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COINTEGRATION ANALYSIS OF PURCHASING POWER PARITY IN REPUBLIC OF CROATIA

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Abstract:
This paper examines the validity of purchasing power parity (PPP) hypothesis in the Republic of Croatia. The main aim is to test whether the PPP Theory holds in the case of the Republic of Croatia and whether the PPP Theory is an appropriate method on which monetary policy makers can rely in determining the size of the market exchange rate deviations from its long-run value. The PPP Theory in the Republic of Croatia has been tested using methods of cointegration analysis. Two cointegration tests have been applied: Engle-Granger test and ADL test. The existence of the long-run relationship between the price level in the EMU (expressed in Croatian Kuna) and the price level in the Republic of Croatia has been tested using monthly observations of average nominal Croatian Kuna exchange rate against Euro, Consumer Prices Index in the Republic of Croatia (2005=100) and the Harmonised Index of Consumer Prices for the European Monetary Union (2005=100) in the period from January 2000. to December 2012. Based on the Engle-Granger test, it can't be concluded if there is a long-run relationship between the two price levels. The non-existence of the long-run relationship between two price levels has also been confirmed by the ADL cointegration test. Thus, on the basis of the cointegration tests it can be concluded that the PPP hypothesis in the Republic of Croatia has not been confirmed.

Keywords: Purchasing power parity theory, Engle-Granger cointegration test, ADL cointegration test.

Jel Classification: E31

INTRODUCTION

In the case of small open economies, such as Croatian economy, during the globalisation and financial liberalization, the exchange rate plays very important role. Republic of Croatia has so called floating operated exchange rate, which means that exchange rate is formed liberally on exchange market, and Croatian National Bank prevents excessive exchange rate fluctuations and maintains its stability. The outcome of that are frequent arguments about exchange rate overvaluation, and therefore it is

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very important to establish whether the exchange rate in Republic of Croatia is in accordance with theoretical grounds.

Exchange rate has a great significance in economical theory and at the same time it presents important variable of economic politics, and therefore its fluctuations can have great influence on many macroeconomic indicators like prices, interest rates, unemployment, import, export etc.

The stability and determined exchange rate level often appear as declarative objects of economic policy. Initial point of measuring exchange rate deviation according to overvaluation or underestimation of domestic currency is the equilibrium exchange rate.

The methodology which is offered by purchasing power parity theory provides calculation of equilibrium exchange rate. Purchasing power parity theory is one of the basic theories, which tends to define long-run equilibrium exchange rate and it assumes that in normal terms of free trade, nominal exchange rate is determined on the basis of relationship between domestic and foreign price levels. Therefore parity of purchasing power is exchange rate that equals domestic and foreign price levels.

Aim of this paper is to test if purchasing power parity theory is valid in Republic of Croatia and is the purchasing power parity relevant method on witch holders of economic policy can rely during the defining size of market exchange rate deviation from its long-run value.

The theory of purchasing power parity in Republic of Croatia is tested by cointegration analysis method. The long run equilibrium exchange rate is formed, based on purchasing power parity theory. Two cointegration tests were conducted, Engle–Granger cointegration test and ADL cointegration test.

1. THE PURCHASING POWER PARITY THEORY

The purchasing power parity theory relates exchange rate, domestic price level and foreign price level and it is one of the oldest theories of exchange rate, at the same time it is very important theory of forming exchange rate in international economy.

Theoretical basis on which purchasing power parity theory was created is the law of one price. The purchasing power concept was firstly introduced by Swedish economist Cassel (1918) although the idea originated since 15^{th} and 16^{th} century.

Purchasing power parity theory is based on law of one price and price index at home and abroad. In most of the countries different price indexes are calculated as for example Consumer prices index, Producers prices index and GDP deflator. Though in the purchasing power parity theory, any of previously mentioned indexes could be used, the Consumer prices index is the most frequently used. Consumer prices index is usually constructed as weighted average of the prices of individual goods (basket of goods), where the weight of each good is calculated like share of income spent by householders for purchasing of that good during the selected period of time.

There are different forms of the low of one price that is the absolute law of one price and relative law of one price. Both forms can be applied on individual products and price indexes.

Absolute purchasing power parity theory derives from absolute law of one price with terms that prices indexes in both countries are calculated in identical way and for identical basket of goods which participates in international exchange. Absolute purchasing power parity (PPP) is valid when the nominal foreign rate between two currencies is such that purchasing power of domestic currency unit is completely the same at home and abroad, once it is expressed in foreign currency (Taylor and Taylor 2004).

Because of all conditions that must be satisfied for absolute purchasing power parity theory to be valid, which is impossible to achieve in practice, it is considered that theory is at least approximately achieved because of the existence of international exchange of goods (Taylor and Taylor 2004).

Logarithm form of the absolute purchasing power parity theory version is (Sarno and Taylor 2001)

$$s_t = p_t - p_t^*, \tag{1}$$

where the p_t and p_t^* are logarithm of domestic index prices P_t and foreign index prices P_t^*, and s_t logarithm of nominal exchange rate S_t. Relative law of one price is followed by relative purchasing power parity theory. In accordance with relative purchasing power parity theory changes in nominal exchange rate are equal to changes in relative prices. Relative purchasing power parity theory can be expressed as

$$s_{t+1} - s_t = (p_{t+1} - p_t) - (p_{t+1}^* - p_t^*) \,. \tag{2}$$

According to relative purchasing power parity the rate of change of nominal exchange rate is equal to difference between rates of change of domestic and foreign index prices. Thus, relative purchasing power parity theory is valid if the rate of change of nominal exchange rate in certain period is equal to difference of inflation rates in observed countries during the same period of time, so the purchasing power of domestic currency unit is relatively equal to its purchasing power in foreign country once it is expressed in foreign currency, with assumption that nominal exchange rate is equal in the beginning and in the end of defined period (Taylor and Taylor 2004).

Real exchange rate Q_t is relative price of goods in two countries and it is defined as followed

$$Q_t \equiv S_t \frac{P_t^*}{P_t} \,. \tag{3}$$

Logarithm of real exchange rate q_t with expression (3) can be defined as

$$q_t \equiv s_t - p_t + p_t^* . \tag{4}$$

Real exchange rate is nominal exchange rate adjusted to relative price changes in land and in foreign country.

Real exchange rate can be considered as measure of deviation from purchasing power parity. Since the real exchange rate is equal to zero when the absolute purchasing power parity theory is valid, apropos it is equal constant in case the relative purchasing power parity theory is valid, the changes of real exchange rate present deviation from purchasing power parity.

The fact that purchasing power parity is derived from law of one price in a way that instead of prices of goods, the prices index is used, causes difficulties. Namely, in theory itself it is assumed that index prices in different countries are calculated in the same way, what is not a case. Not only weights of particular assets are different from one country to another, but also baskets of goods that are used for calculation of consumer prices index can be significantly different or they may include international, nontraded goods. Still, particular countries price indexes are used in empirical researches and therefore it is considered that purchasing power parity theory is approximately correct. It is common that consumer prices index which is calculated by Central Bureau of Statistics is chosen for corresponding price index, during the purchasing power parity theory testing.

In Republic of Croatia the parity theory is researched in several empirical studies. Cointegrational analysis of purchasing power parity theory for Republic of Croatia is conducted by Pufnik (1996) and Egert (2005). In her analysis, Pufnik (1996) is testing purchasing power parity as balanced long run condition of real rate exchange with Engle-Granger cointegration method and concludes that purchasing power principle in Republic of Croatia is not achieved in long period. Study, conducted by Egert (2005) resulted with the same conclusion. Using the unit root tests with two structural break, Payne, Lee, and Hofler (2005) failed to confirm purchasing power parity in Republic of Croatia. Testing the purchasing power parity applicability as a long-run equilibrium of real exchange rate for 17 European economies in transition, among others including and Republic of Croatia, Sideris (2006) realises that theory is not valid in Republic of Croatia.

Tica (2006) and Sonora and Tica (2008) conduct studies that confirmed hypothesis of purchasing power parity as a long run real exchange rate in Republic of Croatia. In first of those studies, Tica (2006) is testing hypothesis of purchasing power parity using the unit root test in period since 1952.–2003. It is concluded that bilateral real exchange rates are stationary, which means that purchasing power parity theory is valid in Republic of Croatia. Sonore and Tica (2008) conducted panel unit root tests with and without structural breaks in order to test purchasing power parity theory in countries of Middle and East Europe, and former Yugoslav countries in period 1994–2006. They conclude that real exchange rate is stationary in Republic of Croatia and that the purchasing power parity hypothesis is valid. By testing the stationary of real exchange rate with four unit root test in eight transitional countries including the Republic of Croatia as well, Ali and Ozturk (2010) presented in their study that the real effective exchange rate is unstationary, and that the purchasing power parity theory is not does not hold in all six countries in long run.

In regards to other empirical researches of purchasing power parity theory in Republic of Croatia, this paper's novality is testing of the purchasing power parity theory with ADL cointegration test.

2. METHODOLOGY AND DATA SOURCES

In order to test purchasing power parity theory in Republic of Croatia, it is necessary to include three variables in empirical analysis: nominal exchange rate (price of foreign currency unit expressed in Croatian Kuna), price levels in Republic of Croatia expressed in Croatian Kuna and price levels in foreign countries expressed in foreign currency.

Monthly data of three time series are used in empirical analysis: the average nominal exchange rate HRK/EUR, Consumer prices index in Republic of Croatia (PPI) (2005=100), Harmonised consumer prices index for European Monetary union (HICP)

(2005=100), in period since January 2000, to December 2012. Thus, all three observed time series have 156 monthly observations. Data source for average nominal exchange rate HRK/ EUR is Croatian National Bank, for consumer prices index in Republic of Croatia is Croatian Central Bureau of Statistics, and data on Harmonised consumer prices index for EMU are taken from Eurostat. Base year for consumer prices indexes is 2005.

All three time series are seasonally adjusted in order to eliminate influence of seasonal factors.

Seasonally adjustment was conducted by X12 ARIMA method. The logarithm transformation of time series was also conducted in order to stabilise variance. Seasonally adjustment and logarithm time series are indicated as follows:

$\{e_t\}$ - time series of the average nominal exchange rate,

$\{p_t\}$ - time series of the consumer price index in Republic of Croatia (2005=100),

$\{p_t^*\}$ - time series of the harmonised consumer prices index for EMU (2005=100).

According to purchasing power parity theory real exchange rate $\{q_t = e_t - p_t + p_t^*\}$ must be stationery. It is possible, alternatively, to test purchasing power parity theory by testing existence of cointegration between series $\{e_t + p_t^*\}$ and $\{p_t\}$. Time series $\{f_t = e_t + p_t^*\}$ is constructed for that purpose and it represents price level in EMU expressed in Croatian Kuna (HRK). In order to satisfy purchasing power parity theory, time series $\{f_t\}$ and $\{p_t\}$ must be cointegrated.

To test validity of purchasing power parity theory two cointegration tests were conducted: Engle-Granger test and ADL test. Cointegration test was conducted on the basis of the equation.

$$f_t = \beta_0 + \beta_1 p_t + \mu_t \,, \tag{5}$$

where β_0 and β_1 present parameters and μ_t residual. The absolute purchasing power parity theory requires that $\beta_0 = 0$ and $\beta_1 = 1$, and relative purchasing power parity theory that $\beta_1 = 1$.

Before conducting the cointegration tests, it is necessary to determine basic characteristics of observed time series, thus to determine are the time series stationary and if they are un- stationary it is needed to determine their order of integration.

To test the order of integration for observed time series after descriptive analysis the following units root test's was applied: the augmented Dicky-Fuller ADF test, DF-GLS test and KPSS test.

Since the unit root tests confirmed that for both observed time series order of integration is one, the Engle Granger test of cointegration is conducted, thus the long run equation is estimated. The long run equation is estimated by regressing variable f_t on p_t and vice versa.

To establish existence of cointegration between observed variables, the stationarity of residuals from each regression equation was tested using The augmented Dicky-Fuller ADF unit root test. After that, the ADL cointegration test was conducted.

Unlike Engle-Granger, in order to apply ADL cointegration test it is necessary to assume that one of the variables is weakly exogenous. The variable is weakly exogenous in cointegration system if it ¨doesn't¨ respond on deviation from long-run equation. With weak exogenous assumption of p_t variable the following regression equation is estimated

$$\Delta f_t = \beta_0 + \beta_1 f_{t-1} + \beta_2 p_{t-1} + \beta_3 \Delta p_t + A_1(L)\Delta f_{t-1} + A_2(L)\Delta p_{t-1} + \nu_t , \qquad (6)$$

β_0, β_1, β_2 i β_3 are parameters, $A_1(L)$ and $A_2(L)$ are lag operators which lag length is *p* respectively *q*, and ν_t is innovation process. Since the variables are not treated symmetrically it is not necessary that the lag length for both variables is equal (Enders 2010).

After the appropriate lag length for both variables were chosen and the adequacy of model was tested, the ADL cointegration test was conducted. Thus the p-statistic was calculated for the null hypothesis $\beta_1 = 0$ and it was compared to critical values that depend on number of *I* (1) regressors k, the adjusted sample size T^a and deterministic components in model *d*. Considering that regression equation (6) contains constant, but not the trend $d = 1$, and that are two $I(1)$ regression variables $k = 2$, t-statistic is compared to critical values (Table 1).

Table 1. Critical values for ADL cointegration test in the case of two I(1) regression variables and the model with constant but no trend (d = 1)

Constant but not trend (d=1)					
Number $I(1)$ regressor variables	Significance level	Adjusted sample size T^a 50	100	150	200
$k = 2$	1%	-3.954	-3.874	-3.834	-3.811
	5%	-3.279	-3.247	-3.231	-3.221
	10%	-2.939	-2.924	-2.916	-2.911

Source: Enders (2010)

The E-Views statistic package was used in data analysis.

3. EMPIRICAL RESULTS

Three variables were used during the purchasing power parity theory testing; nominal exchange rate (price of foreign currency unit expressed in Croatian Kuna), price level in Republic of Croatia expressed in Croatian Kuna and price level in foreign country expressed in foreign currency. After basic analysis characteristics of time series the Engle-Granger test and ADL cointegration test were conducted.

3.1. Basic characteristics of time series

In order to test basic characteristics of time series, the descriptive analysis was conducted and their stationarity, as well as their order of integration was tested. Time series are marked in following mode: average nominal rate HRK/EUR, consumer prices index in Republic of Croatia, (2005=100) - HRCPI, harmonised consumer prices index for European Monetary Union (HICP) (2005=100) – EACPI.

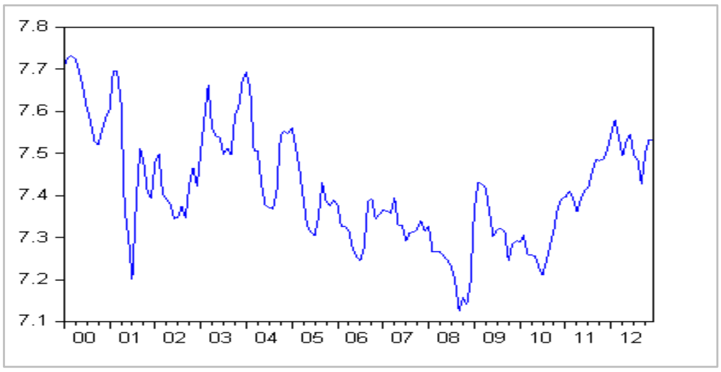

Figure 1. Graphical view of average nominal exchange rate - HRK/EUR (Croatian National Bank)

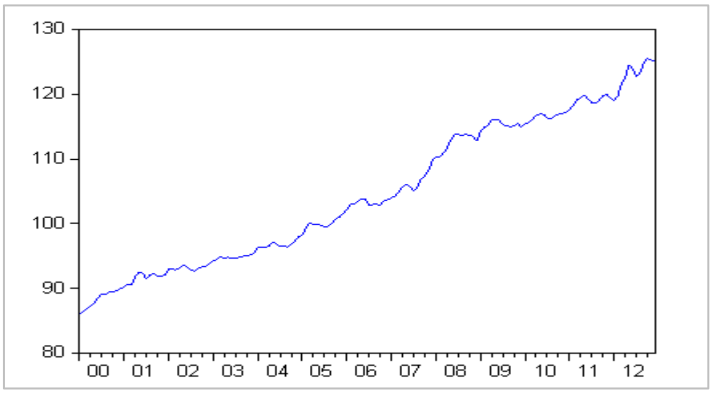

Figure 2. Graphical view of consumer prices index in Republic of Croatia (2005=100) – HRCPI (Croatian Bureau of Statistics)

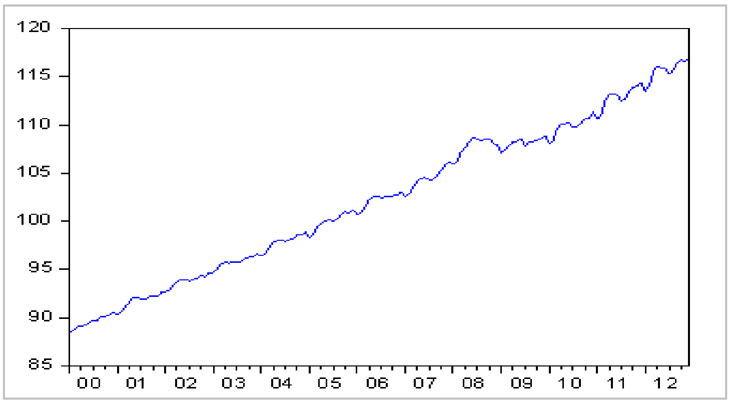

Figure 3. Graphic view of harmonised consumer prices index for European Monetary Union (2005 = 100) – EACPI (Eurostat)

Graphical view of average nominal exchange rate HRK/EUR shows that observed time series doesn't have tendency of returning on average level as well as it doesn't have tendency of decreasing or increasing during the whole observed period, unlike graphic views of consumer prices index in Republic of Croatia and harmonised consumer prices index for EMU, which show that time series don't have tendency of returning on average level, but the tendency of decreasing is noticeable during the whole observed time period. The basic descriptive time series indicators are presented in Table 2 (author's caclulations).

Table 2. Basic descriptive indicators

Time series	Number of observations	Average value	Standard deviation	Minimal value	Maximum value	Kurtosis	Skewness
HRK/EUR	156	7.418	0.134	7.126	7.733	2.573	0.372
HRCPI	156	104.690	11.256	86.100	125.600	1.665	0.177
EACPI	156	102.287	8.074	88.440	116.950	1.838	0.036

Time series are seasonally adjusted and time series HRK/EUR_SA, HRCPI_SA, EACPI_SA are obtained, and their logarithm transformation was conducted. Time series transformed in that mode are marked as following:

e_t = log(HRK/EUR_SA), p_t = log(HRCPI_SA), p_t^* = log(EACPI_SA).

In order to test purchasing power parity theory with cointegration tests and selected model (5), the time series price level in EMU (expressed in HRK) $\{f_t = e_t + p_t^*\}$ was constructed.

Required condition for cointegration test conducting is that observed time series a integrated of the same order, and for that purpose, the stationarity and order of integration of time series $\{f_t\}$ and $\{p_t\}$ were tested.

In Figure 4, the graphical view of time series $\{f_t\}$ and $\{p_t\}$ and their first differences are presented.

It is noticeable on Figure 4. (left side of image) that even observed time series in levels, have no tendency of returning on average level, that tendency is present at first differences of observed time series (right side of Figure 4). Thus, the graphic views of observed time series and their first differences lead to conclusion that order of integration for both observed time series is one.

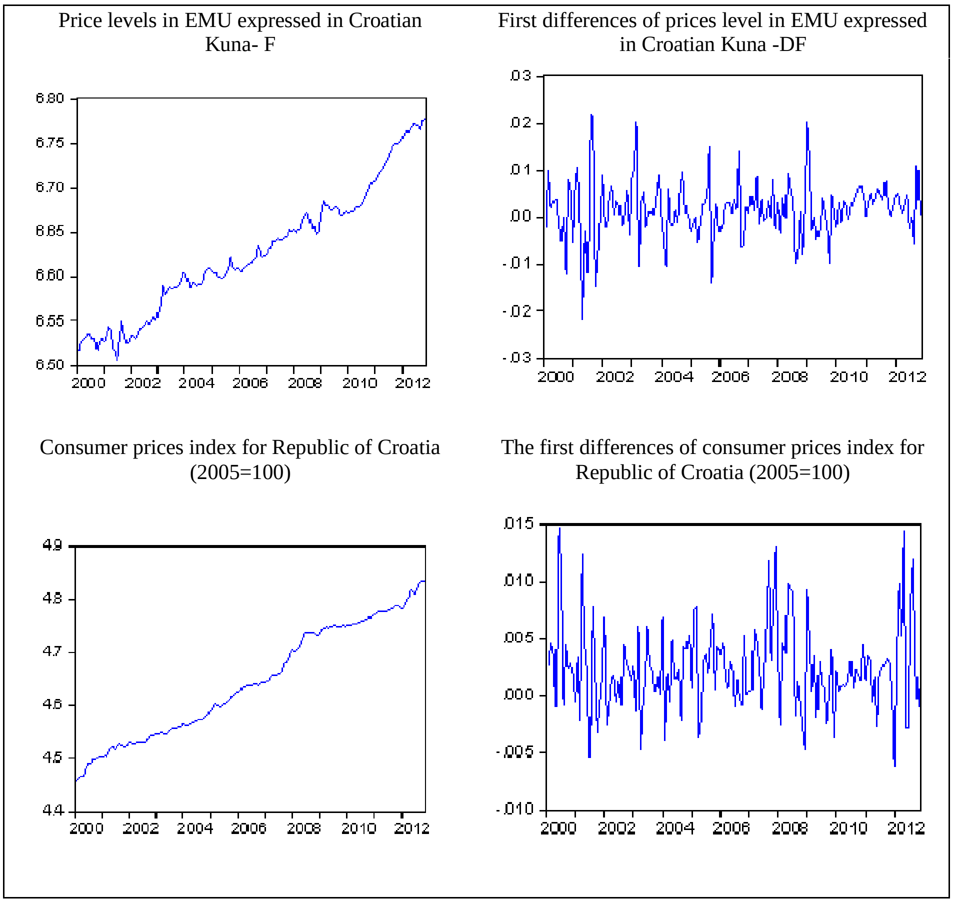

Figure 4. Time series in levels and first differences (Croatian national bank, Central Bureau of Statistics, Eurostat)
Note: D marks first differences

To formally test stationarity, the following unit root tests were conducted: The augmented Dicky-Fuller ADF, test DF-GLS test and KPSS test. Results (author's calculation) of unit root tests are presented in Table 3., Table 4., and Table 5.

Table 3. ADF test

	ADF test								
	Level								
	Without constant and trend			Constant			Constant and trend		
Variable	Test statistic	Lag lenght	Proba-bility	Test statistic	Lag lenght	Proba-bility	Test statistic	Lag lenght	Proba-bility
p_t	7.839872	0	1.0000	-0.201837	0	0.9344	-1.854998	0	0.6729
f_t	3.224690	0	0.9997	0.316873	0	0.9785	-2.633895	0	0.2660

Table 3. (*continued*)

	First diferencies								
Variable	Test statistic	Lag lenght	Proba-bility	Test statistic	Lag lenght	Proba-bility	Test statistic	Lag lenght	Proba-bility
Δp_t	-3.272821*	3	0.0012*	-11.25129*	0	0.0000*	-11.21428*	0	0.0000*
Δf_t	-11.04335*	0	0.0000*	-10.38638*	1	0.0000*	-10.45332*	1	0.0000*

Note: * the notes rejection of null hypothesis of the unit root existence at the 1% level of Significance

Table 4. DF-GLS test

	DF-GLS test								
	Level					First differences			
	Constant		Constant and trend			Constant		Constant and trend	
Variable	Test statistic	Lag lenght	Test statistic	Lag lenght	Varijable	Test statistic	Lag lenght	Test statistic	Lag lenght
p_t	5.509052	0	-1.824552	0	Δp_t	-11.26123*	0	-11.28054*	0
f_t	2.495861	0	-2.416088	0	Δf_t	-9.995822*	0	-10.05679*	1

Note: * the notes rejection of null hypothesis of the unit root existence at the 1% level of Significance

Table 5. KPSS test

	KPSS test				
	Level			First differences	
	Constant	Constant and trend		Constant	Constant and trend
Variable	Test statistic		Variable	Test statistic	
p_t	1.529621*	0.141634***	Δp_t	0.077343	0.076963
f_t	1.46923*	0.168449**	Δf_t	0.197214	0.088123

*Note:** the notes rejection of null hypothesis of the stacionarity at the level of significance 1%,
** the notes rejection of null hypothesis of the stacionarity at the level of significance 5%,
*** the notes rejection of null hypothesis of the stacionarity at the level of significance 10%.

Critical values for ADF test as for the DF-GLS test with constant as well are taken from MacKinnon (1996), and for DF-GLS test with constant and trend from Elliott, Rothenberg, and Stock (1996), optimal lag length's in both tests are selected according to Schwarz's information criteria. In the case of KPSS test critical values are taken from Kwiatkowski et al. (1992), and the bandwidth is determined by using Bartlett kernel.

Most of the unit root test's lead to conclusion that for both time series $\{f_t\}$ and $\{p_t\}$ order of integration is one at the usual levels of significance. Exception is the result of KPP test with trend and constant that refers to stationarity of time series $\{f_t\}$ at the level of significance 5%. Since the graphical view of time series $\{f_t\}$ and $\{p_t\}$ and their first differences (Figure 4) and most of conducted unit root tests lead to conclusion that series $\{f_t\}$ and $\{p_t\}$ are integrated order one it can be concluded that time series $\{f_t\}$ and $\{p_t\}$ are integrated order one or *I(1).*

After conducting unit root tests and concluding that both time series are *I(1)*, which formally confirmed conclusion given by analysis of graphical views, the cointegration tests can be conducted.

3.2. Results of Engle-Granger test

According to mutual graphic view of time series $\{f_t\}$ and $\{p_t\}$ which is presented in Figure 5. (author's calculation), can be concluded that analysed time series have similar dynamic during the time, thus that in long term they follow mutual trend. This implies possibility that observed variables are cointegrated.

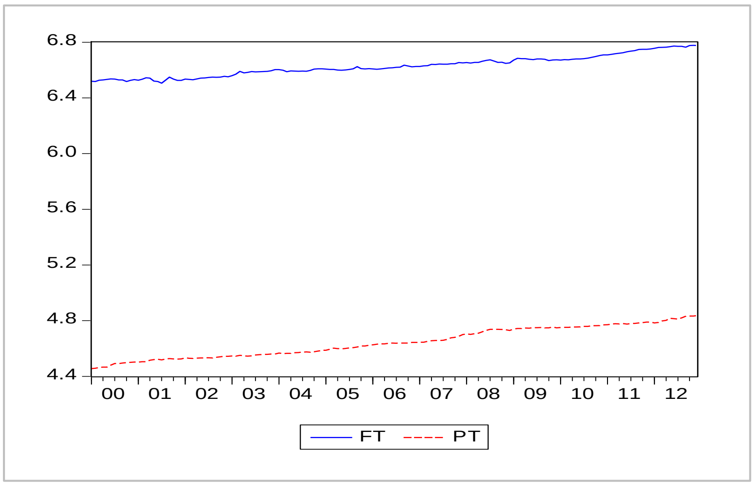

Figure 5. Mutual graphic view of time series: price levels in EMU expressed in Croatian Kuna - $\{f_t\}$ and consumer prices index in Republic of Croatia (2005=100)- $\{p_t\}$

Since in previous chapter it was concluded that both time series are integrated order one, the Engle–Granger cointegration test was conducted. Firstly, the long-term equation was estimated by regression of variable f_t on variable p_t. Results of estimated regression equation are presented in Table 6. (author's calculation) and cointegrational equation is

$$\hat{f}_t = 3.572467 + 0.657853\, p_t. \tag{7}$$

Table 6. Cointegration equation – $\hat{f}_t = \hat{\beta}_0 + \hat{\beta}_1 p_t$

Dependent variable: f_t	Coefficient	Standard error	t-value	p-value
Constant	3.572467	0.063211	56.51695	0.0000
p_t	0.657853	0.013604	48.35780	0.0000

The graphic view of estimated residuals from equation (7), Figure 6. (author's calculation) indicates stationarity of residual sequence. Stationarity of residual sequence from equation (7) is tested by ADF unit root test which results are presented in Table 7 (author's calculation).

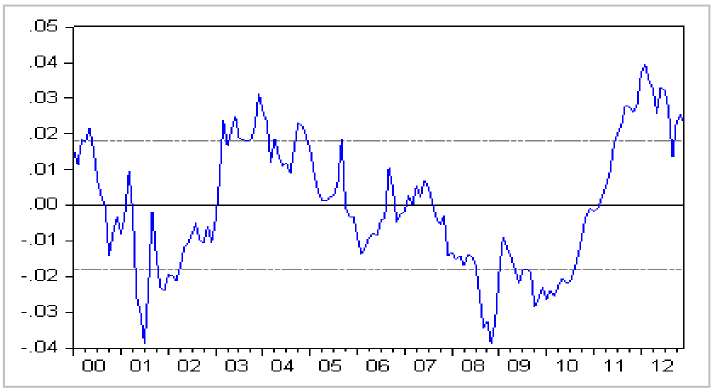

Figure 6. Graphic view of residual sequence from cointegration equation (7)

Table 7. ADF test of residual sequence form cointegration equation (7)[2]

ADF test Without constant and trend				
Coeficient	Srandard error	ADF test value	Lag lenght	Propapility
-0.902028	0.080400	-11.21930	0	0.0000

It can be seen from table 7. that ADF test value is -11.21930. ADF test value is compared to critical values of ADF test in case of cointegration equation with two variables[3] and adjusted sample size 154.

At the level of significance of 1% and the sample size 100, critical value is -4.008, and if the sample size is 200, the critical value is -3.954.

ADF test value is less than critical values so the null hypothesis of nonstationarity of residual sequence is rejected at the usual significant levels. Thus, residual sequence from cointegration equation (7) are stationery, and variables f_t and p_t are cointegrated.

Analysis is preceded with estimation of long-term equation by regression of variable p_t on variable f_t. In Table 8. (author's calculation) the results of such estimated equation are given and estimated cointegrated equation is

$$\hat{p}_t = -4.807950 + 1.426175 f_t. \quad (8)$$

[2] Optimal lag length for ADF test of residual sequence from equation (7) is selected by Schwarz's information criterion.

[3] Critical values for Engle-Granger cointegration test in case of two variables and when the cointegration relation contains constant in cointegration vector are taken from Enders (2004.).

Table 8. Cointegration equation – $\hat{p}_t = \hat{\alpha}_0 + \hat{\alpha}_1 f_t$

Dependent variable: p_t	Coefficient	Standard error	t-value	p-value
Constant	-4.807950	0.195497	-24.59349	0.0000
f_t	1.426175	0.029492	48.35780	0.0000

With ADF unit root, which results are in Table 10., the stationarity of residual sequence from equation (8) is tested and graphic view of estimated residuals from equation (8) is given on Figure 7 (author's calculation).

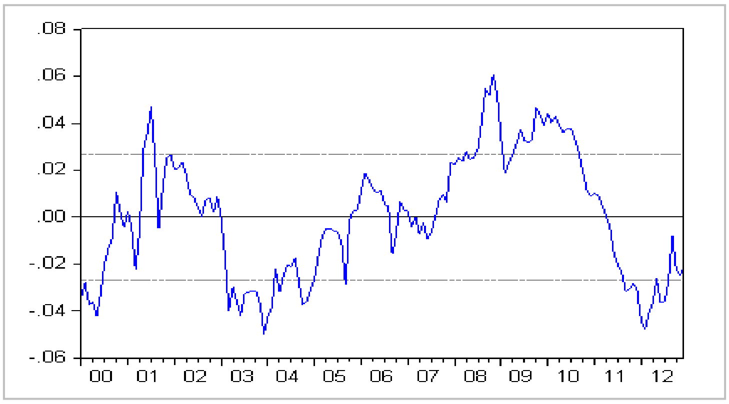

Figure 7. Graphic view of residual sequence from cointegration equation (8)

Table 9. ADF test of residual sequence from cointegration equation (8)[4]

ADF test Without constant and trend				
Coefficient	Standard error	ADF test value	Lag lenght	Probability
-0.062852	0.027377	-2.295780	0	0.0238

If the value of ADF test value -2.295780 (Table 9 - author's calculation) is compared to critical values of ADF test in case of cointegration equation with two variables and adjusted sample size 154, it can be concluded that the usual significance levels variables f_t and p_t are not cointegrated.

Thus, conduction of Engle Granger cointegration test by regression of variable f_t on variable p_t test indicates on existence of long run relationship between prices level in Republic of Croatia and prices level in European Monetary Union (expressed in HRK). While, results of Engle Granger cointegration test which is conducted by regression of variables p_t on variable f_t doesn't indicate existence of long-run relationship between

[4] Optimal lag length for ADF test of residual sequence from cointegration equation (8) is selected by Schwarz's information criterion

two price levels. So, on the basis of Engle Granger test the theory of purchasing power parity in Republic of Croatia cannot be neither confirmed nor denied.

3.3. ADL cointegration test results

Considering the results of Engle Granger cointegration test analysis is continued with ADL cointegration test.

In order to conduct ADL cointegration test it is necessary to assume that one of the variables is weakly exogenous. During the testing of cointegration existence between price level in Republic of Croatia (variable p_t) and price levels in EMU expressed in Croatian Kuna (variable f_t) by ADL cointegration test it is assumed that price levels in Republic of Croatia are weakly exogenous variable thus price levels in Croatia does not respond to the discrepancy from the long-run equilibrium relationship.

In order to conduct ADL cointegration test equation (6) is estimated. In equation (6) variables are not treated symmetrically so the selected lag lengths for variables p_t and f_t don't necessary have to be equal.

In order to select the appropriate numbers of lag lengths models ADL(0,0), ADL(0,1), ADL(1,0), ADL(1,1), ADL(2,0), ADL(2,1), ADL(0,2), ADL(1,2) and ADL (2,2) have been estimated. After analysing estimated models for both variables lag lengths one ware selected ADL(1,1) model estimation results are presented in Table 10. Table 10. (author's calculation) shows that ADL (1,1) model is

$$\underset{}{\Delta f_t} = \underset{(3.914154)}{0.627332} - \underset{(-3.807553)}{0.230271\, f_{t-1}} + \underset{(3.659778)}{0.194171\, p_{t-1}} + \underset{(7.208068)}{1.298622\, \Delta p_t} + \underset{(2.033306)}{0.199028\, \Delta f_{t-1}} - \underset{(-2.214014)}{0.497775\, \Delta p_{t-1}}, \quad (9)$$

under estimated parameters t- values are given in brackets

Table 10. ADL(1,1) model

			ADL(1,1) model			
Variable	Constant	f_{t-1}	p_{t-1}	Δp_t	Δf_{t-1}	Δp_{t-1}
Δf_t	0.171112	-0.051080	0.036303	0.372815	0.101549	-0.238824
	(0.105427)	(0.029438)	(0.020151)	(0.181457)	(0.079675)	(0.165133)
	[1.623043]	[-1.735143]	[1.801553]	[2.054565]	[1.274538]	[-1.446251]

Note: standard error (), and t-value in []

On estimated model standard diagnostic tests were conducted. ADL(1,1) model passes all diagnostic tests except heteroscedasticity test and therefore the standard errors were corrected with Newey–West's correction.

For null hypothesis of no cointegration between variables p_t and f_t, $\beta_1 = 0$, the t-test value is -1.735143.

The regression equation (9) contains constant but not trend ($d = 1$) and two $I(1)$ regression variables ($k = 2$) and it was estimated based on 154 observations. The corresponding adjusted sample size, calculated with $T^a = T - (2k-1) - d$ is

$T^a = 124 - (2 \cdot 2 - 1) - 1 = 120$. Critical test value, Table 1., for adjusted sample size $T^a = 100$ and at the significance level 5% is -3.231. After comparison t-test value with critical values of test, the null hypothesis of no cointegration cannot be rejected, and it is concluded that variables are not cointegrated.

CONSLUSION

In this paper, it was tried to determine whether the theory of purchasing power parity was satisfied in Republic of Croatia. Using the data se of nominal exchange rate of the Croatian Kuna against euro (HRK/EUR), Consumer prices index in Republic of Croatia (PPI) (2005=100), and Harmonised consumer prices index for European monetary Union (HICP) (2005=100), the existence of long-run relationship between price levels in EMU (expressed in HRK) and price levels in Republic of Croatia. The long run relationship between two price levels was tested by Engle-Granger cointegration test and ADL cointegration test.

Based on Engle-Granger test it can not be concluded whether there is long run relationship between two price levels or not. ADL cointegration test doesn't confirm the existence of long run relationship between two price levels.

Accordingly, on the basis of cointegration tests, it can be concluded that the hypothesis of purchasing power parity is not valid, so the purchasing power parity can not be considered as an adequate method for determining the size of deviations of market exchange rate HRK/EUR from its long run value.

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