



Munich Personal RePEc Archive

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

Liew, Venus Khim-Sen ; Chia, Ricky Chee-Jiun and Ling, Tai-Hu

Universiti Malaysia Sarawak, Universiti Malaysia Sabah,
Universiti Malaysia Sabah

2009

Online at <http://mpra.ub.uni-muenchen.de/15794/>
MPRA Paper No. 15794, posted 18. June 2009 / 12:12

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

Venus Khim-Sen Liew^{a,b,*}, Ricky Chee-Jiun Chia^b and Tai-Hu Ling^b

^a *Department of Economics, Faculty of Economics and Business, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia.*

^b *Labuan School of International Business and Finance, University Malaysia Sabah, Jalan Sungai Pagar, 87000 Labuan, Malaysia.*

This version: 16 January, 2009.

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.

* Corresponding author. Department of Economics, Faculty of Economics and Business, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia. E-mail address: venusliew@yahoo.com Tel.: +6082582415; fax: +6082671794.

Long-run validity of purchasing power parity and rank tests for cointegration for Central Asian Countries¹

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 substantially 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 (Azerbaijan, 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 distributed 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 study².

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 relationship³. 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 adjustment⁴. 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.* \(2003, 2004, 2008\)](#), [Anurao *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:

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

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 $R(x_t) = \text{Rank of } x_t \text{ among } (x_1, x_2, \dots, x_T)$ 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:

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

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:

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

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:

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

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, Kyrgyzstan 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 analogue 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 Azerbaijan, 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.

Acknowledgements:

The authors are thankful to an anonymous referee and an editor for constructive comments and encouragement on the earlier draft of this paper. Full responsibility for any errors that may remain rests on the authors.

References:

Anoruo, E., Liew, V.K.S. and Elike, E. (2006) Nonlinear real exchange rate behavior: are the african currencies exceptional? *International Research Journal of Finance Economics*, 1, 97 – 110.

Breitung, J. (2001) Rank tests for nonlinear cointegration. *Journal of Business and Economic Statistics*, 19, 331 – 340.

Doğanlar, M. (2006) Long-run validity of purchasing power parity and cointegration analysis for Central Asian countries. *Applied Economics Letters*, 13, 457 – 461.

Dumas, B. (1992) Dynamic equilibrium and the real exchange rate in a spatially seperated world. *Review of Financial Studie*, 5, 153–180.

Engle, R.F. and Granger C.W.J. (1987) Cointegration and error correction: representation, estimation, and testing. *Econometrica*, 55, 251 – 276.

Johansen, S. (1988) Statistical analysis on cointegration vectors. *Journal of Economic Dynamics and Control*, 12, 231 – 254.

Johansen, S. (1991) Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica*, 59, 1551 – 1581.

Liew, V.K.S. (2004) Nonlinear Adjustment of ASEAN-5 Real Exchange Rates: Symmetrical or Asymmetrical? *Economics Bulletin*, Vol. 6 No. 8, 1 – 8.

Liew, V.K.S., Baharumshah, A.Z. and Chong, T.T.L. (2004) Are Asian Real Exchange Rates Stationary? *Economics Letters*, 83, 313 – 316.

Liew, V.K.S., Chong, T.T.L. and Lim, K.P. (2003) Inadequacy of linear autoregressive model for real exchange rates: empirical evidence from Asian economies, *Applied Economics*, 35, 1387 – 1392.

Liew, V.K.S., Lee, H.A. and Lim, K.P. (2008) Purchasing power parity in Asian economies: further evidence from rank tests for cointegration. *Applied Economics Letters*, 1-4 iPrint, DOI: 10.1080/13504850601032057.

Ma, Y. and Kanas, A. (2000) Testing for nonlinear Granger causality from fundamentals to exchange rates in the ERM. *Journal of International Financial Markets, Institutions and Money*, 10, 69 – 82.

Pesaran, H.M. and Shin, Y. (1999) An autoregressive distributed lag modelling approach to cointegration analysis. In: S. Storm, ed., *The Econometrics and Economic Theory in the 20th Century*. Cambridge: Cambridge University Press.

Phillips, P.C.B. and Hansen, B.E. (1990) Statistical inference in instrumental variable regression with $I(1)$ processes. *Review of Economic Studies*, 57, 99 – 125.

Stock, J.H. and Watson, M.W. (1993) A simple estimator of cointegrating vectors in higher order integrated systems. *Econometrica*, 61, 783 – 820.

Taylor, A.M. and Taylor, M.P. (2004) The Purchasing power parity debate. *Journal of Economic Perspectives*, 4, 135 – 158.

Taylor, M.P. (2003) Purchasing power parity. *Review of International Economics*, 11, 436–452.

Taylor, M.P. (2006) Real exchange rates and purchasing power parity: mean reversion in economic thought. *Applied Financial Economics*, 16, 1–17.

Taylor, M.P. and Peel, D.A. (2000) Non-linear adjustment, long-run equilibrium and exchange rate fundamentals, *Journal of International Money and Finance*, 19, 33 – 53.

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^*	$B_3^*[1]$	$B_3^*[2]$
Azerbaijani	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
<i>Critical Values</i>				
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)
Azerbaijani	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.

Bertola, G. and Svensson, L.E.O. (1993) Stochastic devaluation risk and the empirical fit of target zone models, *Review of Economic Studies*, **60**, 689–712.

Dumas, B. (1992) Dynamic equilibrium and the real exchange rate in a spatially separated world, *Review of Financial Studies*, **5**, 153–180.

Obstfeld, M.. and Taylor, A.M. (1997) Nonlinear aspects of goods-market arbitrage and adjustment: Heckscher's commodity points revisited, *Journal of the Japanese and International Economies*, **11**, 441–479.