PURCHASING POWER PARITY INFLUENCE ON REAL EXCHANGE RATE BEHAVIOR IN ROMANIA[1]

Nicolae Ghiba
"Alexandru Ioan Cuza" University of Iaşi
ghiba.nicolae@yahoo.com

Abstract: *Purchasing Power Parity (PPP) represents a fundamental concept in exchange rate modeling. The main idea is given by equality between prices in two different countries when expressing in the same currency.*

This paper aims to analyze the behavior of real exchange rate between EURO and Romanian new leu (RON) under PPP paradigm. We use the Augmented Dickey-Fuller and Phillips-Perron stationarity tests in order to check real exchange deviations from PPP. Also, we investigate the existence of a connection between long-term between nominal exchange rate and industrial producer price indices from Romania and euro area. The main conclusions of this research highlight that PPP doesn't holds; real exchange rate stationarity tests doest not confirm the stationarity, thus between the aforementioned three variables it doesn't exists any equilibrium relation.

Keywords: purchasing power parity, real exchange rate, stationarity, cointegration
JEL Classification: F31, C32, E31

1. INTRODUCTION

One of the most important theories in international finance refers to purchasing power parity. In absolute form, two price indices should have the same value after the conversion in the same currency. In its relative form, the theory reflects the equality between exchange rate modifications and price indices differential among countries. In reality, the price indices are elaborated using different products and weights, making the comparison difficult in being accurate. Also, the transportations costs, tariffs, taxes (or any other trade restrictions) and arbitrage operations influence the real exchange rate.

The theory was elaborated by Gustav Cassel in 1932 and it was empirically developed until nowadays. The main studies focus on the real exchange rate stationarity tests (considered the "PPP strong form") and on the cointegration of nominal exchange rate, a domestic price index and a foreign price index (considered the "PPP weak form).

International finance theory reflects two puzzles about PPP validity: there is no consensus in obtaining similar conclusions about PPP in long term (the first puzzle) and the real exchange rate

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has a higher volatility in short term, compared with a slower mean reversion adjustment in the long-run (the second puzzle).

The empirical analysis on the Central and Eastern Europe emerging countries found arguments in sustaining PPP validity for Romania and/or the countries from region but also its rejection. In a recent study, Acaravci and Ozturk (2010) argue that real effective exchange rate is non-stationary if we neglect the structural breaks, otherwise the results being valid for Romania and Bulgaria.

As methodology we used the Augmented Dickey-Fuller (ADF) stationarity test for the real exchange rate (the equation left-side) and the Engle-Granger methodology for the relationship between nominal exchange rate, domestic and foreign price index.

The present paper is structured in six parts as following:

- theoretical formulation and model development;
- a literature review about the empirical evolution of the model and a brief Central and Eastern Europe countries presentation under PPP paradigm;
- a presentation of the methodology that we used;
- data sources and preliminary tests;
- the most important empirical results;
- concluding remarks.

2. THEORETICAL FORMULATION AND MODEL DEVELOPMENT

The purchasing power parity has two forms:

- an absolute form that reflects the same price for a good in domestic and foreign market when we are expressing it in the same currency:

$$P_{i,t} = NER_t P^*_{i,t},\ i=1,2,\ldots,n, \qquad (1)$$

- a relative form which implies an equality between exchange rate volatility and price indices:

$$\frac{P^*_{i,t+1} NER_{t+1}}{P_{i,t+1}} = \frac{P^*_{i,t} NER_t}{P_{i,t}},\ i=1,2,\ldots,n, \qquad (2)$$

where NER_t is the nominal exchange rate at moment t and P_t, P^*_t represent the domestic price index, respectively foreign price index at moment t.

The absolute form implies the relative form, but the influence isn't valid for the inverse relationship. The purchasing power parity is correctly elaborated if the internationally traded goods are perfect substitutable, there aren't transport cost and other impediments which can affect the international trade.

PPP is important in analyzing the real exchange rate behavior. As we know, the real exchange rate (RER_t) can be computed as a multiplication between nominal exchange rate and the ratio between foreign and national prices:

$$RER_t = NER_t * \frac{P_t^*}{P_t} \qquad (3)$$

In logarithmic form, the relationship can be written as:

$$\log(RER_t) = \log(NER_t) + \log(P_t^*) - \log(P_t) \qquad (4)$$

If we use small cases, we get the next relationship:

$$rer_t = ner_t + p_t^* - p_t \qquad (5)$$

Empirical literature on the purchasing power parity relies on the relationship no. 5. PPP can be tested using real exchange rate stationarity test or cointegration methodologies: Engle-Granger (as a bivariate approach) or Johansen methodology (as a multivariate option) for the relationship between the nominal exchange rate, domestic price index and foreign price index).

3. PURCHASING POWER PARITY IN CENTRAL AND EASTERN EUROPE (CEE) EMERGING COUNTRIES. A LITERATURE REVIEW

3.1 Evolutions in empirical literature

Early empirical PPP approaches (in '70s) had analyzed following relationship:

$$ner_t = \alpha + \beta p_t + \beta^* p_t^* + u_t \qquad (6)$$

Authors who studied the relationship 6 had applied coefficient restrictions tests: β=1, β*=-1. If the coefficients are equal and they have opposite signs we have a "symmetry condition". If the coefficients are equal with the unity and they have opposite signs we get a "proportionality condition" (Frenkel, 1981).

In the second part of '80s, economists developed the stationarity as a measure for the permanent deviation form purchasing power parity level.

In the end of ‘80s, Engle and Granger (1987), followed by Johansen (1988) found a strong equilibrium relationship between variables using a new concept: the cointegration. The null hypothesis is given by the permanent deviations form linear combination between exchange rate and prices. Their methodologies were considering a success and it influenced empirical research until today.

More appropriate to nowadays new approaches regarding purchasing power parity were been developed:

- tests on longer time periods, which include various currency arrangements according to what happened in the international monetary system;
- tests that are using panel data and stationarity procedures;
- new econometric techniques based on nonlinearities.

3.2 Power purchasing parity evidences in transition countries

One of the first PPP modern approaches of European Central-Eastern countries was made by Choudry in 1999. Analyzing a group of four countries (*Romania*, Poland, Russia and Slovenia) he found that PPP holds in its relative form for Slovenia and Russia.

In an extensive analyze on a large group of countries from this region (Bulgaria, Czech Republic, Hungary, Poland, *Romania* and Slovak Republic in 1991-1998 period) Christev and Noorbakhsh, (2000) identified a long-run term relationship between prices and the exchange rate, despite the law of one price, proportionality and symmetry violation. Sideris (2006) examine the PPP validity for a long time horizon using cointegration for a 17 transition economies and find the same symmetry and proportionality violation, but also evidence of PPP validity in the long-run.

Taylor and Sarno (2001) found an evident appreciation trend of the real exchange rate for the region’s countries in ‘90s period. They consider that real shocks are more important than the nominal ones in exchange rate determination.

Kim and Korhonen (2002) studied the PPP using real exchange rate stationarity for panel series in five countries: Czech Republic, Hungary, Poland, Slovak Republic and Slovenia, and argue that PPP doesn’t holds. A similar approach for the transition countries finds that PPP holds (Solakoglu, 2006).

Using the Johansen cointegration methodology in 1994-2000 periods, Barlow (2003) reached to a set of different results when combining the states between them. Koukouritakis (2009) analyzed PPP validity between twelve new member states of European Union (Bulgaria, Cypru, Czech

Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic and Slovenia) by using Johansen cointegration test. He offers arguments in favor of a long-run equilibrium relationship between the nominal exchange rate and prices for Bulgaria, Cypru, Romania and Slovenia (Koukouritakis, 2009).

Using non-linearity in PPP analyze, the theory is confirmed for Bulgaria, Croatia, Czech Republic, Hungary, Macedonia, Poland, Romania and Slovak Republic (Cuestas, 2009). A similar study on region find that PPP holds in Romania and Bulgaria, if we consider the structural breaks in the real exchange rate volatility (Acaracvi şi Ozturk, 2010).

4. METHODOLOGY

The purchasing power parity in a simplified form denotes that the modification degree of a currency is approximately equal to the difference between domestic and foreign price indices:

$$er_t = p_t - p_t^* + d_t, \qquad (7)$$

where er_t is the exchange rate in a logarithmic form and p_t, respectively p_t^* are the logarithms of the national and foreign price index. d_t denotes the deviations from purchasing power parity and it is associated with real exchange rate movements (rer_t):

$$rer_t \equiv er_t + p_t^* - p_t \qquad (8)$$

Under these conditions, we admit that purchasing power parity holds in the long-run if the real exchange rate is a stationary series. A variable is stationary if it has a tendency in returning to a constant value. In other words, its trajectory must be around a mean value or around a linear trend. Economically, this means that any shock on series is temporary and it is absorbed in time. In practice, almost every variable is stationary and must be differenced. Hence, the exchange rate is nonstationary for the most cases and the series is first order integrated (requires just one differentiation).

The econometric theory refers to a null hypothesis that claims a unit root in series. In our case, the real exchange rate is nonstationary. The most popular stationarity test were developed by Dickey and Fuller (ADF stationarity test), respectively by Phillips and Perron (1988). The difference between them is given by the less stringent restrictions on error process for Phillips-Perron test. These tests are important because it is necessarily for us to know the order of integration of our variables. If the obtained t-statistisc and associated probability reflect null hypothesis acceptance, than we conclude that purchasing power parity doesn't holds.

Testing real exchange rate stationarity through Augmented Dickey-Fuller entails three assumptions: the intercept presence, the presence of an intercept and a time trend, and finally, the absence any deterministic element. For each supposition, we have build three different relationships:

a) model A: includes both a drift and a linear time trend

$$\Delta rer_t = a_0 + \gamma * rer_{t-1} + a_2 * t + \varepsilon_t \qquad (9)$$

b) model B: random walk with a drift

$$\Delta rer_t = a_0 + \gamma * rer_{t-1} + \varepsilon_t \qquad (10)$$

c) model C: pure random walk

$$\Delta rer_t = \gamma * rer_{t-1} + \varepsilon_t \qquad (11)$$

For researchers, the most important coefficient is γ. If its value equals zero, than the real exchange rate sequence contains a unit root (the series is nonstationary). The test estimates a regression equation using ordinary least squares, in order to determine an estimated value for γ and associated standard error. In EViews 7, the associated probability indicates the rejection or acceptance of null hypothesis.

Engle and Granger (1987) tested the cointegration between a set of integrated variables of first order: l(1). Their procedure is based on estimating the long-run relationship through regression, saving the residuals and testing their stationarity. If the the residuals are stationary, then the variables are cointegrated. Their stationarity shows that the purchasing power parity holds in the long run. In order to find relevant conclusions it is necessarily to use first order integrated series l(1) which need a single differentiation.

According to Engle and Granger, if the $er_t + p_t^*$ and p_t are cointegrated, PPP holds in the long-run under following conditions (Enders, 2009):

- between $er_t + p_t^*$ and p_t of the form $er_t + p_t^* = \beta_0 + \beta_1 * p_t + \mu_t$ exists a linear combination;
- residuals (μ_t) are stationary;
- variables have the same integration order.

5. DATA SOURCES AND PRELIMINARY RESULTS

After the socialist period, Romania "fought" with a highly inflation. The National Bank of Romania is trying to sustain a stable exchange rate in its goal of maintaining the prices stability in a domestic goods market characterized by many prices reported to the euro. During the recent crisis, inflation has grown with great effects on real exchange rate volatility compared with the nominal level.

Among others, Romanian inflation rate were affected by the regulated prices – its level is appreciated at 21% in the consumer price index, but the regulation is generally applied to the non-tradable part of the economy. According to Halpern and Wyplosz (2001), if over 10% of an economic sector is oriented to exports, we say that sector is tradable. The most prosper economic sector in this sense is the industrial one. PPP principles are based on the tradable part of the Romanian economy and, hence we consider that using an industrial producer price index is more adequate in our analysis.

Purchasing power parity is analyzed for the period between 2000 (January) and the second half of 2011 (September) using monthly data taken from following sources:

- National Bank of Romania Interactive Database for the nominal exchange rate between euro and Romanian new leu;
- Eurostat for the industrial producer price index in Romania and Euro area.

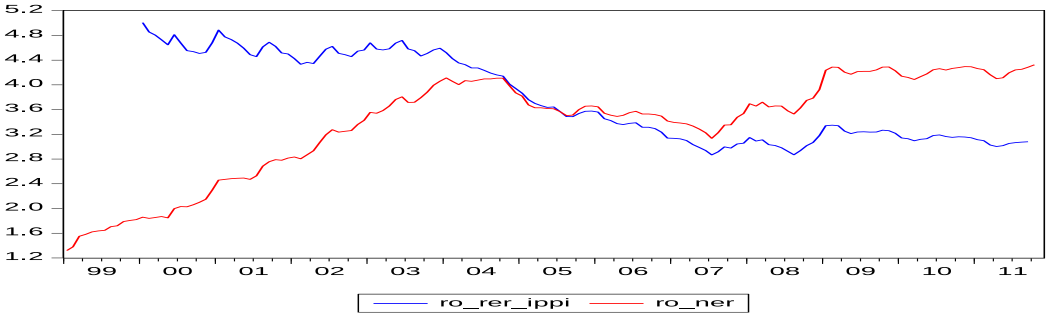
In our empirical analysis we use following abbreviations:

Table 1- Abbreviations used in empirical analysis

e_ippi	Industrial producer price index in the Euro Area
ro_ner	Nominal exchange rate between EURO and Romanian new leu
ro_ippi	Industrial producer price index in Romania
ro_rer_ippi	Real exchange rate between EURO and Romanian new leu deflated with the industrial producer price indices
d(*)	Reflects the variable in first difference
l, log(*)*	Reflects the logarithmic form of the variable

The evolutions of real and nominal exchange rate deflated with the industrial producer price index are reflected bellow, in the figure 1:

Figure 1- Nominal and real exchange rate deflated with industrial producer price index in 2000M01-2011M0 (EUR/RON)

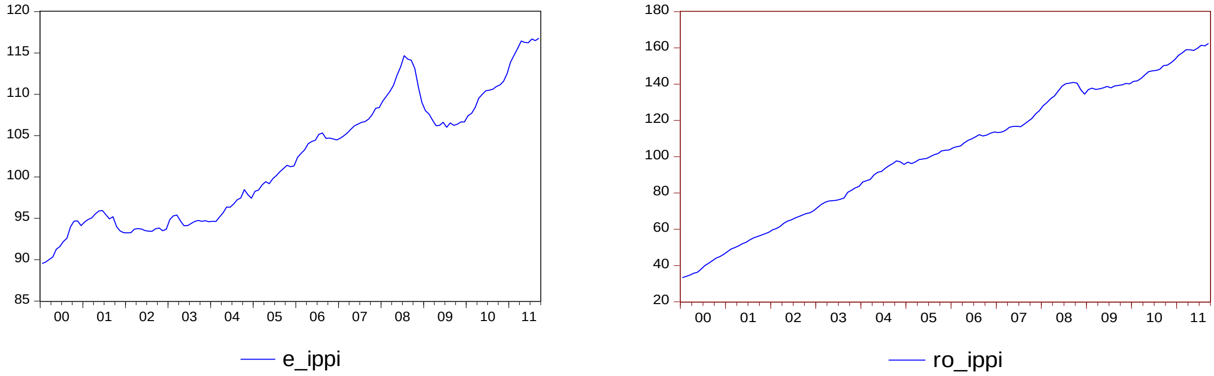


Source: graph made using National Bank of Romania Interactive Database for nominal EUR/RON exchange rate and Eurostat database for real exchange rate calculation

Based on the graphic representation it seems that our variables (nominal and real exchange rate) follow a random walk process with no visible evidence of an explosive trajectory or a deterministic time trend.

Before starting the empirical analysis we analyze the series characteristics in order to find the integration order. This information is useful in cointegration analysis, later developed in this paper.

Figure 2 - Industrial producer price index in Euro area (e_ippi) and in Romania (ro_ippi) in 2000M01-2011M09 period (2005=100)



Source: EUROSTAT

Using above graphical representation, both series look to be nonstationary. To be sure, we test this assumption using Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) stationarity tests.

Table 2 - Stationarity results for nominal exchange rate and industrial producer price index for Romania and Euro Area

Variable	ADF t-statistic	ADF Prob.	PP adj. t-statistic	PP adj. Prob.
Nominal exchange rate in level (with intercept)	-2.441548	0.1324	-2.360979	0.1548
Nominal exchange rate in first difference (with intercept)	-7.325311	0.0000	-7.347952	0.0000
IPPI in Romania in level (with intercept and trend)	-2.520531	0.3179	-2.387062	0.3847
IPPI in Romania in first difference (with intercept and trend)	-8.404971	0.0000	-8.507142	0.0000
IPPI in Euro Area in level (with intercept and trend)	-2.365533	0.3959	-2.190288	0.4909
IPPI in Euro Area in first difference (with intercept and trend)	-6.420188	0.0000	-6.480072	0.0000

Source: author's calculations

According to the results from the table 2, all three series are first order integrated and they need a differentiation in order to stationaries them. We included in our analysis an intercept, respectively an intercept and a trend, using statistical significant coefficients for both of them. Hence, nominal exchange rate between euro and Romanian new leu is a nonstationary series that follows a random-walk with drift and industrial product price indices are nonstationary series which include both a drift and linear time trend.

6. EMPIRICAL RESULTS

Our methodology is based on:

- testing real exchange rate stationarity for all 3 assumptions: model A (with drift and linear time trend), model B (for a random walk with a drift) and model C (for a pure random walk);
- applying Engle-Granger two-step methodology in assessing the cointegration between nominal exchange rate, domestic and foreign industrial producer price indices.

Table 3 - Real exchange rate EUR/RON stationarity test results

Model	Variable	Coefficient	Standard error	t-statistic	Prob.
Model A	**l_ro_rer_ippi(-1)**	**-0.031514**	**0.019139**	**-1.646562**	**0.1020**
	d(l_ro_rer_ippi(-1))	0.319431	0.081396	3.924410	0.0001
	Intercept	0.047124	0.030802	1.529887	0.1284

	Trend	-0.000112	8.50E-05	-1.318190	0.1897
Model B	**l_ro_rer_ippi(-1)**	**-0.008360**	**0.007622**	**-1.096819**	**0.2747**
	d(l_ro_csr_ipip(-1))	0.302004	0.080533	3.750077	0.0003
	Intercept	0.008746	0.010085	0.867244	0.3873
Model C	**l_ro_csr_ipip(-1)**	**-0.001812**	**0.001044**	**-1.735384**	**0.0849**
	d(l_ro_csr_ipip(-1))	0.301133	0.080454	3.742948	0.0003

Source: author's calculations

For al three models, t-statistic and related probability denote that the shock have a permanent influence on the real exchange between euro and Romanian new leu. The t-statistic values for intercept and trend show that the real exchange rate can be assimilated to a pure random process. The standard error values display a high unpredictability for real exchange rate volatility. Enders (2009) argues that in Bretton-Woods post-period, the real exchange rate manifest a higher volatility. As a conclusion, we find that PPP doesn't holds.

After we tested the left-side of the equation, we apply Engle-granger methodology in order to test the bivariate cointegration. This means that we must use two series. According to Enders (2009), both series must be first order integrated. As a result, we estimate the long-run equilibrium by regressing $f\_ro_t = \log(ro\_ner_t) + \log(e\_ippi_{tt})$ on $\log(ro\_ippi_t)$.

First of all, we test the stationarity of $f\_ro_t = \log(ro\_ner_t) + \log(e\_ippi_{tt})$ and $\log(ro\_ippi_t)$ using Augmented Dickey-Fuller and Phillips-Perron tests. Granger sustains that an equation is consistent if a modification in the exogenous variable influences the endogenous variable. In this order, he reflected the importance of the same integration order for our variables. In order to find the integration order for our variables, we apply two stationarity tests: Augmented Dickey-Fuller and Phillips-Perron. The results are presented in table 4:

Table 4 - Stationarity results for regressions variables

Stationarity test type	Variable	t-statistic	Prob.
Augmented Dickey-Fuller	f_ro=log(ro_ner)+log(e_ippi) in level	-3.073500	0.1168
	f_ro=log(ro_ner)+log(e_ippi) in first difference	-8.559115	0.0000
	log(ro_ippi) in level	-2.520531	0.3179
	log(ro_ippi) in firs difference	-8.404971	0.0000
Phillips-Perron	f_ro=log(ro_ner)+log(e_ippi) in level	-2.716186	0.2318
	f_ro=log(ro_ner)+log(e_ippi) in first difference	-8.545642	0.0000
	log(ro_ippi) in level	-2.387062	0.3847
	log(ro_ippi) in firs difference	-8.507142	0.0000

Source: author's calculations

According to table no. 4, both variable have a unit root (are nonstationary). The variables are nonstationary and must be differenced one time (they are first order integrated and satisfy Engle-Granger condition in order to estimate the equilibrium equation using regression).

Table 5 - Long-run equilibrium equation estimate

Dependent Variable: F_RO				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RO_IPIP	0.006741	0.000259	26.05477	0.0000
C	5.170243	0.028013	184.5655	0.0000

Source: author's calculations

The intercept is statistically significant based on t-statistic value in the long-run equation. The coefficient $\beta_1 = 0{,}006741$ is close to the null value. In the next step we save the residuals and we test the stationarity. In order to determine if the variables are cointegrated we check residuals stationarity. The residuals from both below regression equation are tested for unit root presence, using a long-run equilibrium relationship:

$$\Delta \hat{\mu}_t = a_1 * \hat{\mu}_{t-1} + \sum a_{i+1} * \Delta \hat{\mu}_{t-1} + \varepsilon_t \qquad (12)$$

The results are reflected in table 6:

Table 6 - Residual stationarity test results

			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-3.037792	0.1259
Test critical values:	1% level		-4.025426	
	5% level		-3.442474	
	10% level		-3.145882	
*MacKinnon (1996) one-sided p-values.				
Dependent Variable: D(RESID01)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID01(-1)	-0.038446	0.012656	-3.037792	0.0029
D(RESID01(-1))	0.322437	0.078043	4.131521	0.0001
C	0.007232	0.002914	2.481559	0.0143
@TREND(2000M01)	-8.34E-05	3.56E-05	-2.342990	0.0206

Source: author's calculation

According to the information from table 6, we find that PPP doesn't hold in long-run in Romania if we use the Engle-Granger methodology.

CONCLUDING REMARKS

Our results reject PPP validity for the Romanian case for both situations. Real exchange rate stationarity tests reflect permanent deviation of form the purchasing parity level. Using the Engle-

Granger methodology, we couldn't find a long-run cointegration between nominal exchange rate and price indices. Hence, PPP is rejected in long-run. Due to the fact that Engle-Granger methodology has many limitations, we intend to use Joahansen multivariate procedure in order to test the cointegration.

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