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# Explaining the long-term real equilibrium exchange rates through purchasing power parity (PPP): An empirical investigation on Egypt, Jordan and Turkey

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**This study aims at testing the validity of PPP as a long-term equilibrium condition for bilateral exchange rates in three emerging economies of the Middle East, namely Egypt, Jordan and Turkey through the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) unit root tests. Results of the ADF and PP unit root tests indicate that the null hypothesis of non-stationary real exchange rate can not be rejected in all cases implying that PPP fails to hold in all three countries. Using the KPSS test, the null hypothesis of trend stationary real exchange rate can not be rejected in all cases indicating that the real exchange rate in the three countries is stationary when a trend is included. Therefore, PPP in these countries is not sensitive to the choice of the base country but can be influenced by the type of test employed.**

**Key words:** PPP, unit root tests, ADF test, KPSS test, PP test.

## INTRODUCTION

Fluctuations in the exchange rate may have a significant impact on the macroeconomic fundamentals such as interest rates, prices, wages, unemployment, and the level of output. This may ultimately result in a macroeconomic disequilibrium that would lead to real exchange rate devaluation to correct for external imbalances (Parikh and Williams, 1998). Since the breakdown of the Bretton-Woods system of fixed exchange rate in the early 1970s, the movement of exchange rates has frequently been a topic of interest. This is because exchange rates affect all walks of life and daily transactions. Therefore, it is of immense importance to be able to explain the movement of exchange rates. There exist four mainstream methods through which long-run equilibrium exchange rate can be determined. These are the Balance of Payments Flow approach, Real Interest Rate Differential model, Purchasing

Power Parity (PPP), and the monetary model. Purchasing Power Parity is the most conventional and fundamental means through which the long-term equilibrium exchange rate can be explained.

PPP is the most conventional and fundamental means through which the long-term equilibrium exchange rate can be explained. It states that the exchange rate between two countries should reflect the relative purchasing power of the two countries. The validity of this hypothesis is traditionally tested through examining the stationarity of the real exchange rate. A stationary real exchange rate indicates that there exists a long run relationship between nominal exchange rate and, domestic and foreign prices, which validates the PPP hypothesis and hence its use as a tool for determining the equilibrium exchange rate. Rejection of the PPP hypothesis not only invalidates its usefulness as an exchange rate determination tool, but also disqualifies the monetary approach, which requires that the PPP hypothesis holds. The PPP theory draws on the law of one price, which says that arbitrage will lead to prices of the same products becoming equal everywhere. The PPP assumes that arbitrage will lead to an equalization

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of prices across countries. The PPP states that the long run exchange rate between two countries is equal to the ratio of their relative price levels. The purpose of the present study is to test the hypothesis of PPP for three emerging economies of the Middle East, namely Egypt, Jordan and Turkey through the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) test, and the Kwiatkowski, Phillips, Schmidt, and Shin (KPSS) tests. The rest of the article is structured as follows. The next section reviews the empirical literature on exchange rate determination. Section III provides a brief account of different approaches of exchange rate determination. Section IV describes the data and methodology employed. Section V presents the empirical results emerging from the study, and the last section provides conclusions that emerge from the study.

## LITERATURE REVIEW

There exists a rich literature on the validity of the PPP hypothesis. In general, studies have found evidence showing persistent deviations from PPP. Studies by Roll (1979), Frankel (1981, 1986), Adler and Lenmann (1983), Hakkio (1986), and Taylor (1988) fail to reject the hypothesis that real exchange rate follows a random walk. Studies, by Frankel and Mussa (1985) Edwards (1989), Roll (1979), and Pippenger (1982) reveal that deviations from PPP follow a random walk process which implies that the deviations from PPP are cumulative and permanent such that PPP does not hold. Studies by Abouf and Jorian (1990) find evidence that verifies long-run PPP based on multivariate unit root tests performed on first differences rather than levels. Cheung and Lai (1993) and Chen (1995) find some fragmented support for PPP based on co-integration analysis. Lothian and Taylor (1997), based on panel data, verified long-run PPP through use of multivariate unit root tests.

Cheung and Lai (1998) find evidence in favor of mean reversion using fractional cointegration. In short, empirical results from the past studies have been mixed and conflicting. Most studies concluded that PPP does not hold. Mark (1990) did not reject the null of a unit root and the null of no-cointegration. On the contrast Chen (1995) used monthly data from five European countries over the period 1973:4 - 1990:12 concluded that the PPP hypothesis is upheld. Taylor and Sarno (1988) using data for five developed countries over the period 1973 - 1985 did not reject the null hypothesis of no-cointegration between the nominal exchange rate and relative price levels. In a recent study, Feridun (2005) finds evidence that does not favor mean reversion in the log real exchange rates for the exchange rates US Dollar-French Franc, US Dollar- German Mark, and US Dollar-Great Britain Pound for both monthly and quarterly observations. Hence, the present study fails to verify PPP based on these three exchange rates. Hung and Jan

(2002) show that the PPP does not hold for most Asian markets. Montiel (1997); Baharaumshah and Ariff (1997); and Weliwita (1998) show non-stationary real exchange rate. Froot and Rogoff (1994); and Rogoff (1996) show a slow parity reversion. Kuo and Mikkola (1999); Glen (1992); and Lothian and Taylor (1996) reject the random walk hypothesis in the real exchange rate.

Meese and Rogoff (1983) show a contrary result to the theory of PPP; they conclude that the real exchange rate follows a random walk, implying that time series can fluctuate without bound. Some studies focus on the development of econometric models based on economic fundamentals. Mark (1995), MacDonald (1996), Uysal and Barty (1997), and Taylor and Peel (2000) attribute the predominant source of real exchange rate fluctuations to the effect of real disturbances. On the other hand, Michael et al. (1997), Taylor et al. (2000), and Taylor and Peel (2000) investigated the issue of nonlinear adjustments for exchange rate movements post-Bretton Woods era, which are beyond the scope of the present study.

## MODELS OF EXCHANGE RATE DETERMINATION

### The Balance of Payments Flow approach

Under the Balance of Payments Flow approach, the domestic price of a foreign currency is determined by the intersection of the market demand and supply curves for that foreign currency (Copeland, 2000). This approach models the demand and supply for foreign exchange as determined by the flows of currency created by international transactions. According to this model, the supply and demand for a currency arise from trade in goods and services, portfolio investment, and direct investment, that is, the flows related to the balance of payments. Equilibrium exchange rates are determined when the balance of payments is in equilibrium.

Exchange rates will move in response to a balance of payments imbalance and, therefore, will restore the equilibrium to the balance of payments. According to the model, a relative rise in domestic economic activity results in depreciation of the domestic currency, while a relative rise in domestic interest rates results in an appreciation of the domestic currency. Also, an expected appreciation of the domestic currency will result in an immediate rise in the domestic currency's value (Rosenberg, 1996).

### The Real Interest Rate Differentials and Monetary models

According to the real interest rate differential model, the real exchange rate between two countries can be explained by changes in real long-term interest rate differentials assuming that the uncovered interest rate parity

holds and the real exchange rate will adjust gradually to its long-run PPP equilibrium rate (Rosenberg, 1996). On the other hand, according to the Monetary Model of exchange rate determination, the exchange rate equals the ratio of the relative money stocks of two countries to relative money demands of these two countries.

### Purchasing Power Parity

The real exchange rate for country  $i$ , if defined with respect to the US Dollar as the numeraire currency, is constructed as:

$$Q_{it} = E_{it} (P_t^* / P_{it}) \quad (1)$$

where  $E_{it}$  is the nominal exchange rate,  $P_t^*$  is the US consumer price index (CPI) and  $P_{it}$  is the CPI for country  $i$ . According to PPP, in the absence of transportation costs, tariffs and other barriers to trade, and with free trade, the same good should cost the same across national boundaries. Markets enforce the law of one price, because the pursuit of profit tends to equalize prices of identical goods in different countries. Even though short run deviations from PPP may occur, the PPP relationship is expected to hold in the long run. Under absolute PPP the nominal exchange rate is proportional to a ratio of domestic to foreign price levels:

$$s_t = \alpha + \beta_0 p_t - \beta_1 p_t^* \quad (2)$$

where  $s_t$  is the nominal exchange rate, and  $p_t$ ,  $p_t^*$  are, respectively domestic and foreign prices, all measured in logs. Equation (4) is known as a trivariate relationship. A bivariate relationship between the nominal exchange rate and the domestic to foreign price ratio is given by:

$$s_t = \alpha + \beta (p_t - p_t^*) + u_t \quad (3)$$

This PPP framework does impose an a-priori restriction on the co-integrating vector. The difference between the PPP framework represented by equation (5) and (6), is that in the latter the symmetry condition on the price coefficients has been imposed. Another specification of PPP that is commonly used in unit root tests is given by

$$q_t = s_t - p_t + p_t^* \quad (4)$$

where  $q_t$  is the real exchange rate. The PPP equation (5) requires  $\beta = 1$ , this also implies  $\beta_1 = -\beta_0$ , which imposes the joint symmetry/proportionality restriction. Since all unit root tests on the real exchange rate assume implicitly that such a restriction holds, a failure of these tests to find evidence favoring mean reversion in the real exchange rate may be caused by a failure of such a restriction.

### DATA AND METHODOLOGY

The study used quarterly data from International Financial Statistics (IMFs) over the period 1976:1 to 2000:1. The data contain the nominal exchange rate defined as the market rate per U.S. dollar and the consumer price index. The nominal exchange rate is calculated between each tested country and base countries. For example the nominal exchange rate between Jordan and Japan and between Jordan and Germany is calculated using the cross-exchange rates ¥ - US\$, DM - US\$, and JDs - US\$.

It is important that variables that are non-stationary must be treated differently from those that are stationary, a series properties and behaviour can be influenced by its stationarity or otherwise. Many economists blame the failure to reject the null hypothesis of non-stationary real exchange rate on the short spans of data used for lack of power in the standard tests, as the Augmented Dickey-Fuller test (ADF), and Phillip-Perron test (PP). Diebold and Rudebusch (1991) conclude that the unit root tests proposed by Dickey and Fuller have low power against fractionally-integrated processes. Cheung and Lai (1993) using data for five developed countries over the period 1914 - 1989 show evidence of co-integration in Canada, France, and Italy. A very debatable issue arises from the use of standard tests compared to more powerful one, for example, Kwiatkowski; Phillips; Schmidt; and Shin (1992). Murray and Papell (2002) conclude that the confidence intervals are wide enough to be consistent with anything from models with nominal rigidities to models where PPP does not hold.

Recent studies blame the failure of the PPP on the lack of power in the standard tests. For example, Nusair (2003) using quarterly data from Indonesia, Korea, Malaysia, Singapore, the Philippines, and Thailand over the period 1973:2 - 1999:4 show that when using the ADF and PP unit root tests, strong evidence of stationary real exchange is found for only Indonesia, and weak evidence is detected for Korea and Thailand, but when using KPSS test, strong evidence of stationary real exchange is found for Indonesia, Korea, Malaysia, and Thailand. He concludes that PPP does hold in four out of the six Asian countries. Erlat (2003), did not favor absolute PPP hypothesis in its purest form, on the other hand he indicate that the absolute version of the "quasi" PPP hypothesis cannot be rejected.

This study aims to test the validity of PPP in Jordan, Egypt and Turkey over the period 1976 - 2000, using Germany, Japan, and United States of America as base countries. The study uses the standard unit root tests as the Augmented Dickey-Fuller test (ADF) and Phillips-Perron test (PP) to test the null hypothesis of non-stationary real exchange rate, also it uses more powerful tests as the Kwiatkowski, Phillips, Schmidt, and Shin test (KPSS) and Perron test to test the null of stationary real exchange rate.

This study proceeds as follows. In Section 2 we identified the source of data. Section 3 describes the methodology. Section 4 presents the empirical results. Section 5 is a general conclusion. The methodology used to test the validity of PPP in this paper is unit root tests; in particular the Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test, and the KPSS test. The ADF and PP unit root tests are used to test the null hypothesis of non-stationary real exchange rate against the alternative of stationarity, and the KPSS test is used to test the null hypothesis of stationary real exchange rate against the alternative of non-stationarity.

#### The ADF Unit Root test

Levin et al. (2002) indicate that when there is not enough time-series variation to produce good power in the ADF test, a relatively small amount of cross-section variation can result in substantial improvement.

The ADF test is estimated by the next model;

$$\Delta r_t = \mu + \delta t + \rho r_{t-1} + \sum_{j=1}^k \mu_j \Delta r_{t-j} + v_t \quad (8)$$

where  $k$  is the number of lags in the ADF test; to determine that the errors are white noise, a maximum number of 12 lags are used. If  $\rho$ , the coefficient of interest is  $\rho < 0$  then the real exchange rate is stationary.

**The PP Unit Root test**

In empirical studies, however, the null hypothesis of a unit root in the deviations from parity can often not be ruled out using ordinary testing procedures. Dumas (1992) consider models of real exchange rate determination which take transactions costs into account. They suggests that the larger the deviation from PPP, the stronger the tendency to move back to equilibrium. The result is a nonlinear, mean-reverting stochastic process.

The PP test is estimated by the next model

$$r_t = \theta_0 + \theta_1 \left(t - \frac{T}{2}\right) + \theta_2 r_{t-1} + \zeta_t \quad (9)$$

The test statistic  $Z(\theta_{i2})$  for the null hypothesis  $\theta_{i2} = 1$ . The number of lag truncation is controlled by Barlett Kernal spectral estimation method.

**The KPSS unit root test**

Followed by Kwiatkowski et al. (1992), to test null hypothesis of stationarity, the KPSS test is estimated by the next model;

$$y_t = \xi + V_t + \mathcal{E}_t \quad (10)$$

Where  $\mathcal{E}_t$  is a stationary process and  $V_t$  is a random walk given by:  $V_t = V_{t-1} + u_t$ , and  $u_t$  is assumed to be identically and independently distributed with zero mean and constant variance, the initial value  $V_0$  is fixed and serves as the intercept. The null hypothesis of trend stationarity is tested by estimating equation (3) as follows. Let  $\hat{\mathcal{E}}_t$ , for  $t = 1, 2, \dots, T$ , be the residuals from regressing the series  $y_t$  on intercept and trend, let  $S_t = \sum_{i=1}^t \hat{\mathcal{E}}_i$  be

the partial sum of residuals, and let  $\hat{\sigma}_\epsilon^2$  be the estimate of the error variance from regression (3), which is defined as the sum of

squared errors divided by  $T$ , that is.,  $\hat{\sigma}_\epsilon^2 = T^{-1} \sum_{t=1}^T \hat{\mathcal{E}}_t^2$ , then the

KPSS test ( $LM$ ) can be written as:

$$LM = \sum_{t=1}^T S_t^2 / \hat{\sigma}_\epsilon^2 \quad (11)$$

The null hypothesis of trend stationarity is accepted if the value of the KPSS test statistic is less than its critical value.

**EMPIRICAL RESULTS**

To test the null hypothesis of non-stationary real exchange rate, the real exchange rate is calculated as defined in equations (8) and (9) and are estimated with a constant and a time trend. The null hypothesis of stationary real exchange rate is tested using the KPSS test by estimating equation (9), and then calculating the test statistic in equation (10) to determine whether the real exchange rate series are stationary. Table 1 shows the percentage change in the nominal exchange rates and the price ratios for created sub-periods and for the entire period from 1976:1 to 2000:1. It is clear that in the long run the PPP does hold. For example, over the period 1976:1 - 2000:1, the price level increased to 44% relative to the US price level and the JDs depreciated against the US\$ by 115%. On the other hand during some created sub-periods the theory of PPP was violated implying that PPP does not hold in the short run. For example, over the period 1976:1 - 1980:1, the price level increased by 6.68% relative to the US price level. Instead of depreciating, as PPP theory suggests, the JDs increased as well by 9% against the US\$. Also over the period 1996:1 - 2000:1, the price level increased by 11% relative to the Japanese price level, the JDs increased by 1.17% against the Japanese Yen.

Table 2 shows that the null hypothesis of a unit root in the ADF and PP tests can not be rejected for all cases which show that the real exchange rate in Jordan is not stationary, which prove that the results are not sensitive to the choice of the three different base country. In other word, the real exchange rate is non-stationary. Also, Table 2 shows results of testing the null hypothesis of stationary real exchange rate using the KPSS test. There is evidence that the null hypothesis of trend stationary real exchange rate can not be rejected at the 5% significance level.

Table 3 shows the results of the confirmatory analysis for the nominal and real exchange rates in the three emerging countries, confirmatory analysis joins the null of a unit root and the null of stationarity together. The results show that stationarity is confirmed for the three countries since the null of a unit root is rejected and the null of stationarity is accepted.

**Conclusions**

Using the ADF and PP unit root tests, the null hypothesis of non-stationary real exchange rate can not be rejected for all cases implying that PPP fails to hold in Egypt, Jordan and Turkey. Using the KPSS test, the null hypothesis of trend stationary real exchange rate cannot be rejected for all cases indicating that the real exchange rate in Egypt, Jordan and Turkey is stationary if a trend is included. We conclude that PPP in Egypt, Jordan and Turkey is not sensitive to the choice of the base country

**Table 1.** Percentage change.

Time period	JDs/US\$1	JDs/DM1	JDs/¥1	P-US	P-GER	P-JA
1976:1 – 1980:1	-9.09	31.99	13.01	6.68	29.98	19.34
1980:1 – 1984:1	23.33	-19.14	30.03	-3.81	4.01	8.38
1984:1 – 1988:1	-8.10	47.68	65.79	-7.73	1.26	1.14
1988:1 – 1992:1	100	107.40	99.35	46.59	55.99	58.31
1992:1 – 1996:1	4.41	15.06	26.74	4.74	4.94	14.31
1996:1 – 2000:1	0.00	-11.45	-1.17	-0.96	3.23	10.97
1976:1 – 2000:1	115.15	233.09	507.88	43.97	131.36	152.49
Time period	EGP/US\$1	EGP/DM1	EGP/¥1	P-US	P-GER	P-JA
1976:1 – 1980:1	12.28	23.87	26.35	15.34	31.23	11.03
1980:1 – 1984:1	-32.01	-11.09	-24.39	-11.32	26.23	10.21
1984:1 – 1988:1	21.98	34.23	67.21	8.29	9.36	3.23
1988:1 – 1992:1	53.23	29.78	67.23	66.87	43.32	98.12
1992:1 – 1996:1	43.76	33.44	34.27	11.21	19.23	21.28
1996:1 – 2000:1	11.85	32.32	42.21	26.44	8.24	9.67
1976:1 – 2000:1	76.98	96.84	67.38	63.19	98.41	79.52
Time period	TRY/US\$1	TRY/DM1	TRY/¥1	P-US	P-GER	P-JA
1976:1 – 1980:1	11.93	28.21	22.87	10.28	32.11	27.09
1980:1 – 1984:1	32.85	56.93	43.90	65.37	37.89	21.07
1984:1 – 1988:1	17.57	24.45	37.12	16.83	42.64	3.43
1988:1 – 1992:1	14.67	17.99	32.67	65.71	43.89	26.59
1992:1 – 1996:1	22.78	43.69	54.99	21.09	11.91	17.44
1996:1 – 2000:1	32.33	21.11	29.72	12.33	13.23	12.98
1976:1 – 2000:1	43.33	23.99	57.48	66.99	76.39	54.21

**Table 2.** Unit root tests for log of the real exchange rate over the period 1976:1 - 2001:1.

Test statistic	The base country		
	U.S.	Germany	Japan
ADF test with trend/ JDs	-2.1816(1)	-1.5977(1)	-1.6939(1)
ADF test no trend/ JDs	-0.8468(1)	-0.7034(0)	-1.0758(0)
PP test with trend/ JDs	-2.0444(4)	-1.5334(4)	-1.5032(3)
PP test no trend/ JDs	-0.8735(4)	-0.9012(4)	-1.1078(2)
KPSS test with trend/ JDs	0.1260(7)**	0.1741(7)**	0.1501(7)**
KPSS test no trend/ JDs	1.1344(7)	0.8380(7)	1.1203(7)
Test statistic	U.S.	Germany	Japan
ADF test with trend/ EGP	-1.2872(1)	-2.7821(0)	-0.2102(2)
ADF test no trend/ EGP	-0.2132(1)	-2.3211(1)	-1.2182(0)
PP test with trend/ EGP	-0.9545(1)	-1.8291(2)	-1.6217(2)
PP test no trend/ EGP	-1.8534(2)	-1.9821(3)	-2.9021(2)
KPSS test with trend/ EGP	0.1371(7)**	0.1992(5)**	0.1210(6)**
KPSS test no trend/ EGP	2.2187(5)	1.1292(5)	2.2108(6)
Test statistic	U.S.	Germany	Japan
ADF test with trend/ TRY	-1.2112(0)	-1.7228(0)	-1.9858(1)
ADF test no trend/ TRY	-1.2096(1)	-1.9287(2)	-0.9757(1)
PP test with trend/ TRY	-1.2919(2)	-1.9289(2)	-1.5672(2)
PP test no trend/ TRY	-1.7625(1)	-0.9872(2)	-1.8728(2)
KPSS test with trend/ TRY	0.1928(5)**	0.1128(6)**	0.1391(6)**
KPSS test no trend/ TRY	0.3927(6)	1.3219(6)	1.8327(6)

\*\* denotes acceptance of the null hypothesis at the 5% significance level.

**Table 3.** Confirmatory analysis for the nominal and real exchange rates.

Country	Nominal exchange rate			Real exchange rate		
	$H_{ADF}$	$H_{KPSS}$	Result	$H_{ADF}$	$H_{KPSS}$	Result
Egypt	Reject	Accept	Stationary	Reject	Accept	Stationary
Jordan	Reject	Accept	Stationary	Reject	Accept	Stationary
Turkey	Reject	Accept	Stationary	Reject	Accept	Stationary

$H_{ADF}$  denotes the null hypothesis of a unit root with the ADF test.  $H_{KPSS}$  denotes the null hypothesis of level stationary with the KPSS test.

but can be influenced by the type of test. Confirmatory analysis for the nominal and real exchange rates in the three emerging countries confirmed stationarity.

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