Modeling purchasing power parity using co-integration: evidence from Turkey

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Modeling Purchasing Power Parity Using Co-integration: Evidence from Turkey

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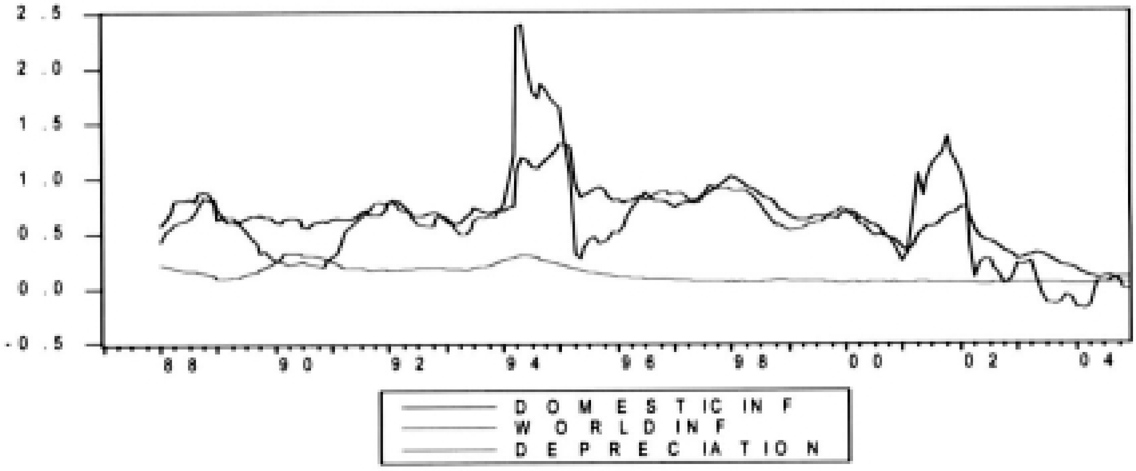
ABSTRACT

In this study, we consruct a co-integration model of the Turkish economy using high frequency data to examine the validity of the purchasing power parity (PPP) theory. The *ex-post* estimation results derived from the analysis of monthly observations for the January 1987 – December 2004 period generally support the use of the PPP theory in predicting the movement of currency values in the Turkish economy.The methodology developed in this study can be used in other countries to ensure the success of economic policies that depend on the existence of PPP relationship.

INTRODUCTION

During the 1990s, the Turkish economy endured a highly unstable growth performance with chronic double-digit inflation that impacted the course of many domestic macroeconomic aggregates (Ertuğrul and Selçuk, 2002: 13-40; Korap, 2006; and Saatçioğlu and Korap, 2006). Figure 1 below indicates that, beginning in 1989 when capital account liberalization was completed, to 1999, large differences between the domestic and foreign inflation rates existed, along with parallel movements between currency depreciation rates and domestic inflation. Given the observed behavior of the data in Figure 1 for DEPRECIATION (the annualized depreciation rate of nominal exchange rate of Turkish Lira (TL) / US$) versus the DOMESTICINF (the annualized inflation rate based on consumer price index (CPI)) and WORLDINF (the representative annualized CPI-based world inflation), an argument can be made for the existence of PPP relationships in the Turkish economy.

Figure 1: Data Characteristics



The data for domestic variables originate from the electronic data delivery system of the Central Bank of the Republic of Turkey (CBRT) and the sources for world price level and inflation are the IMF-IFS CD-ROM data base.

PURPOSE

Given the behavior of the variables in Figure 1, it is warranted to examine whether PPP relationships hold in the Turkish economy. To empirically analyze this proposition, we apply contemporaneous estimation techniques. If the results of our analyses are positive, policy makers can be confident of the success of economic programs they devise to manage domestic currency values and domestic inflation. In the following sections, an economic model is developed and used to empirically reveal the existence of PPP relationships in the Turkish economy. Finally, we present our conclusions and discuss future research opportunities.

A MODEL FOR TESTING THE EXISTENCE OF THE PPP HYPOTHESIS

We start by relating the PPP relationships to the law of one price. Froot and Rogoff (1994) express that for any good i,

$$p_t^d = p_t^f + e_t \qquad (1)$$

where p_t^d is the log of the domestic currency price of good i, p_t^f is the analogous foreign-currency price, and e_t is the log of the domestic currency price of foreign exchange, ensuring identical prices of unfettered trade in goods. Letting equation (1) hold for every individual good would lead to the assumption that it must hold for any identical basket of goods. Even if the law of one price fails for individual goods, it is possible that the deviations cancel out when averaged across a basket of goods (Froot and Rogoff, 1994). Moreover, adopting an international perspective generally allows the use of price indices from different countries with varying weights and mixes of goods across these countries, rather than using identical baskets, as hypothesized in the PPP theory. Finally, international price indices for identical baskets of goods can still be constructed for this purpose.

Relaxing the PPP Assumptions

Instead of using the absolute form of the PPP relationships in equation (1), we can develop a weak form of the PPP theory. Following Salvatore (1998: 466), the absolute PPP theory would give the exchange rate that equilibrates trade in goods and services while completely disregarding the capital account. A nation experiencing capital outflows would have a deficit in its balance of payments, while a nation receiving capital inflows would have a surplus if the exchange rate was the one that equilibrated international trade in goods and services. A second objection to the absolute PPP theorem comes from the assumption that this version of the PPP would not give the exchange rate that equilibrates trade in goods and services because of the existence of many non-traded goods and services whose prices in part depend on relative productivity levels (Jonsson, 2001: 247). Considering these deficiencies, the relative or weak form of PPP can be suggested to analyze the theory where the change in the exchange rate over a period of time would be proportional to the relative changes in the price levels in different countries over the same time period. In this sense, Taylor and Taylor (2004) express that the relative PPP would hold if the absolute PPP holds, but the absolute PPP does not necessarily hold when the relative PPP holds, since it is possible that common changes in nominal exchange rates may be happening at different levels of purchasing power of the currencies examined.

In addition, we can consider the pricing to market theory of Dornbusch (1985) and Krugman (1986) that examines why the import prices fail to fall in proportion to the exchange rate appreciation. The pricing to market theory emphasizes that, due to the imperfect competition problems, there is a price stickiness phenomenon in international trade. With constant elasticity of demand, producers who are monopolists or oligopolists working under imperfect competition conditions may charge different prices in different countries, while exchange rate changes would not cause fluctuations in relative prices charged (Obstfeld and Rogoff, 2000). This is possible because there are many industries that can supply separate licences for the sale of their goods at home and abroad (Sarno and Taylor, 2002: 70).

Empirical Flwas in Prior Studies

Taylor (2000) considers methodological problems in prior studies such as employing low frequency data and linear model specification. As a result, such studies do not empirically support the PPP theory since such specification problems can lead to bias towards findings of slow convergence of real exchange rates to the long run equilibrium.

Thus, the existence of a long run equilibrium relationship between the domestic price level, nominal (spot price of) exchange rate, and the foreign price level, all expressed in logarithms and with statistically significant *a priori* signs, would give support to the absolute PPP theory. Froot and Rogoff (1994) and Taylor (1996) emphasize that an obvious problem with equation (1) above is that exchange rates and prices might reasonably be considered endogenous and are simultaneously determined, and so there is no compelling reason to put exchange rates on the left hand side, rather than vice-versa. In this sense, single equation results may be seriously misleading due to a simultaneity bias and / or invalid conditioning (Gökcan and Özmen, 2001). The other requires that contemporaneous time series estimation techniques be employed to test the PPP hypothesis, considering the integration properties of the relevant variables to search for a valid long run relationship constructed by means of economic theory.

Two Methods to Test for the PPP Relationships

If there is a co-integrating relationship such as equation (1) in which all the variables are integrated at order 1, their combinations constructing real exchange rate (re_t) in equation (2) below should not follow a random walk process. Instead, the relationship should be stationary or has a mean-reverting process that is equal to a constant. Otherwise, the presence of unit roots in the real effective exchange rate series leads us to reject the validity of the PPP theory and determine that price stabilization programs will be ineffective at the macroeconomic level (Yıldırım, 2003: 7).

Alternatively, following Cashin and McDermott (2003: 323-324) and Civcir (2002), we can use the half-life of real exchange rate shocks to test the validity of the PPP theory. Thus, rather than using conventional analyses testing whether the real exchange rate shocks are mean-reveting or not, we now focus on measuring the duration of the shocks to the real exchange rate and characterize the extent of parity reversion in terms of estimates of half-life of deviations from the PPP, where the half-life is defined as the time required for half the magnitude of a unit shock to the level of a series to dissipate. If the real exchange rate shock dissipates with more than a 5-year half-life, this would indicate a lack of PPP relationships and a low convergence speed in real exchange rates (Chen and Engel, 2004).

Thus, concentrating on the contemporaneous co-integration analysis of testing the PPP theory using these two estimation methods, unitary coefficients resulting from the likelihood ratio (LR) tests would lead us to accept the evidence in favor of the strong form of the PPP relationships to hold in the long run. To compare the results of these two tests, we follow Froot and Rogoff (1994) and assume that the unit root testing procedure for the PPP relationships determines whether the real exchange rate in equation 2 below is stationary,

$$re_t \equiv e_t - p_t^d + p_t^f \qquad (2)$$

while the co-integration approach asks whether $e_t - \mu^* p_t^d + \mu^* p_t^f$ is stationary for any constant μ and μ^*. Thus, for the latter approach we relax the symmetry and proportionality restrictions that $\mu = \mu^* = 1$. Alternatively, these special cases can be tested in a co-integration analysis with appropriate restrictions using LR tests (Metin, 1994; Telatar and Kazdağlı, 1998: 51-53; Gökcan and Özmen, 2001; Civcir, 2002; Yazgan, 2003: 143-147; Erlat, 2003: 70-97; Yıldırım, 2003: 3-14; and Özdemir, 2004: 243-265).

EXAMINING THE EXISTENCE OF THE PPP RELATIONSHIPS IN TURKEY

We now contruct an empirical model for the Turkish economy to examine the existence of the PPP theory using monthly data for the period of January 1987 – December 2004. We use a variaty of econometric procedures available in the program EViews 5.1. The data we use are taken form the electronic data delivery system of the CBRT for domestic variables and from the IMF-IFS CD-ROM data base for foreign price level information.

Following Johansen and Juselius (1992: 211-244), we indicate seasonally unadjusted values in natural logarithms.

For the domestic price variable, the Turkish consumer price (p^d) index data with the base year 1987: 100 are used. In theory, the choice of benchmark country for foreign price level (p^f) should be immaterial for the PPP relationship. However, the choice matters in practice due to, for instance, unusual swings of the currency considered for this variable during the model estimation period. The solution is to set the benchmark in relation to a world-average basket of currencies (Taylor, 1996). For this purpose, we employ the wholesale world CPI based price index taken from IMF-IFS CD ROM database using series code 00164...ZF... The spot exchange rate of TL / US$ is taken into account for the exchange rate variable. We also add eleven centered seasonal dummies which sum to zero over a year as an exogenous variable. Thus, the linear term from the dummies disappears and is taken over completely by the constant term, and only the seasonally varying means remain (Johansen, 1995: 84).

Time Series Properties of the Variables Used

The next step in our econometric analysis is to investigate the time series properties of the variables. Granger and Newbold (1974: 111-120) indicate the occurrence of the spurious regression problem when using non-stationary time series causing unreliable correlations within the regression analysis. First, by using the augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests, we compare the ADF and PP statistics obtained with the MacKinnon (1996: 601-618) critical values available in EViews 5.1. For the case of stationarity, we expect that these statistics are larger than the MacKinnon critical values in absolute value and that they have a minus sign. Although differencing eliminates the trend, we report the results of the unit root tests for the first differences of the variables with a linear time trend in the test regression in Table 1 below. For the MacKinnon critical values, we consider 1% and 5% level critical values for the null hypothesis of the existence of a unit root. The numbers in parentheses are the lags used for the ADF stationary tests and augmented up to a maximum of 12 lags using monthly observations, and we add a number of lags sufficient to remove serial correlation in the results, while the Newey-West bandwidths are used for the PP test. The choice of the optimum lag for the ADF test is decided on the basis of minimizing the Schwarz Information Criterion (SC). The symbols '*' and '**' indicate the rejection of a unit root for the 1% and 5% levels, respectively.

Table 1: Unit Root Tests (assuming constant & trend)

Variable	ADF test (in levels)	PP test (in levels)	ADF test (in first differences)	PP test (in first differences)
p^d	2.2286 (2)	2.6679 (2)	-8.8767 (0)*	-9.1818 (15)*
p^f	-0.2483 (2)	-0.2483 (2)	-3.7190 (12)**	-7.4122 (4)*
e	0.2054 (1)	0.6404 (4)	-9.1385 (0)*	-9.0005 (4)*

Test Critical Values	ADF and PP
1% level	-4.001516
5% level	-3.430963

Examining the results of the unit root tests, we see that the null hypothesis that there is a unit root cannot be rejected for all the variables using constant & trend terms in the test equation in the level form. Inversely, for the first differences of all variables the null hypothesis of a unit root is strongly rejected. So we accept that all the variables contain a unit root, that is, they are non-stationary in their level forms, but stationary in their first differenced forms, thus enabling us to test for co-integration.

Determining Co-integration

As a third step, we examine whether the variables used are co-integrated with each other. Engle and Granger (1987: 251-276) indicate that even though economic time series may be non-stationary in their level forms, there may exist some linear combination of these variables that converge to a long run relationship over time. If the series are individually stationary only after differencing, a linear combination of their levels may still be stationary demonstrating that the series are co-integrated. That is, they cannot move too far away from each other in a theoretical sense (Dickey, et al, 1991: 58). For this purpose, we estimate a VAR-based co-integration relationship using the methodology developed in Johansen (1995) in order to specify the long run relationships between the variables considered making use of EViews 5 User's Guide by QMS (2004: 735-748). Let us assume a vector autoregression (VAR) of order p,

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bx_t + \varepsilon_t \tag{3}$$

where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables such as constant term, linear trend, seasonal dummies, and crisis variables and ε_t is a vector of innovations, i.e. independent Gaussian variables with mean zero and variance Ω. Such exogenous variables are often included to take account of short run shocks to the system, such as policy interventions and shocks or crises which have an important effect on macroeconomic conditions. It is worth noting that including any other dummy or dumy-type variable will affect the underlying distribution of test statistics, so that the critical values for these tests are different depending on the number of dummies included (Haris, 1995: 81). We can write this VAR as,

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \tag{4}$$

where:

$$\prod_{i=1}^{p} = \Sigma\, \mathrm{A}_i - \mathrm{I} \qquad\qquad \Gamma_i = - \sum_{j=i+1}^{p} \mathrm{A}_j \tag{5}$$

Granger represetation theorem asserts that if the coefficient matrix Π has a reduced rank $r < k$, then there exist kxr matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is I(0). The rank r is the number of co-integrating relations and each column of β is the co-integrating vector. The elements of α are known as the adjustment parameters in the vector error correction (VEC) model and measure the speed of adjustment of particular variables with respect to a disturbance in the equilibrium relationship. Johansen's method is to estimate the Π matrix from an unrestricted VAR and to test whether we can reject the restrictions implied by the reduced rank of Π.

This method performs better than other estimation methods even when the errors are non-normal distributed, the dynamics are unknown, and the model is over-parameterized by including additional lags in the error correction model (Gonzalo, 1994: 225). Also the model does not suffer from the problems of normalization. Thus, we first determine the lag length of our unrestricted VAR model for which the maximum lag number selected is 12 based on the monthly frequency data used. Next, we consider sequential modified LR statistics employing

Sims' small sample modification. This approach compares the modified LR statistics to the 5% critical values starting from the maximum lag, and decreases the lag one at a time until the first rejection is obtained (QMS, 2004: 709). In our case, reduction of the system to 11 lags is accepted with an LR statistic of 2.952014, but reduction to 10 lags is first rejected with an LR statistic of 17.58262.

Determining Long-Run Co-integration Relationships

Fourth step is to estimate the long run co-integrating relationship between the variables by using two likelihood test statistics offered by Johansen and Juselius (1990: 169-210). These procedures determine the maximum eigenvalue for the null hypothesis of r versus the alternative of $r+1$ co-integrating relationships and trace for the null hypothesis of r co-integrating relations against the alternative of k co-integrating relations, for $r = 0, 1, \dots, k-1$ where k is the number of endogenous variables. Table 2 reports the results of Johansen Co-integration Test using max-eigen (λ max) and trace (λ trace) tests based on the critical values taken from Osterwald-Lenum (1992: 461-472) and on more recent p-values from MacKinnon, et al (1999: 563-577), also available from the VAR and COINT procedures in EViews 5.1.

For the co-integration test, we restrict the intercept and trend factors into our long run variable space, assuming that the trend factor can include the effects of other factors which are not considered in our co-integrating analysis. At this point we follow Pantula (1989: 256-271) principle also used by Johansen (1992: 383-397) and Harris (chapter 5) who suggest the need to test the joint hypothesis of both the rank order and the deterministic components, and the former tries to demonstrate how to use the tables in Johansen and Juselius (1990: 169-210) for conducting inference about the co-integration rank. After normalizing the co-integrating vector using the domestic price level to give the variables economic meaning, both the trace and max-eigen statistics in Table 2 jointly indicate one co-integrating vector in the long-run variable space.

Equation (6) below describes the normalized co-integrating vector relationship between the domestic and foreign price level and the exchange rate (standard errors in ( ) & t-statistics in [ ]),

$$p^d = -7.418175 + 1.022819\, e + 1.900940\, p^f - 0.021264@TREND(87M1) \quad (6)$$

$$\begin{array}{ccc} (0.14411) & (0.28155) & (0.00747) \\ [7.09728] & [6.75172] & [2.84553] \end{array}$$

All the signs match *a priori* expectations and have statistical significance. A one-to-one relationship exists between the domestic price level and the spot price of the nominal exchange rate. Such a finding is also verified when we apply a -1 homogeneity restriction between these variables and obtain a $\chi^2(1) = 0.0130119$, with a probability of 0.909158, a result which cannot reject the null of homogeneity.

Thus, estimation results in our paper give support to the use of the PPP theory in managing the Turkish economy. In addition, the significant adjustment coefficients given in Table 2 below verify the co-integrating relationship between these variables such that the deviations from equilibrium can be corrected by constructing vector error correction models transferring the long-run knowledge from the co-integrating space to these variables. Finally, system diagnostic tests in Table 3 below reveal that the use of high frequency data ensures that no serial correlation problem occurs for the 12^{th} degree estimates and non-normality for residuals creates no problem in our model (Gonzalo, 1994: 203-233).

Concluding Comments and Suggestions for Future Research

This study investigates whether the PPP relationships are valid for the Turkish economy. Considering high frequency data for the period of Januay 198 – December 2004 and applying a contemporaneous co-integration estimation methodology reveal that there exists a significant, one-to-one relationship between the domestic price level and the spot value of nominal exchange rate. However, the same relationship between the domestic price level and the foreign price level is rejected using homogeneity restrictions, although the predicted relationship equation has the correct *a priori* signs. Thus, we give support to the proposition that the PPP theory is valid for the Turkish economy.

The CBRT can be confident that its economic stabilization programs will be successful, especially when focused on lowering the domestic inflation rate through the management of the foreign exchange rates. Future studies may examine the time series characteristics of the real exchange rate indices used by the CBRT. A finding that the series are of stationary would give support to the results obtained in this study.

Table 2: Rank Test Assuming Linear Deterministic Trend Restricted in Co-integrating Space

Null Hypothesis	$r = 0$	$r \leq 1$	$r \leq 2$
Eigenvalue	0.168175	0.062942	0.043479
λ trace	59.89328	22.33021	9.068218
0.05 Critical Value	42.91525	25.87211	12.51798
Prob.	0.0005 (*)	0.1297	0.1762
λ max	37.56306	13.26199	9.068218
0.05 Critical Value	25.82321	19.38704	12.51798
Prob.	0.0009	0.3073	0.1762

Both Trace and max-eigenvalue tests indicate 1 co-integrating equation at the 0.05 level

(*) denotes rejection of the hypothesis at the 0.05 level

Unrestricted co-integrating coefficients

p^d	e	p^f	@TREND(87M02)
7.036131	-7.196689	-13.3526	0.149615
2.063689	1.734807	2.231040	-0.163111
14.77402	-11.91691	-3.799435	-0.120539

Unrestricted adjustment coefficients (alpha)

D(p^d)	-0.006128	0.000647	-0.000218
D(p^f)	-0.010018	0.001949	0.006416
D(e)	-0.000627	-0.000727	-7.92E-05

One co-integrating equation(s) (standard error in parentheses)

p^d	e	p^f	@TREND(87M02)
1.000000	-1.022819	-1.900940	0.021264
	(0.14411)	(0.28155)	(0.00747)

Adjustment coefficients (standard error in parentheses)

D(p^d)	-0.043114 (0.00779)
D(e)	-0.070489 (0.02170)
D(p^f)	-0.004413 (0.00181)

Multivariate statistics for testing stationarity

Variable	p^d	e	p^f
$\chi^2(2)$	28.53248	22.68232	8.950347
p-value	0.000001	0.000012	0.011388

Table 3: Vector Diagnostic Tests

VEC Residual Serial Correlation LM Test (probabilities: chi-square tests with 9 d.o.f.)

H0: no serial correlation at lag order h

Lags	LM-Stat	Prob.
12	12.41122	0.1905

VEC Residual Normality Test

H0: residuals are multivariate normal

Skewness	$\chi^2(3) = 178.2255$	Prob. 0.0000
Kurtosis	$\chi^2(3) = 1646.123$	Prob. 0.0000
Jarque-Bera	$\chi^2(6) = 1824.349$	Prob. 0.0000

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