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Revisiting Purchasing Power Parity for Central Asian Countries Using Threshold Cointegration Tests

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Abstract

This study finds evidence supportive of the Purchasing Power Parity for Azerbaijan and Kazakhstan using threshold cointegration tests. This finding suggests the existence of an asymmetry relationship between exchange rate and relative prices. The asymmetric relationship may be due to the heavily regulated price and exchange rate systems in these transition economies for the benefits of trade competiveness.

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I. Introduction

The long-run relationship between nominal exchange rate and relative price postulated by the Purchasing Power Parity (PPP) hypothesis has been extensively examined by cointegration and unit root tests[1]. Today, literature on the study of PPP using data from developed and developing economies is voluminous[2]. Relatively, data on less developed and transition economies are rarely applied (Doğanlar, 2006; Bahmani-Oskooee and Hegerty, 2009)[3]. Doğanlar (2006) filled up this literature gap by examining the long-run validity of the PPP hypothesis for three selected Central Asian transition economies. For this purpose, a wide range of cointegration techniques including the residual-based test for cointegration method proposed by Engle and Granger (1987), fully modified OLS procedure due to Phillips and Hansen (1990), autoregressive distributive lag (ARDL) approach postulated by Pesaran and Shin (1999), and Johansen (1988, 1991) multivariate cointegration technique, have been included in Doğanlar (2006) to test the long-run validity of the various versions of the PPP hypothesis for Azerbaijan, Kazakhstan and Kyrgyzstan. Upon a throughout investigation, Doğanlar (2006) obtained results that uniformly indicate no long-run relationship between exchange rate and relative price levels, and subsequently the author contended that the PPP hypothesis was not upheld for all the three transition economies. Using several improved versions of the Dickey-Fuller type unit root tests, which are not included in Doğanlar (2006), namely, the DF-GLS test of Elliot *et al.* (1996), the panel unit root tests of Maddala and Wu (1999) and Choi (2001), as well as the nonlinear unit root of Kapetanios *et al.* (2003), this stduy still find no supportive evidence for the PPP hypothesis[4].

Note that all those adopted tests assumed a symmetrical relationship between exchange rate and relative prices by construction. In this conjunction, although there has been a widely-held belief of the symmetrical adjustment dynamics of nominal exchange rate towards the PPP equilibrium (see, for instance, Baum *et al.*, 2001), there is no reason to pre-assume that the PPP equilibrium relationship, if any, must exist in a symmetrical fashion. In fact, it had been shown in Enders and Dibooglu (2001) and Liew (2004) that such adjustment process is asymmetry in nature. Liew (2004) asserted that the responses of market adjustment mechanism towards over-valuation and under-valuation of nominal exchange rates as compared to the PPP equilibrium follow asymmetric path. Besides, Enders and Dibooglu (2001) argued that asymmetric adjustment could be primarily due to prices that are sticky in the downward direction.

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[1] See Taylor (1988), Taylor and McMahon (1988) and Mark (1990) for the earliest applications of the unit root and multivariate cointegration tests introduced in the late 1980s.

[2] Taylor (2003; 2006), among others, contain a comprehensive survey on PPP study and Taylor (2009) overviews the most recent empirical evidence on the PPP hypothesis.

[3] See Bahmani-Oskooee and Hegerty (2009) for an excellence survey of PPP study in less developed and transition economies.

[4] These additional results are reported in the next section.

In addition, Enders and Granger (1998) demonstrated that conventional unit root and cointegration tests have low power in the presence of asymmetric adjustment. Furthermore, the above-mentioned tests are parametric in nature in which their results are dependent on the specification of the test. In sharp contrast, based on nonparametric tests, Liew *et al.* (2009) were able to provide evidence supportive of the PPP hypothesis for these countries. Therefore, it is possible that the unfavourable results from the transition economies are due to the negligence of asymmetric adjustment in the specification of the testing procedures.

The purpose of this study is to re-investigate the long-run relationship between nominal exchange rate and relative prices for the above transition economies, by taking into the account of asymmetric adjustment. For this purpose, the Threshold Autoregressive (TAR) and Momentum-TAR (M-TAR) cointegration tests for unit root postulated by Enders and Granger (1998) are employed in this study[5].

This paper is organised as follows. The following section provides more results from symmetric unit root tests. Section III discusses the methodology employed in this study and the results obtained. Section IV contains our concluding remarks.

II. Additional Results from Symmetric Unit Root Tests

Doğanlar (2006) adopted a wide range of symmetric unit root tests but was unable to identify any long-run validity of the various versions of the PPP hypothesis for Azerbaijan, Kazakhstan and Kyrgyzstan. This section reports the failure of other additional symmetric unit root tests in revealing supportive evidence for the PPP hypothesis. In line with Doğanlar (2006) and Liew *et al.* (2009), this study employs monthly data spanning from 1995:1 to 2002:12 for Azerbaijan, Kazakhstan, Kyrgyzstan and USA. The required USD-denominated nominal exchange rates and Consumer Price Indices as proxy of price levels are taken from *International Financial Statistics* published by the International Monetary Fund. The real exchange rate series is derived from the equation: $lnRER_t = lnNER_t + lnP_t^* - lnP_t$, where *NER* is the nominal exchange rate and P refers to the general price level. The asterisk (*) indicates the foreign component, whereas the subscript t shows that the value of the variable is time-dependent. The resultant series, which depict nonlinear feature, are plotted in Figure 1.

[5] These tests are based on the threshold autoregression (TAR) model first introduced by Tong and Lim (1980). The model is able to capture a smooth and asymmetric adjustment towards equilibrium. See also Enders and Dibooglu (2001) for the application of these tests in the European countries.

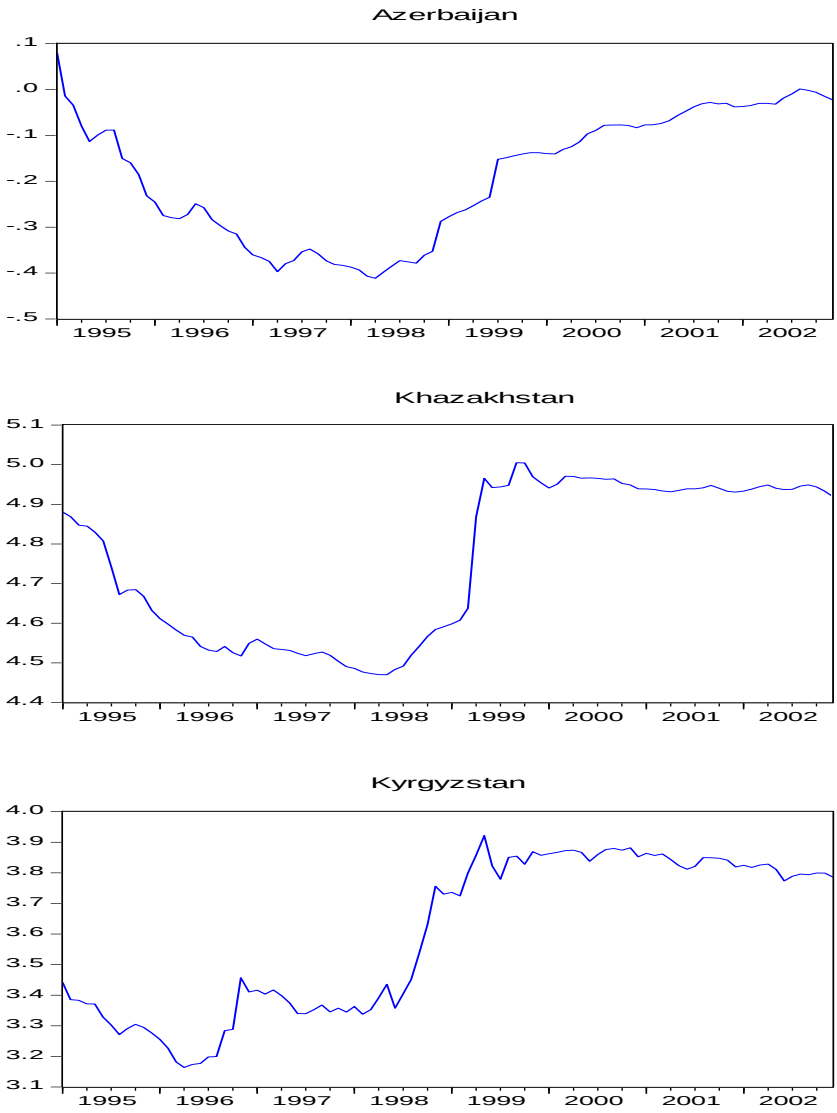

Figure 1. Real Exchange Rates (in Natural Logarithm)

Results from several improved versions of Dickey-Fuller type unit root tests, which are not included in Doğanlar (2006), namely, the DF-GLS test of Elliott *et al.* (1996), the panel unit root tests of Maddala and Wu (1999) and Choi (2001), as well as the nonlinear unit root of Kapetanios *et al.* (2003) are reported in this section.

Elliott *et al.*, (1996) proposed to extract the constant and trend effects from the series of interest using the general least squares (GLS) method, prior to the estimation of the Dickey and Fuller (1979) test, yielding the so-called DF-GLS test. It has been shown that the DF-GLS test has the best overall performance in terms of small-sample size and power, dominating the ordinary Dickey-Fuller test (Baum, 2001; Vougas, 2007). Vougas (2008) further demonstrated that the DF-GLS test has good size even when there is a

neglected level or trend break under the null hypothesis. The DF-GLS test is applied on the real exchange rate series of Azerbaijan, Kazakhstan and Kyrgyzstan in this study and the results are reported in Table 1. Table 1 shows that none of the series is stationary based on this test, implying no evidence of long-run relationship between nominal exchange rates and relative prices of the three countries under consideration.

Table 1. The DF-GLS Test Results

Country	Intercept	Intercept + Linear Trend
Azerbaijan	-0.714(1)	-0.744(1)
Kazakhstan	-0.866(2)	-1.087(2)
Kyrgyzstan	-0.343(0)	-1.236(0)
Critical Value		
1%	-2.59	-3.61
5%	-1.94	-3.05
10%	-1.61	-2.76

Notes: The optimal lag order k given in parentheses is determined based on AIC. Critical values are provided by MacKinnon (1996).

Recently, many empirical evidences, for example, van Dijk and Franses (2000), Sarno (2000), Baum *et al.* (2001), Shively (2005), Baillie and Kilic (2006), and etc, showed that financial time series are mostly nonlinear in nature. To cater for nonlinearity, Kapetanios *et al.* (2003) extended the DF and ADF unit root tests by allowing for nonlinear adjustment. It is shown in Table 2 that there is still no evidence favoring the PPP hypothesis although nonlinear adjustment in exchange rate has been taking into estimation.

Table 2. The Kapetanios *et al.* (2003) Nonlinear Unit Root Test Results

Country	Intercept	Intercept + Linear Trend
Azerbaijan	-1.487(12)	-1.711(12)
Kazakhstan	-1.203 (5)	-1.617(5)
Kyrgyzstan	-1.997(6)	-3.271(6)
Critical Value		
1%	-3.48	-3.93
5%	-2.93	-3.40
10%	-2.66	-3.13

Notes: The optimal lag order k is determined based on AIC. The p-value is bootstrapped from 1999 replications with sample size of 96 observations in each replication.

Having considered nonlinearity, we next examine the PPP hypothesis using panel unit root tests, which have been shown to outperform univariate unit root tests when the sample period is short. Besides, Holmes (2002) also reported that panel unit root tests exploit the cross-country variations of the data in estimation, and therefore they can yield higher test power than univariate unit root tests. Two of these tests due to Maddala and Wu (1999) and Choi (2001) are employed and the results as shown in Table 3 reveal evidence against the PPP hypothesis, however.

Table 3. The Panel Unit Root Tests Results

	Individual Effects		Individual Effects + Linear Trends	
Individual Country	*t*- statistic	*p*-value	*t*- statistic	*p*-value
Azerbaijian	-0.938 (2)	0.772	-2.866 (2)	0.178
Kazakhstan	-0.859 (2)	0.797	-2.371 (2)	0.390
Kyrgyzstan	-0.666 (0)	0.849	-1.640 (0)	0.770
Panel	Test Statistic	*p*-value	Test Statistic	*p*-value
ADF - Fisher Chi-square[a]	1.298	0.972	5.854	0.440
ADF - Choi Z-stat[b]	1.507	0.934	-0.267	0.395

Notes: Null hypothesis: Unit root (assumes individual unit root process). The optimal lag order *k* given in parentheses is determined based on AIC. [a] See Maddala and Wu (1999).
[b] See Choi (2001).

All-in-all, this section shows that using symmetric unit root tests, the findings of no supportive evidence for the PPP hypothesis in Doğanlar (2006) cannot be overthrown even though the GLS, nonlinear and panel unit root tests, which have improved power and size compared to conventional unit root tests are employed.

III. Threshold Cointegration Tests and Findings

To cater for asymmetric adjustment, Enders and Granger (1998) generalized the Dickey-Fuller test to consider the null hypothesis of a unit root against the alternative hypothesis of a Threshold Autoregressive (TAR) model or Momentum-TAR (M-TAR) model. This Enders-Granger test can be specified as:

$$\Delta z_t = \rho_1 z_{t-1} I_t + \rho_2 z_{t-1}(1 - I_t) + \sum_{i=1}^{k} \alpha_i \Delta z_{t-i} + \varepsilon_t \qquad (1)$$

where z_t is demeaned or/and detrended of real exchange rate[6], $y_t = \ln(q_t) + \ln(p_t^*) - \ln(p_t)$, where q_t represents the nominal exchange rate defined as the price of foreign currency in domestic term, whereas p_t^* and p_t are foreign and domestic price levels respectively.

[6] To accommodate stochastic processes with nonzero or/and linear deterministic trends.

I_t is an indicator function that assumes the value of one if $\mu_{t-1} \geq \tau$, and zero if $\mu_{t-1} < \tau$, where $\mu_{t-1}=\{z_{t-1}, \Delta z_{t-1}\}$ and τ is the threshold value which governs the adjustment dynamic.

Suppose $\mu_{t-1} < \tau$, the indicator function $I_t = 0$, such that

$$\Delta z_t = \rho_2 z_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta z_{t-i} + \varepsilon_t, \quad (2)$$

and if $\mu_{t-1} \geq \tau$, $I_t = 1$ so that

$$\Delta z_t = \rho_1 z_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta z_{t-i} + \varepsilon_t. \quad (3)$$

Depending on specification of μ_{t-1}, the test is capable of detecting cointegration with TAR (when $\mu_{t-1}=z_{t-1}$) and M-TAR (when $\mu_{t-1}=\Delta z_{t-1}$) adjustments.

Equation (1) encompasses two conventional augmented Dickey-Fuller (ADF) unit root tests, specified in Equations (2) and (3). The principle of the Enders-Granger test is that if ρ_1 and ρ_2 are simultaneously zero, the series is non-stationary (random walk). The null hypothesis of $\rho_1 = \rho_2 = 0$ may be tested by the Φ test statistic, which follows a non-standard *F* distribution. If the unit root hypothesis is rejected, the series is assumed to be stationary (mean-reverting), implying long-run relationship between exchange rate and relative price with asymmetric adjustment.

The results of TAR and M-TAR tests are reported in Tables 4 and 5 respectively. These tables reveal that the null hypothesis of no cointegration can be rejected in favor of the alternative hypothesis of long-run cointegration with asymmetrical adjustment at 10% significance level for Azerbaijan based on both tests, whereas rejection of the null hypothesis for Kazakhstan is provided by the M-TAR test. It is possible that our results detect price and exchange rate regulation favoring trade competitiveness in the individual economies, so much so that asymmetric responds are given to over-valuation and under-valuation of nominal exchange rates[7]. As for Kyrgyzstan, in contrast to Liew *et al.* (2009) that employed nonparametric tests, no cointegration are detected by the parametric tests applied in this study. Interested researchers could explore the nature of cointegration relationship by taking up other specifications in their tests.

[7] High extend of government intervention in the pricing and exchange rate systems are typical in transition economies (Doğanlar, 2006; Bahmani-Oskooee and Hegerty, 2009).

Table 4. The TAR Test Results

Country	Threshold, τ	Φ statistic	p-value
Azerbaijan	0.044	6.952 (6)	0.068
Kazakhstan	-0.041	3.758(5)	0.280
Kyrgyzstan	0.025	2.570(6)	0.153

Notes: The optimal lag order k reported in parentheses is determined based on AIC, see Enders and Dibooglu (2001). The p-value is bootstrapped from 1999 replications with sample size of 96 observations in each replication.

Table 5. The M-TAR Test Results

Country	Threshold, τ	Φ statistic	p-value
Azerbaijan	-0.003	4.612(12)	0.038
Kazakhstan	0.011	35.678(12)	0.000
Kyrgyzstan	0.044	4.608(4)	0.205

Note: See Table 4.

IV. Concluding Remarks

Overall, the current study demonstrates that unit root tests which do not consider asymmetric adjustment failed to find long-run relationship between nominal exchange rate and relative prices for the three Central Asian transition economies[8]. Instead, evidence of long-run relationship with asymmetric adjustment could be found by the Threshold cointegration tests of Enders and Granger (1998) for Azerbaijan and Kazakhstan. This study contributes to the literature by uncovering evidence favoring the PPP hypothesis for these two economies with unit root tests that allow for asymmetric adjustment. Our finding has important policy implications for the transition economies.

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[8] By controlling for the sample period of study, this study is able to convincingly show that the failure of the detection of PPP in Doğanlar (2006) was due to the fact that asymmetric tests were not adopted in it. This study applies additional tests (nonlinear and panels, which are not considered in Doğanlar, 2006) and the results are consistent with Doğanlar (2006). It is only when asymmetric tests are further applied in this study that PPP could be detected.

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