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## **TESTING FOR PURCHASING POWER PARITY FOR SELECTED CIS COUNTRIES USING THE SIEVE BOOTSTRAP**

### **Abstract:**

Purchasing power parity (PPP) is widely discussed theory to explain the determination of exchange rates. PPP implies a long-run relationship between the nominal exchange rate and the relative price levels. PPP holds in the long run once the real exchange rate is a stationary process. This study examines the validity of PPP for Commonwealth of Independent States (CIS) namely Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Russia and Ukraine for the period 1995M1-2015M11. In this study we perform stationary test on three bases. In the first place, we initiate conventional unit root tests such as ADF and KPSS. Secondly, we utilize unit root tests allowing for structural break. Last but not least, we use a sieve bootstrap unit root test to avoid possible discrepancies between the actual and nominal rejection probabilities in hypothesis testing of unit root. In conclusion unit root test results performed show that there is a large disagreement on the validity of PPP in CIS countries. Given the span and characteristics of the period which involves a significant break such as 1998 Russian economic crisis, we conclude that PPP holds for Armenia, Belarus, Kazakhstan and Kyrgyzstan, while it does not hold for Azerbaijan, Russia and Ukraine.

### **Keywords:**

Purchasing Power Parity; Real Exchange Rate; Transition Economies

**JEL Classification:** C12, C15, F31

## Introduction

Purchasing power parity (PPP) is one of the important theories of exchange rate determination in international economics. The law of one price, which argues that any homogenous commodity must be having the same price anywhere under perfect competition, is the basic foundation of PPP. Combining these two, it is possible to express the following generalized proposition: “if purchasing power of any two countries is the same, then exchange rate between currencies of these two countries would be in equilibrium” (Sarno and Taylor, 2003). Testing the validity of PPP is of critical importance not only for international monetary economy but also in terms of political issues. As the validity of this hypothesis is directly associated with exchange rate parity and adjustment of exchange rate policy, its importance extends to many financial stability plans, structural adjustment policies and economic reform programs.

There is a great deal of literature on PPP and some of the studies with the several methodologies have implemented to test the validity of PPP in the long run. A large variety of unit root tests has been employed to test this hypothesis. A real exchange rate turning back to a constant average is consistent with PPP, whereas PPP does not hold in case of a non-stationary real exchange rate. If real exchange rate is constant, then it does not move off the average value, making PPP hypothesis valid (Sarno and Taylor, 2003). It is evident that applied researches have not yet reached to a consensus on validity of PPP hypothesis. Depending on the econometric tools and data ranges used, the results may vary. Moreover, co-integration tests are also employed to test long-term validity of PPP. These tests investigate the co-integration relationship between nominal exchange rate and domestic and overseas prices. The existence of co-integration relationship indicates the validity of PPP hypothesis. This study has an effort to present the details of most recent studies that use contemporary economic techniques.<sup>1</sup>

Several empirical studies have implemented to test the validity of PPP hypothesis for CIS countries. CIS' liberalization programs started in the early 1990s. Most countries dealt with the drastic increases in budget deficits, debts and inflation. Several institutional and structural adjustments that occurred in transition countries have undergone several phases of economic changes. Economy was depended on heavy industry and monopolistic firms and international trade was formed by state agreements under the socialist model. In the process of transformation there were differences between countries (Fisher and Gelb, 1991). Donnorummo (2006) indicate that three factors are very important for the success of transition process including historical background and circumstances, policies and the presence or absence of military conflicts. As Commonwealth of Independent States (CIS)' countries are in the

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<sup>1</sup> For detailed discussions of the theoretical and empirical aspects of PPP and the real exchange rate, please see the works of MacDonald and Taylor (1992), Taylor (1995), Rogoff (1996), Taylor and Sarno (1998), Doğanlar (1999), Lothian and Taylor (2000), Sarno and Taylor (2002), Taylor (2004), Taylor and Taylor (2004), and the references cited there in.

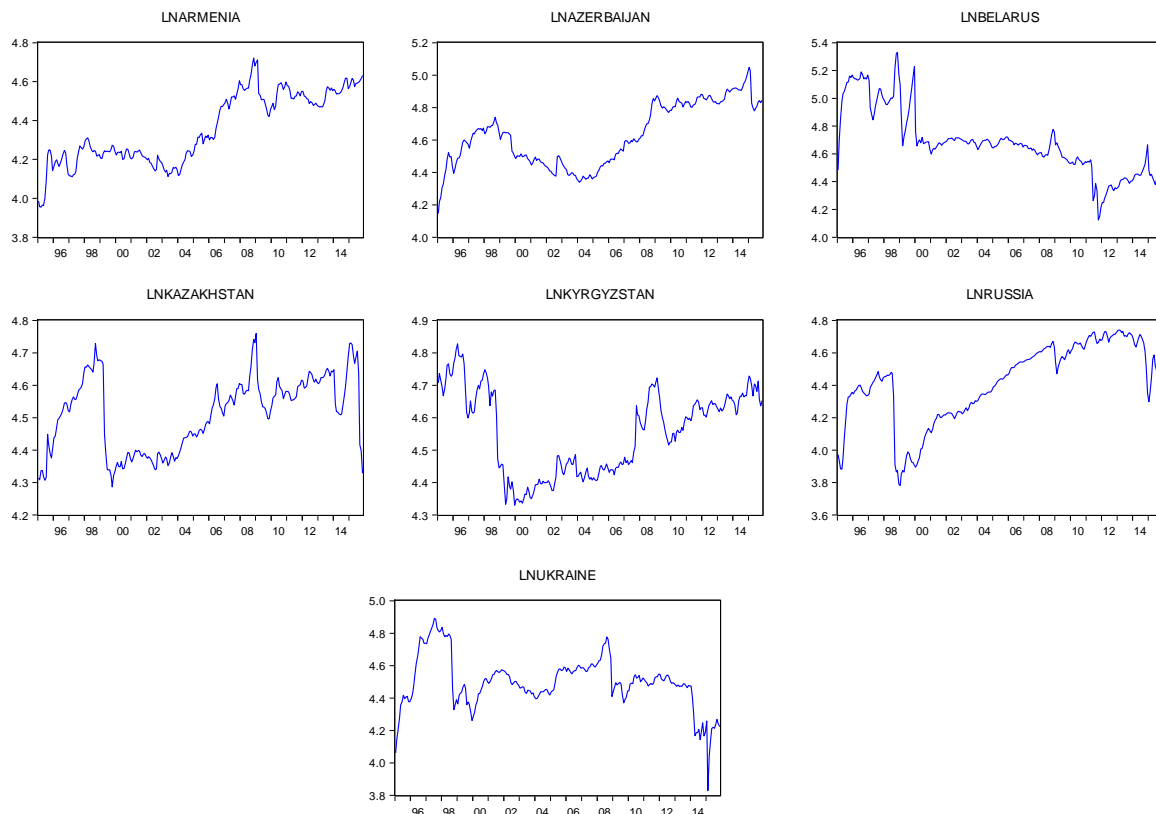
process of transition for the market economy it is important to examine whether PPP holds for these countries because of its economic implications.

Empirical evidence on the stationarity of real exchange rates for transition economies is abundant and the results are mixed. The most common approach in testing the PPP hypothesis is to utilize the unit root test(s) on the real exchange series. Choudhry (1999) found some evidence to support relative PPP for Russia and Slovenia. Barlow (2003) found mixed results for Poland, the Czech Republic and Romania. Acaravci and Ozturk (2010) found weak evidence to support long-run PPP for eight transition countries. He et al. (2013) found that PPP does not hold for Hungary, the Czech Republic and Russia. Lu et al. (2012) found an evidence of PPP for Estonia, Hungary, Poland, Romania and Russia. Teletar and Hasanov (2009) found evidence that support PPP for CIS economies. Varamini and Lisachuk (1998) found some evidence in favor of PPP for Ukraine. Solakoglu (2006) found that PPP holds for Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia and Ukraine. Doğanlar (2006) found no evidence for PPP for Azerbaijan, Kazakhstan and Kyrgyzstan countries. Apergis (2003) found no evidence in favor of PPP for Armenia. Sideris (2006) found no evidence for Belarus, Georgia, but weak evidence for Moldova, Russia and Ukraine. Chang et al. (2011) found evidence in favor for PPP for Bulgaria, the Republic of Czech, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Russia. Hung and Weng (2011) found significant support for the PPP for Azerbaijan, Kyrgyzstan and Kazakhstan.

The paper is organized as follows. The next section presents data and empirical methodology, the third concludes.

## **Data**

Real exchange rate in logarithmic terms for the period 1995M1-2015M11. Figure 1 shows the real effective exchange rate series of countries.

**Figure 1. The real effective exchange rate series of countries.**

## Empirical Results

As the empirical strategy, we utilize from three unit root tests. Firstly we perform ADF as a conventional unit root test. Secondly, we apply a sieve bootstrap unit root test proposed by Psaradakis (2001). As the final tool of our empirical strategy we check stationary condition of the series using Zivot-Andrews, allowing for single endogenous structural break.

ADF test can be performed by using the models

$$\text{Model A: } \Delta Y_t = \phi_1 + \delta Y_{t-1} + \phi_3 t + \sum_{i=1}^m \alpha_i \Delta Y_{t-i} + u_t$$

$$\text{Model B: } \Delta Y_t = \phi_1 + \delta Y_{t-1} + \sum_{i=1}^m \alpha_i \Delta Y_{t-i} + u_t$$

$$\text{Model C: } \Delta Y_t = \delta Y_{t-1} + \sum_{i=1}^m \alpha_i \Delta Y_{t-i} + u_t$$

In investigating the validity of PPP hypothesis for the selected countries, we focus on the models testing whether the series can be characterized as a random walk with or without drift. Therefore our primary concern is on whether  $\delta = 0$  in Model B and Model C. However, for the sake of illustration we estimate both model A, B, and C. In ADF test we follow methodology proposed by Enders (2008). To this end, first we consider the significance of autoregressive coefficient  $\delta$  in model B. If the null of unit root is not rejected, we proceed to test the joint hypothesis that  $\delta = 0, \phi_1 = 0$ .

If this null is rejected, then we retest the hypothesis  $\delta = 0$  using standardized normal distribution and base our comments on the stationarity of the series on model B. However, if this null cannot be rejected, we rule out model B, and estimate model C. The critical values used in the test with the standardized normal distribution are -2.33, -1.65 and -1.28 for 1%, 5% and 10% significance levels, respectively.

Besides, in Psaradakis' unit root approach we also use the same model forms to conclude about the presence of stationarity of the series and depend on model B and C. In this approach we generate sample specific critical values at the conventional significance levels using the empirical distribution of the series.

**Table 1. ADF unit root test results**

Series	ADF							
	Model A			Model B			Model C	
	k	t	$f_3$	k	t	$f_1$	k	t
<i>Armenia</i>	1	3.321587***	5.614914*	1	-2.039123	2.874868	1	1.169128
<i>Azerbaijan</i>	1	-2.149752	2.452847	1	-1.890132	2.425057	1	1.045866
<i>Belarus</i>	1	5.624488***	15.88718***	2	-1.956007	2.037149	2	-0.592162
<i>Kazakhstan</i>	1	-2.628709	4.120754	1	-2.853103***	4.070123*	1	-0.077101
<i>Kyrgyzstan</i>	1	-2.318541	3.243985	1	-2.130657	2.285914	1	-0.237597
<i>Russia</i>	2	-2.643301	4.073448	2	-2.567490	3.510037	2	0.508145
<i>Ukraine</i>	1	3.537640***	7.188504**	1	-2.814644***	3.965078*	1	-0.008925

Critical Values for Phi-3 test; 8.43; 6.34; 5.39, for Phi-1 test; 6.52; 4.63; 3.81. Standardized Normal Critical Values; -2.33; -1.64; -1.28, for 1%, 5%, and 10% significance levels, respectively.

Table 1 shows ADF unit root test results. According to the results, null of unit root cannot be rejected Armenia, Azerbaijan, Belarus, Kyrgyzstan and Russia in Model B and C. In other words, ADF test results reveal that PPP hypothesis is invalid for these countries. On the other hand, we can reject the null of unit root in model B for Kazakhstan and Ukraine with 99% confidence with a significant intercept. This finding indicates that PPP hypothesis holds for both Kazakhstan and Ukraine.

**Table 2. Psaradakis (2001) unit root test results**

		Psaradakis (2001)								
		Model A			Model B			Model C		
Series	Specification	k	t	Critical values	k	t	Critical Values	k	t	Critical Values
<i>Armenia</i>	<i>AR(1)</i>	1	-3.321587*	-4.751832; -3.711193; -3.226008	1	-2.039123	-4.444999; -3.368404; -2.816921	1	1.169128	-1.889907; -1.317952; -0.9984735
<i>Azerbaijan</i>	<i>AR(1)</i>	1	-2.149752	-4.920612; -3.806716; -3.131115	1	-1.890132	-3.883651; -2.580477; -2.07753	1	1.045866	-2.159047; -1.519781; -1.200079
<i>Belarus</i>	<i>AR(1)</i>	1	-5.624488***	-5.597821; -4.288301; -3.708578	2	-1.956007	-5.483197; -3.864789; -3.138044	2	-0.592162	-1.979964; -1.461504; -1.212556
<i>Kazakhstan</i>	<i>AR(1)</i>	1	-2.628709	-4.087898; -3.229033; -2.833489	1	-2.853103*	-4.234049; -3.163724; -2.696258	1	-0.077101	-1.808483; -1.289222; -1.0028
<i>Kyrgyzstan</i>	<i>AR(1)</i>	1	-2.318541	-3.206393; -2.701993; -2.475054	1	-2.130657	-3.322288; -2.743603; -2.478055	1	-0.237597	-2.02482; -1.431106; -1.139933
<i>Russia</i>	<i>AR(2)</i>	1	-3.249277	-5.817855; -4.552358; -3.883074	1	-2.754597	-5.118003; -4.079603; -3.579606	1	0.356705	-1.729952; -1.282173; -1.022883
<i>Ukraine</i>	<i>AR(1)</i>	1	-3.537640*	-4.513953; -3.645032; -3.216405	1	-2.814644	-5.43442; -4.415866; -3.817888	1	-0.008925	-1.881457; -1.406518; -1.121764

Table 2 shows Psaradakis (2001) Unit Root Test results. In the testing procedure, we first start with specifying AR structure of the series based on Schwarz Information Criteria and use it as a sieve to resample the centralized residuals by which we obtain bootstrapped versions of the original series by recursive substitution. For this purpose, we created 10000 bootstrap replications and calculate  $(\delta^* - 1)/se(\delta^*)$  and derive corresponding distribution for each series. Critical values columns in Table 2 indicate the value of test statistics corresponding to 1%, 5%, and 10% quantile of these distributions. The test results show that PPP hypothesis does not hold for all countries except for Kazakhstan.

**Table 3. Zivot Andrews Unit Root Test results**

Zivot Andrews Unit Root Test						
Breaks	Level		Trend		Level and Trend	
Series	t	Break Date	t	Break Date	t	Break Date
<i>Armenia</i>	-5.533847***	2006M05	-3.797635	2002M04	-5.522717**	2006M06
<i>Azerbaijan</i>	-4.349027	1999M10	-4.120241*	2003M03	-4.381391	2006M06
<i>Belarus</i>	-7.443736***	2000M01	-6.508886***	2001M01	-7.423735***	2000M01
<i>Kazakhstan</i>	-4.585058*	1999M04	-3.073511	2000M07	-5.161477**	1999M04
<i>Kyrgyzstan</i>	-6.156461***	1998M10	-4.574669**	1999M12	-6.574509***	1998M10
<i>Russia</i>	-4.190356	1998M08	-3.533145	1998M10	-3.901653	1998M08
<i>Ukraine</i>	-4.505130	2005M04	-4.138607*	2012M06	-4.472501	2005M04

Table 3 shows Zivot Andrews unit root test results. In this test we consider the model A taking a single endogenous break in level of the series. According to test results, we cannot reject the null of unit root for Azerbaijan, Russia and Ukraine. This implies that PPP hypothesis does not hold in these countries even after allowing a break in level of the real effective exchange rates series of these countries. On the hand, we find evidence in favor of the validity of PPP for Armenia, Belarus, Kazakhstan and Kyrgyzstan. The break dates for all countries are generally clustered around 1998 Russian economic crisis.

## Conclusion

This study examines the validity of PPP for Commonwealth of Independent States (CIS) namely Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Russia and Ukraine for the period 1995M1-2015M11. In this study we perform stationary test on three bases. Unit root test results performed show that there is a large disagreement on the validity of PPP in CIS countries. Firstly, ADF test results show that PPP does not hold in these countries except for Kazakhstan and Ukraine. Psaradakis' bootstrap test results, however, indicate that PPP is invalid in CIS countries except for Kazakhstan only. Furthermore, ZA test results show that PPP holds for Armenia, Belarus, Kazakhstan and Kyrgyzstan, while it does not hold for the other countries. Additionally ZA test reveals that break dates specified for the countries are in line with 1998 Russian economic crisis. This means that these countries are deeply affected by this crisis. In conclusion unit root test results performed show that there is a large

disagreement on the validity of PPP in CIS countries. Given the span and characteristics of the period which involves a significant break such as 1998 Russian economic crisis, we conclude that PPP holds for Armenia, Belarus, Kazakhstan and Kyrgyzstan, while it does not hold for Azerbaijan, Russia and Ukraine.

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