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Abstract

This study finds that Purchasing Power Parity holds in the long-run for Azerbaijan, Kazakhstan and Kyrgyzstan, based on Breitung's (2001) rank tests for cointegration. Results from further analysis indicates that nominal exchange rates and relative prices are nonlinearly interrelated. Trade barriers, transportation costs and government intervention in the pricing system in these countries may have resulted in the establishment of the above-mentioned nonlinear relationship.

Keywords: Purchasing power parity; Cointegration; Nonlinear; Rank tests; Central Asia.

JEL classification: C14; F31.

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Long-run validity of purchasing power parity and rank tests for cointegration for Central Asian Countries[1]

I. Introduction

The existence of long-run relationship between nominal exchange rate and relative price, as postulated by the Purchasing Power Parity (PPP) hypothesis, has been extensively investigated over the past three decades. The attractiveness of testing this hypothesis is that it may provide useful guidelines for economic agents. For instance, the validity of PPP hypothesis reflects well-integrated goods markets and henceforth suggesting the non-existence of arbitraging opportunity between the domestic and foreign countries. Besides, the validity of PPP enables the prediction of long-run exchange rate movement via PPP model or its extended monetary models.

Previously, most studies are conducted using data from a substaintially large range of developed and developing countries; see Taylor (2003), Taylor and Taylor (2004) and Taylor (2006). Recently, Doğanlar (2006) for the first time in the literature, contributes to the discussion by examining the various versions of PPP formulations for Central Asian countries (Azerbaijian, Kazakhstan and Kyrgyztan), which have undergone transitional economy system and thereby trade structure since the broke up of the Soviet Union in 1991. Based on various well-accepted methodologies including the Engle and Granger (1987) test, Johansen (1988, 1991) multivariate cointegration test, fully modified OLS (FOLS) procedure of Phillips and Hansen (1990), as well as the more recently available autoregressive distributived lag (ARDL) technique of Pesaran and Shin (1999), the author was unable to reject the null hypothesis of no cointegration (implying no long-run

[1] Forthcoming in *Applied Economics*.

relationship) between nominal exchange rate and relative prices in all the Central Asian countries under study[2].

The author pointed out that, trade barriers, transportation costs and government intervention in the pricing system, among others, may have resulted in the non-establishment of the long-run PPP in these countries. In this conjunction, theoretical discussion and empirical evidence in the recent literature overwhelmingly suggest that market frictions and government intervention have resulted in nonlinear PPP relationship[3]. Since the tests applied in Doğanlar (2006) are capable of detecting linear relationship only, the non rejection of the null hypothesis show two possibilities. First, these variables move independently. Second, these variables exhibit long-run relationship in nonlinear adjustment[4]. However, it is unknown which case is true here. Consequently, it is natural to extend the study of Doğanlar (2006) using techniques that can distinguish nonlinear from linear cointegration relationship. Motivated by the above concerns, this

[2] Taylor (1988), Taylor and McMahon (1988) and Mark (1990) are among the first studies to test for long-run PPP using the most recently available unit root (residual-based test for cointegration) and multivariate cointegration tests in the late 1980s. There is a general understanding that the power of these tests may be low in the context of short-span of data (Taylor and Taylor, 1994). In this respect, Diebold *et al.* (1991), and Lothian and Taylor (1996, 1997, 2000) are examples of attempts to improve the power of unit root tests for long-run PPP by using long-span of data.

[3] In this regard, nonlinear adjustment in real exchange rate (which implies nonlinear adjustment of exchange rate towards PPP equilibrium) could arise be due, among others, market frictions (Obstfeld and Taylor, 1997; Ma and Kanas, 2000), costs of arbitrage in international goods (see, e.g. Dumas, 1992; Juvenal and Taylor, 2008), the effects of official foreign exchange rate intervention (see, Sarno and Taylor, 2001; Taylor, 2004; Taylor, 2006; Neely and Taylor, 2007; Reitz and Taylor, 2008) or perhaps the effects of the use of technical analysis in the foreign exchange market (see, e.g. Allen and Taylor, 1990; Kilian and Taylor, 2003; Sager and Taylor, 2006; Menkhoff and Taylor, 2007).

[4] Recently, it has been argued that these linear testing procedures may be defective should the PPP holds with nonlinear adjustment (see, for instance, Taylor and Peel, 2000). Evidences of nonlinear adjustment of real exchange rates are provided by Taylor and Peel (2000), Taylor *et al*. (2001), Kilian and Taylor (2003), Liew *et al*. (2003, 2004, 2008), Anuruo *et al*. (2006), and Lothian and Taylor (2008), to name some.

study attempts to revisit the long-run validity of PPP hypothesis for the Central Asian countries considered in Doğanlar (2006) using the rank tests due to Breitung (2001)[5].

The organisation of this paper is as follows. Section II outlines the rank tests for cointegration and for neglected nonlinearity. Section III presents the data and empirical results. The final section concludes this study.

II. Econometric Techniques

This study tests for the long-run relationship between nominal exchange rate (e_t) and relative price (r_t) using the following bivariate rank test statistics proposed by Breitung (2001)[6]:

$$B_1^* = \frac{\sup_{1<t<T} |d_t|}{T\hat{\sigma}_{\Delta d}} \quad \text{and} \quad B_2^* = \frac{\sum_{t=1}^{T} d_t^2}{T^3 \hat{\sigma}_{\Delta d}^2}, \tag{1}$$

where e_t is defined as domestic price of foreign currency (US dollar, USD) and r_t the relative price measured as the ratio of domestic consumer price index (CPI) to foreign CPI. $d_t = R(e_t) - R(r_t)$, for $R(x_t) = \text{Rank of } x_t \text{ among } (x_1, x_2, ..., x_T)$ where T is the sample size and $x_t = \{e_t, r_t\}$. Meanwhile, $\hat{\sigma}_{\Delta d}^2 = T^{-2} \sum_{t=1}^{T} (d_t - d_{t-1})^2$ serves to adjust for possible correlation between the two series of interest.

[5] Briefly, Breitung (2001) proposes two kinds of rank tests, one for the detection of cointegration, and the other one to distinguish linear from nonlinear relationship if cointegration exists.

[6] These tests had been for the first time adopted by Liew *et al*. (2008) to provide evidence supportive of nonlinear PPP for the East Asian economies.

A multivariate version of Breitung's (2001) rank test statistic of the following specification is also employed in this study:

$$B_3^*[k] = T^{-3}\sum_{t=1}^{T}(\tilde{u}_t^R)^2 / \hat{\sigma}_{\Delta\tilde{u}}^2, \qquad (2)$$

where $\tilde{u}_t^R = R(e_t) - \tilde{b}R(r_t)$, in which $\tilde{b}$ is the least squares estimates from a regression of $R(e_t)$ on $R(r_t)$, and $\tilde{u}_t^R$ are the estimated residuals. k is one less the number of variables in which the long-run relationship is tested for. In present case, k=1. $\hat{\sigma}_{\Delta\tilde{u}}^2 = T^{-2}\sum_{t=2}^{T}(\tilde{u}_t^R - \tilde{u}_{t-1}^R)^2$ to circumvent the possible correlation among the variables.

According to Breitung (2001), the sequences of $R(e_t)$ on $R(r_t)$ tend to diverge if there is no cointegration (long-run relationship) between e_t and r_t, whereas the sequences of ranks evolve similarly under cointegration. The null hypothesis of no cointegration between on e_t and r_t is rejected if these tests statistics are smaller than their respective critical values, available in Table 1 of Breitung (2001).

If on e_t and r_t are cointegrated, the linearity nature of the cointegration relationship may then be determined upon estimating the following regression:

$$\tilde{u}_t = c_0 + c_1 r_t + c_2 R(r_t) + \upsilon_t \qquad (3)$$

where $\tilde{u}_t$ stands for the residuals of regressing e_t on a constant and r_t, and compute the score test statistic $T \cdot R^2$, where R^2 is the coefficient of determination of Equation 3. The null hypothesis of linear relationship may be rejected in favor of the alternative hypothesis of nonlinear relationship if the computed statistic exceeds the χ^2 critical values with one degree of freedom.

$B_3^*[k]$ can be extended to test for the long-run relationship among nominal exchange rate, domestic and foreign prices (p_t and p_t^* respectively), where $\tilde{u}_t^R = R(e_t) - \tilde{b}_1 R(p_t) - \tilde{b}_2 R(p_t^*)$ in Equation 2, in which $\tilde{b}_1$ and $\tilde{b}_2$ are the least squares estimates from a regression of $R(e_t)$ on $R(p_t)$ and $R(p_t^*)$, and k=2.

Accordingly, the linearity of the cointegration relationship in this case is obtained by estimating the following regression and compute for the score statistic as in Equation 3:

$$\tilde{u}_t = c_0 + c_1 p_t + c_2 p_t^* + c_3 R(p_t) + c_4 R(p_t^*) + v_t \qquad (4)$$

where $\tilde{u}_t$ stands for the residuals of regressing e_t on a constant, p_t and p_t^*[7].

[7] To deal with plausible serially correlated errors and endogenous regressors, residuals $\tilde{u}_t$ in Equations 3 and 4 are estimated using the Dynamic OLS procedures of Stock and Watson (1993), see Breitung (2001) for the details.

III. Empirical Results

Following the novel study of Doğanlar (2006), this study employs monthly data spanning from 1995:1 to 2002:12 for Azerbaijan, Kazakhstan, Kyrgyztan and USA. The required USD-denominated nominal exchange rates and CPIs are taken from International Financial Statistics of the International Monetary Fund. The results of the Breitung cointegration tests are reported in Table 1. It is evident from Table 1 that the null hypothesis of no cointegration between exchange rate and relative price can be rejected by the B_2^* bivariate rank test statistic at conventional significant levels in all the Central Asian countries under consideration. The $B_3^*[1]$ multivariate rank test statistic also supported the finding of significant cointegration relationship between exchange rate and relative price for the case of Kazakhstan and Kyrgyzstan. Note that B_2^* and $B_3^*[1]$ tests are anologue to the testing of Equation 3 in Doğanlar (2006), which indicates that nominal exchange rate is determined by relative price. Thus, in sharp contrast to the finding obtained from conventional methodologies applied by Doğanlar (2006), the rank tests of Breitung (2001) is able to detect the long-run relationship between exchange rate and relative price in these Central Asian countries.

As for the long-run relationship among exchange rate, domestic price and foreign price as specified by Equation 4 in Doğanlar (2006), it can be seen from the $B_3^*[2]$ test statistic of Table 1 that such relationship exists in the case of Kazakhstan only. This is again in contrast to the finding of no such relationship in all the countries considered by Doğanlar (2006).

It is suspected that the long-run relationship detected in this study are nonlinear in nature. In this regard, the rank test for nonlinearity is conducted for those countries whereby such relationship are found. The results obtained are summarised in Table 2. It is clear from Table 2 that the null hypothesis of linear long-run relationship has been rejected in favor of the alternative hypothesis of nonlinear long-run relationship at 1% significant level for all the countries whereby long-run relationship has been found from the rank tests for cointegration method. This finding of long-run nonlinear PPP may explain the finding of no cointegration relationship between nominal exchange rate and relative prices as reported in Doğanlar (2006), which adopts various cointegration tests that implicitly assume linear PPP relationship.

IV. Conclusions

In a novel study, Doğanlar (2006) tests the long-run validity of PPP hypothesis for Azerbaijian, Kazakhstan and Kyrgyzstan using four types of cointegration tests. None of the tests results show any cointegration relationship between exchange rate and relative price for these Central Asian countries. It is argued that Doğanlar's (2006) finding implies either the variables move independently or they exhibit long-run relationship in nonlinear adjustment. Since there are reasons and evidences from elsewhere to suggest that exchange rate and relative prices may be nonlinearly interrelated, this study revisits the long-run validity of PPP for the three countries using the rank tests for cointegration techniques of Breitung (2001), which can detect PPP relationship, in linear and nonlinear nature. The results obtained provide some clear evidence of nonlinear PPP relationship for these countries. In conclusion, this study provides some evidence to show that PPP

holds for the Central Asian countries after accounting for nonlinearity. Trade barriers, transportation costs and government intervention in the pricing system as discussed in Doğanlar (2006) may have resulted in the establishment of the long-run nonlinear PPP in these countries.

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Table 1
Results of rank tests for cointegration

Country	Variables: e_t, r_t			Variables: e_t, p_t, p_t^*
	Bivariate Rank Test (Autocorrelation Adjusted)		Multivariate Rank Test (Autocorrelation Adjusted)	Multivariate Rank Test (Autocorrelation Adjusted)
	B_1^*	B_2^*	$B_3^*[1]$	$B_3^*[2]$
Azerbaijian	0.3258**	0.0187**	0.0634	0.2550
Kazakhstan	0.4397	0.0107***	0.0178**	0.0113***
Kyrgyzstan	0.5017	0.0144**	0.0236*	0.1427
Critical Values				
10%	0.3941	0.0232	0.0248	0.0197
5%	0.3635	0.0188	0.0197	0.0165
1%	0.3165	0.0130	0.0130	0.0119

Notes: e_t, r_t p_t and p_t^* denote nominal exchange rate, relative price, domestic price and foreign price respectively.
***,**,* Significant at 1,5 and 10% levels respectively.

Table 2
Results of rank test for neglected nonlinearity

Country	Variables: e_t, r_t	Variables: e_t, p_t, p_t^*
	$T \cdot R^2$ (Lag)	$T \cdot R^2$ (Lag)
Azerbaijian	93.4120 (12)***	n.r.
Kazakhstan	94.8458 (12)***	95.4945 (8)***
Kyrgyzstan	95.3300 (12)***	n.r.

Notes: e_t, r_t p_t and p_t^* denote nominal exchange rate, relative price, domestic price and foreign price respectively.
n.r. stands for not relevant as no cointegration exists.
Lag denotes optimum lag selected by Akaike Information Criterion (AIC).
Critical values for 10, 5 and 1% are 2.71, 3.84 and 6.63 respectively.
*** Significant at 1% level.

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