium which increases uncertainty and cyclical fluctuations.