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Jon Håkon Findreng
MSc in Financial Economics
Norwegian School of Economics
Norway
E-mail: j.findreng@gmail.com

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RELATIVE PURCHASING POWER PARITY AND THE EUROPEAN MONETARY UNION: EVIDENCE FROM EASTERN EUROPE

ABSTRACT. This paper examine whether relative purchasing power parity holds for Albania, Bulgaria, Croatia, FYR Macedonia, Romania and Turkey versus Germany over the period January 1999 to May 2013. We investigate the real exchange rate by using a Dickey-Fuller test. Thereafter, we investigate the real exchange rate by allowing for a trend with the origin in the Balassa-Samuelson effect. We also investigate the same pairs using the Engle-Granger cointegration test. However, for the Engle-Granger cointegration test, four of the pairs are excluded as the nominal exchange rate and the price differential are not integrated by the same order. We have investigated the half-life of each pair in each of the three approaches. We find ambiguous results both regarding relative PPP and the speed of adjustment towards the PPP equilibrium. We use the results to investigate whether the Albanian, Bulgarian, Croatian, FYR Macedonian, Romanian and Turkish economies are synchronized with the German economy and if they are ready to enter the European Monetary Union.

***JEL Classification*:** E5, E31 F33

Keywords: Consumer Price Index, Monetary Policy, Monetary System, Currency Union, EMU, Exchange Rates, Economic Indicators

Introduction

There is today a wide discussion in Europe concerning which countries to include in the European Monetary Union (EMU) and how these countries (and the EMU itself) will benefit from a membership. Schadler, Drummon, Kuijs, Murgasova and Elkan (2005) argue that, for countries adopting the Euro, the trade-off is between gain in trade and growth and increased volatility as a result of losing the exchange rate as a shock absorber. Further they conclude that for central European countries (CEC), an adoption of the Euro will hasten real convergence and will at most suffer a modest increase in volatility. The basic question comes down to: when and how to adopt the Euro (Schadler, Drummond, Kuijs, Murgasova, & Elkan, 2005).

One deterministic factor for the loss of increased volatility is the optimum currency area (OCA) criteria. The OCA captures the sensitiveness of a country's economy to real shocks that are asymmetric to those in the currency union. The OCA therefore measures how often the Euro-area monetary policy is likely to be different from the monetary policy necessary for the potential incoming country. In other words, the OCA measures whether the economic cycles in the Euro-area and the economic cycles in the potential EMU-client are synchronized. The OCA criteria also focus on how well the potential client can adopt to shocks without their own monetary policy (Schadler, Drummond, Kuijs, Murgasova, & Elkan, 2005).

This paper discusses relative purchasing power parity (PPP) in some of the countries in the Balkan area versus Germany, which is the largest economy in the EMU. Findings that suggest that PPP holds do not automatically suggest that OCA criteria are fulfilled and that the economies are synchronized. However, positive finding in regards of PPP implies that the real exchange rates share common trends and are driven by economic fundamentals. Thus, positive findings of PPP suggest that the analyzed country is suitable to adopt the euro regarding the terms discussed above (Caporale, Ciferri, & Girardi, 2008). The countries examined in this paper are Albania, Bulgaria, Croatia, FYR Macedonia, Romania and Turkey.

Purchasing Power Parity

PPP is the simple idea that arbitrage enforces national price levels to be equal after converted to the same currency (Rogoff, 1996). Rogoff (1996) writes that most economists believe that PPP is a long term anchor for real exchange rates; however, few take PPP seriously as a short term proposition. There are several variants of PPP.

The Law of one Price

The strictest version of PPP is the law of one price (LOP). The LOP states that after converting prices to one common currency, any good should have the same price across countries. The LOP can be expressed as:

$$P_i = EP_i^*,$$

Where P_i is the domestic price of good *i*, E is the nominal exchange rate (expressed as the price of one unit foreign currency in domestic currency) and P_i^* is the foreign price of good *i* (Rogoff, 1996). Even though some internationally traded goods with default standards such as oil, gold, silver and sugar have the same price regardless of the country, it does not take much imagination to come up with examples that violates the LOP. Rogoff (1996) argues that tariffs, transportation costs, and nontariff barriers make the prices differ.

Absolute Purchasing Power

Absolute PPP requires that after converting prices to one common currency, the sum of prices over a consumer price index should be the same across countries. Absolute purchasing power can be expressed as:

$$\sum P_i = E \sum P_i^*,$$

There are several issues related to measuring absolute PPP. Firstly, it is not clear what consumer price index to use. Consumer price indices might vary in different countries. The indices are not only likely to be different by origin, but goods are introduced and taken away as well as consumption weights are shifting. Governments do not follow an internationalized standard index. Secondly, using indices requires a base year. There is no guarantee that the absolute PPP holds in that specific year. As an extreme example, consider a base year where absolute PPP does not hold, but then converges back to absolute PPP during the analyzed time period. The findings would suggest that the data goes away from absolute PPP, while it really went back to true absolute PPP. A solution to solve the problems regarding absolute PPP is to analyze relative PPP (Rogoff, 1996).

Relative Purchasing parity

Relative purchasing parity requires that a change in the nominal exchange rate is offset by a change in the price differential in the two respective countries. If the nominal exchange rate (expressed as the price of foreign currency in domestic currency) increases, the domestic price level must increase similarly relative to the foreign price level. This can expressed as

$$\frac{\sum P_{it}}{\sum P_{it-1}} = \frac{E_t}{E_{t-1}} * \frac{\sum P_{it}^*}{\sum P_{it-1}^*},$$

where t subscripts denote time (Rogoff, 1996).

Relative PPP predicts that the real exchange rate will be constant in equilibrium. This can be expressed as $R^* = \alpha$, where R^* is the real exchange rate in equilibrium and α is a constant equal the real exchange (which depends on costs of international trade). The real exchange rate can be expressed as $R = E * \frac{P^*}{P}$. When the real exchange rate is at its equilibrium level, there is internal and external balance. With deviations from the equilibrium level, internal and external imbalances might occur. These imbalances will bring the real exchange rate back to its equilibrium level. If for example the real exchange rate is above its equilibrium level, the increased domestic competitiveness will increase the trade balance which leads to a higher pressure in the labour market. The increased trade balance will decrease the nominal exchange rate, at the same time as the higher activity level will lead to higher domestic inflation. Both this factors will push the real exchange rate back down to its equilibrium level (Akram Q. F., 2003).

Empirical Evidence

There is an enormous empirical literature on PPP. Researchers have failed over and over again in explaining PPP as a short term relationship. The lack of a short term convergence between nominal exchange rates and prices is partly due to the stickiness in nominal prices. Jakob A. Frenkel (1978) finds some support for PPP as a short term relationship in countries with hyperinflation. Rogoff (1996) argues that this is not surprising given the overwhelming predominance of monetary shocks.

Researchers have also had problems proving a long term relationship for PPP. Rogoff (1996) argues that every reasonable theory suggests that there should be at least some convergence to PPP. Long term monetary neutrality implies that any shock on the real exchange rate should die out on the long run.

Frankel (1986, 1990) argues that in order to prove a long term relationship of PPP, a large data set is required to increase the power in the econometric model. He was able to prove a long-term relationship for PPP using data for the exchange rate between the U.S. and the U.K. over the period 1869-1984. He estimates a half-life of 4.6 years (Rogoff, 1996). There are many contributions that have provided empirical support of mean reversion for real exchange rates. During the 1990s, there were several articles using different econometric approaches. Rogoff (1996) summarizes the empirical literature and notes that the half-life is in the range of three to five years.

Figure 1 displays the real exchange rates of Albania, Bulgaria, Croatia, FYR Macedonia, Romania and Turkey versus Germany over the period January 1999 to May 2013. Visually, it is clear that all real exchange rates are fluctuating and not perfectly constant over the period. In fact, all real exchange rates have appreciated over the period in favor of the Balkan countries.

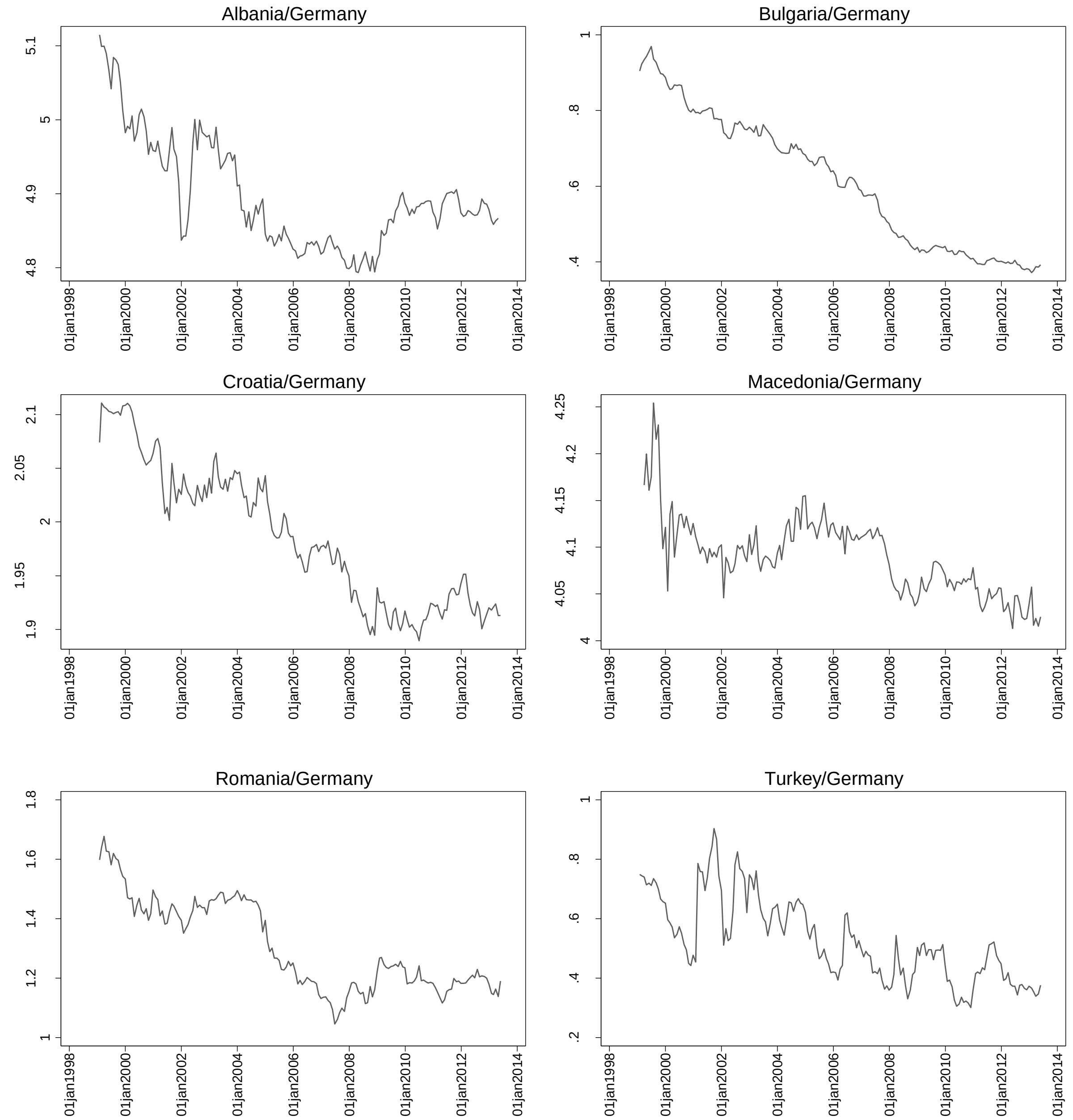
Test of Real Exchange Rates

We can test whether relative PPP holds for a real exchange rate using the Dickey-Fuller test for unit roots. If the null hypothesis for a unit root is rejected, we can state that the real exchange rate is stationary. A stationary real exchange rate implies that the real exchange rate is mean reverting, and that the hypothesis of relative purchasing power holds in the long run. The Augmented Dickey-Fuller test is given by:

$$\Delta r_t = \alpha + \theta r_{t-1} + \delta_1 T + \gamma_1 \Delta r_{t-1} + \cdots + \gamma_p \Delta r_{t-p} + \varepsilon_t,$$

where α is a constant, *r* is the log real exchange rate, *T* is a time trend, $\sum_{i=1}^{p} \delta_i \Delta r_{t-i}$ represents lags, and ε_t is white noise (Kennedy, 2003).[1] Under the null hypothesis that the real exchange rate has a unit root, $\theta = 0$. Under the alternative hypothesis that relative PPP holds in the long run, $\theta < 0$ and $\delta_1 = 0$ (Froot & Rogoff, 1995).

[1] The Dickey-Fuller test is derived in the appendix.



Notes: The figure displays the real exchange rate expressed as $r_t = e_t * \frac{lnCPI^*}{lnCPI_t}$, where e_t is the log of nominal exchange rate, *CPI* is the consumer price index, *t* denotes time and *denotes a Balkan Country. Data is obtained from Bloomberg.

Figure 1. Monthly Real Exchange Rates over the Period January 1999 to May 2013

Table 1 displays the results of the Dickey-Fuller test on all the real exchange rates. This test does not allow for a time trend, and $\delta_1 T$ is therefore excluded from the model. None of the real exchange rates are able to reject the null hypothesis of a unit root. We can therefore not state that relative PPP hold for any of the real exchange rates.

Table 1. Dickey-Fuller test of Real Exchange Rate versus Germany

	Albania	**Bulgaria**	**Croatia**	**Macedonia**	**Romania**	**Turkey**	*Critical Values*		
ADF(q)				*No Trend*			1%	5%	10%

ADF(13)	0.131	0.395	-0.059	0.696	0.119	0.113	-2.590	-1.963	-1.657
ADF(12)	0.107	0.530	0.078	0.672	-0.016	-0.214	-2.590	-1.972	-1.665
ADF(11)	0.127	1.349	0.261	0.856	0.057	-0.297	-2.590	-1.980	-1.673
ADF(10)	0.115	1.501	0.606	0.704	-0.005	-0.616	-2.590	-1.988	-1.681
ADF(9)	0.266	1.839	0.497	0.680	0.112	-0.617	-2.590	-1.996	-1.688
ADF(8)	0.222	1.875	0.407	0.658	0.088	-0.661	-2.590	-2.004	-1.695
ADF(7)	0.124	1.782	0.403	0.374	0.165	-0.713	-2.590	-2.012	-1.702
ADF(6)	0.151	1.839	0.437	0.504	0.289	-0.677	-2.590	-2.019	-1.709
ADF(5)	0.124	2.132	0.138	0.309	0.383	-0.708	-2.590	-2.026	-1.716
ADF(4)	-0.077	1.837	0.231	0.362	0.077	-0.913	-2.590	-2.033	-1.722
ADF(3)	-0.254	1.562	0.003	0.412	-0.029	-1.241	-2.590	-2.039	-1.728
ADF(2)	-0.287	1.678	-0.083	0.348	0.111	-1.301	-2.590	-2.045	-1.733
ADF(1)	-0.236	1.889	-0.133	-0.301	0.113	-1.287	-2.590	-2.051	-1.738
Obs.	158	159	159	157	159	159			

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The test statistics are obtained by using the DFGLS command in STATA.

Even though, none of the real exchange rates are able to reject the null hypothesis of a unit root, we are still able to estimate the speed of how fast a deviation from the equilibrium is adjusted back to the equilibrium level. Table 2 displays the half-life of the real exchange rates estimated by $\frac{\ln 0.5}{\ln(1+\theta)}$, using the coefficient from a Dickey-Fuller test with one lag (Akram Q. F., 2003). The real exchange rate between FYR Macedonia and Germany has a very fast half-life estimation of about 5.3 months, while the real exchange rate between Bulgaria and Germany has a half-life of about 10 years and 9.2 months. These estimates are extremely different and must be treated with caution. The model assumes that the elimination of the deviation caused by a shock happens while all other factors are held still. In reality one can expect shocks to the real exchange rate to happen continuously, leading to a misleading interpretation of the results (Akram, Brunnvatne, & Lokshall, 2003). Looking at the financial turmoil Europe has faced during and after the financial crisis, it seems, in the author's view, that an adjustment with a half-life of several years is slow considering an entrance to the EMU. The Half-Life in the real exchange rates for Albania, FYR Macedonia and Turkey versus Germany are considerably faster than what Rogoff (1996) summarizes as normal based on previous research.

Table 2. Half-Life Based on Dickey-Fuller without a Trend

Country	**Half-life (months)**
Albania	12.5
Bulgaria	131.2
Croatia	37.5
Macedonia	5.3
Romania	28.6
Turkey	9.3

Notes: Half-life is calculated by $\frac{\ln 0.5}{\ln(1+\theta)}$, where the coefficient is obtained from a Dickey-Fuller with one lag.

The Balassa-Samuelson Hypothesis

We were not able to reject the null hypothesis of a unit root for the real exchange rates. Balassa (1964) and Samuelson (1964) argued that rich countries tend to have higher price levels than poor countries. In other words, there can be long term deviations from PPP. The reason for this phenomenon is that rich countries are relatively more productive in the traded sector than poor countries, and that the traded sector is relatively more technological innovative than the non-traded sector. For illustration, we can analyze the development of a poor and a rich country where the currency is fixed. If the rich country experiences more technological innovations in the traded sector, wages will increase in this sector, but prices will not increase because they are bound by international trade and the fixed exchange rate. If the country does not experience the same technological innovations in the non-traded sector, the non-traded sector will have to increase the prices to increase their wages similarly. In other words, the prices has increased in the non-traded part of the consumer price index, and the consumer price index as a whole will increase relatively to the poor country that has not experienced the same development (Rogoff, 1996). The real exchange rate between the two countries is given by

$$R = E * \frac{R.CPI}{P.CPI},$$

where E is the fixed nominal exchange rate (measured by the price of one unit of the rich county's currency in the poor country's currency), $R.CPI$ is the rich country's CPI and $P.CPI$ is the poor country's CPI. If the situation described above occurs and all other variables held fixed, the rich country's CPI will increase. This will lead to an appreciation of the real exchange rate for the rich country.

Table 3. Augmented Dickey-Fuller test With Trend on Real Exchange rates versus Germany

	Albania	**Bulgaria**	**Croatia**	**Macedonia**	**Romania**	**Turkey**	*Critical Values*		
ADF(q)			*With Trend*				1%	5%	10%
ADF(13)	-0.804	-2.135	-2.778*	-1.814	-1.668	-2.764*	-3.492	-2.800	-2.524
ADF(12)	-0.844	-1.961	-2.529	-1.845	-1.911	-3.342**	-3.492	-2.816	-2.538
ADF(11)	-0.818	-1.163	-2.328	-1.671	-1.748	-3.424**	-3.492	-2.831	-2.552
ADF(10)	-0.840	-1.129	-2.048	-1.834	-1.883	-4.038***	-3.492	-2.846	-2.566
ADF(9)	-0.648	-1.002	-2.205	-1.866	-1.603	-3.878***	-3.492	-2.860	-2.579
ADF(8)	-0.704	-1.098	-2.347	-1.899	-1.646	-3.831***	-3.492	-2.874	-2.591
ADF(7)	-0.825	-1.258	-2.391	-2.260	-1.512	-3.808***	-3.492	-2.887	-2.604
ADF(6)	-0.785	-1.330	-2.391	-2.094	-1.306	-3.596***	-3.492	-2.899	-2.615
ADF(5)	-0.825	-1.240	-2.858*	-2.286	-1.184	-3.550***	-3.492	-2.911	-2.626
ADF(4)	-1.136	-1.612	-2.706*	-2.238	-1.626	-3.874***	-3.492	-2.923	-2.636
ADF(3)	-1.427	-1.963	-3.133**	-2.185	-1.775	-4.451***	-3.492	-2.933	-2.646
ADF(2)	-1.469	-1.932	-3.300**	-2.229	-1.586	-4.375***	-3.492	-2.943	-2.655
ADF(1)	-1.391	-1.801	-3.381**	-3.033**	-1.583	-4.157***	-3.492	-2.953	-2.663
Obs.	158	159	159	157	159	159			

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The test statistics are obtained by using the DFGLS command in STATA.

We can allow for the Balassa-Samuelson effect in the real exchange rate by re-running the Dickey-Fuller test on the real exchange rates, but this time including a time trend. In other words, we do not need the criteria of $\delta_1 = 0$. A rejection of the null hypothesis of a unit root will imply that the real exchange rate is mean reverting around a trend. This does not mean that relative PPP holds, but that the deviations can possibly be explained by the Balassa-Samuelson effect. However, a rejection of the null hypothesis can also be a result from other factors.

Table 3 displays the Dickey-Fuller test on all the same real exchange rates with a time trend. The results are now different. Turkey, FYR Macedonia and Croatia are able to reject the null hypothesis. Turkey has significant values for all lags, and has significant values at the one percent level for lag 1 to 10. Croatia is able to reject the null hypothesis of a unit root at the 5 percent level for the model with 1, 2 and 3 lags and at the 10 percent level for 4, 5, and 10 lags. FYR Macedonia is able to reject the null hypothesis at the 5 percent level with 1 lag.

Table 4 displays the half-life based on the Dickey-Fuller test with one lag and a trend. The half-life is now reduced enormously for each real exchange rate. FYR Macedonia, Turkey and Croatia have half-life of 2.3, 3.8 and 5.1 months. The deviations are reduced very fast. Most striking is perhaps the reduction from 131.2 months to 10.4 months for Bulgaria after including a trend in the Dickey-Fuller test. The decrease can most likely be explained by the strong trend in the Bulgarian-German real exchange rate.

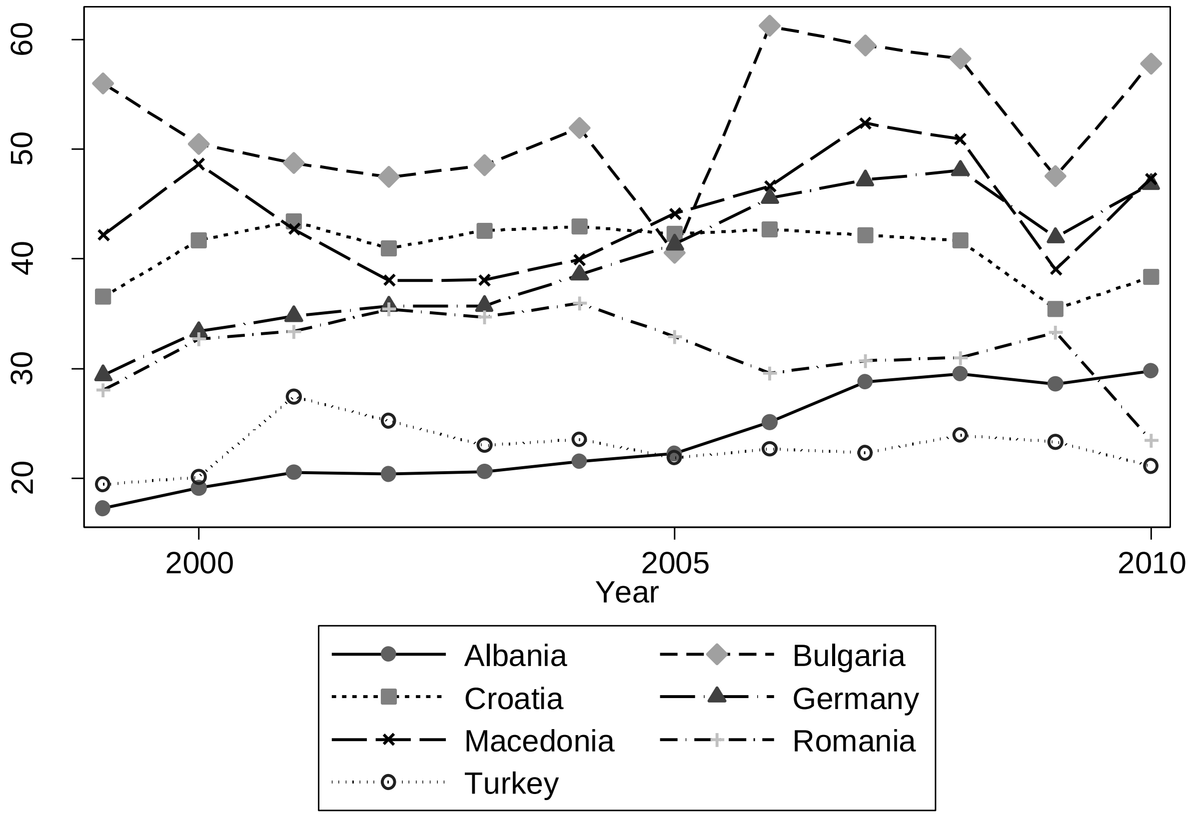
A mean reverting real exchange rate around a trend indicates that the economies are facing the same shocks. However, it is clear from *Figure 1* that Croatia, FYR Macedonia and Turkey have increased their purchasing power versus Germany over the period. If these countries adopt the euro and the trend continuous, the inflation will grow more rapidly than in Germany. If the increase in the consumer price index can be explained by the Balassa-Samuelson Hypothesis, this growth will last until Croatia, FYR Macedonia and Turkey reach the same level as Germany in the traded sector. In other words, it seems like the three economies are moving in the right direction in terms of entering the EMU. The argument that the economics are exposed to the same shocks is a strong one, and this is also the background for this paper. However, it is likely that they will face different development in inflation and an independent monetary policy is favorable until the relationship in relative PPP is stable without including a trend.

Figure 2 graphs the export as a percentage of total GDP. It is likely that a technological improvement in the traded sector relative to the non-traded sector will increase export as a part of GDP. Interestingly, the countries with the highest increase are Albania and Germany. A high increase in German technology in the traded sector should implicate a positive trend in the real exchanger rate towards the other countries. From figure 1, it is clear that all real exchange rates decrease. By the visually impression of *Figure 2*, it seems like the trending real exchange rates cannot be explained by the Balassa-Samuelson hypothesis. Égert, Drine, Lommatzsch and Rault (2003) use an econometric approach on the Central and Eastern Europe countries and find that the appreciation in the real currency for countries that technological innovative can only be limitedly explained by the Balassa-Samuelson effect.

Table 4. Half-Life Based on Dickey-Fuller test with a Trend

Country	**Half-life (months)**
Albania	10.4
Bulgaria	19.0
Croatia	5.1
Macedonia	2.3
Romania	14.3
Turkey	3.8

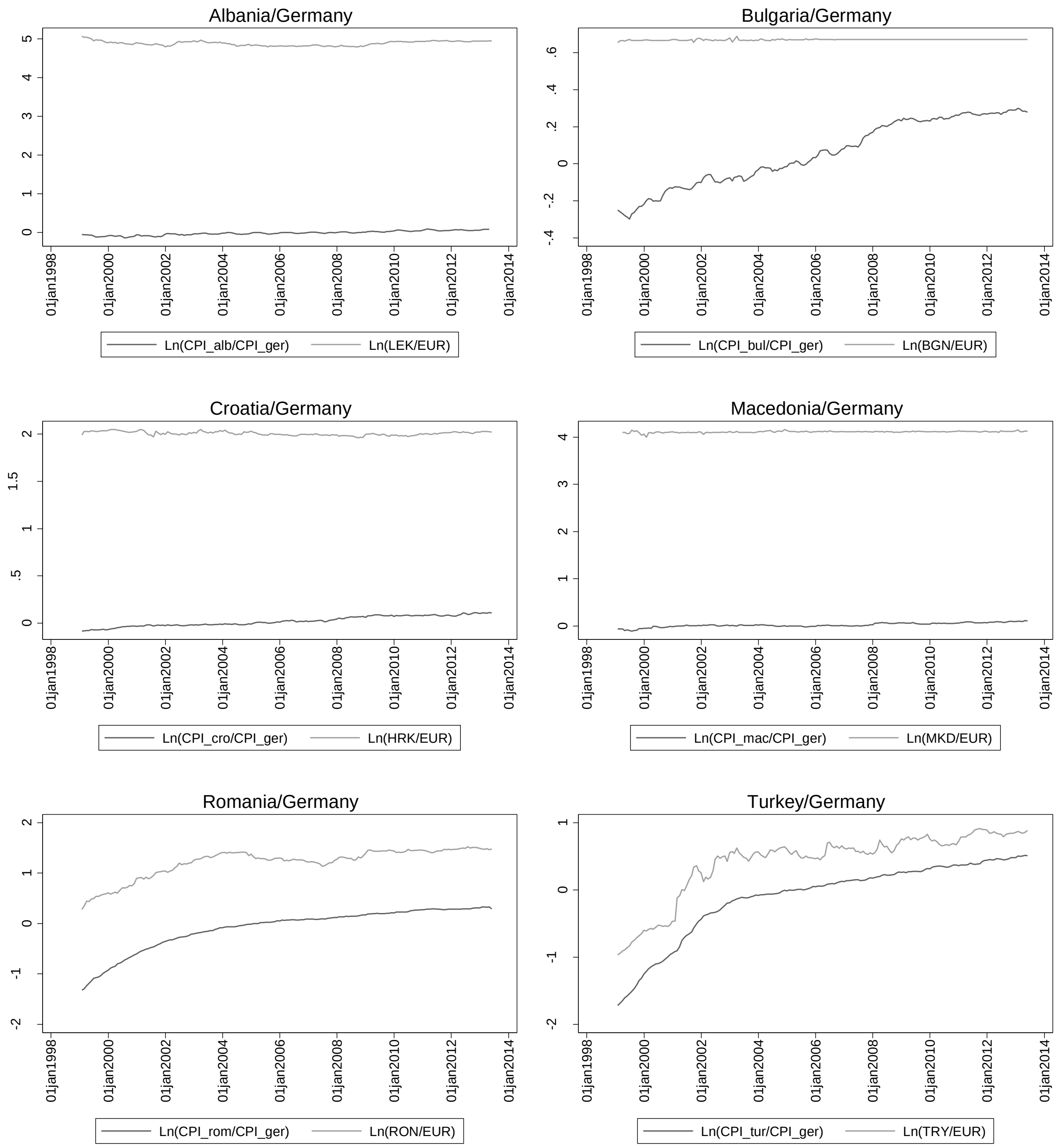
Notes: Half-life is calculated by $\frac{\ln 0.5}{\ln(1+\theta)}$, where the coefficient is obtained from a Dickey-Fuller with one lag and a trend.



Notes: Data obtained from the World Bank.

Figure 2. Export as a Percentage of GDP

Figure 3 displays the development in nominal exchange rates and price level differentials between Albania, Bulgaria, Croatia, FYR Macedonia, Romania and Turkey versus Germany. It is clear that the nominal exchange rate is more volatile than the price differentials for all pairs. This suggests that price levels are sticky relatively to the nominal exchange rates. For the Bulgaria-Germany relationship, it seems like the two series are not dependent on each other. The nominal exchange rate has increased rapidly, while the price differential has followed a relatively straight line. For the Turkey-German relationship it seems like the two series follow each other quite closely. For the remaining pairs, it is harder to determine whether the graph indicates relative PPP.



Notes: The graph shows the relationship of the log nominal exchange rate and the log price differential in the Balkan countries versus Germany. A close relationship between the series indicates relative PPP.

Figure 3. Monthly Nominal Exchange Rates and Price Levels over the Period January 1999 to May 2013

Cointegration Test

If the nominal exchange rate and the price differential follow a random walk, a regular OLS regression of the nominal exchange rate on the price differential can produce spurious regression results. To solve this problem, we can use the Engle-Granger cointegarion test to test for any linear combination of the two time series (Wooldrigde, 2009).[2] By using the Engle-Granger test for cointegration, we test a weaker form of relative PPP. The Enge-Granger test is designed to test whether there is a long-run equilibrium relationship between two series. However, the adjustment mechanism is not specified (Froot & Rogoff, 1995). We

[2] See the Appendix for a discussion about spurious regressions and the Engle-Granger cointegration test.

are using a bivariate test where we test the relationship between the nominal exchange rate and the development of the price differential.

The procedure consists of three steps. The first step is determining whether the time series are integrated by the same order. *Table 8* in the appendix displays the result of a Dickey-Fuller test for unit roots on the time series in level form. The exchange rate between Germany and Bulgaria, Germany and Croatia, Germany and FYR Macedonia and the price differential between Albania and Germany are rejecting the null hypothesis of a unit root. These series are therefore stationary. *Table 9* displays the Dickey-Fuller test on all times series in their first difference form. All series are able to reject the null hypothesis of a unit root. Thus, we are left with Romania and Germany and Turkey and Germany being the only two pairs were both the price differential and the exchange rate integrated of order one. No other pairs are integrated with the same order. Note that if we had a pair where both series were integrated with order zero, we could use a regular OLS regression to test for relative PPP.

The second step involves a regression of the nominal exchange rate on the price differential. The OLS regression is given by $e_t = \beta \frac{cpi}{cpi}{}_t^*$, where e_t is the log nominal exchange rate, and $\frac{cpi}{cpi}^*$ is the log price differential (* denotes a Balkan country) and *t* denotes time.

The third step involves obtaining the residual from step two and then tests the residual for a unit root using the Dickey-Fuller test. *Table 5* displays the results from the Dickey-Fuller test on the residuals. The residual from the relationship between Turkey and Germany is able to reject the null hypothesis of a unit root at the one percent significance level for 1 to 10 lags, at the five percent significance level for 11 and 12 lags, and at the ten percent level for 13 lags. This implies that the there is a linear relationship between the log price differential and the log nominal exchange for the Turkey-Germany relationship. In other words, Turkey-Germany passes the weak form of relative PPP. The cointegration test is not able to reject any unit root for the residual in the Romania-Germany relationship. Thus, we do not find any statistically proof of relative PPP between Romania and Germany. Considering that we are still not able to prove relative PPP between Romania and Germany using a weaker test implies that Romania is not ready to enter the EMU.

Table 5. Engle-Granger Cointergration test

Lags	**Romania**	**Turkey**
13	-1.321	-1.820
12	-1.480	-2.214
11	-1.368	-2.315
10	-1.482	-2.769
9	-1.304	-2.719
8	-1.338	-2.739
7	-1.249	-2.765
6	-1.107	-2.643
5	-1.022	-2.644
4	-1.338	-2.910
3	-1.447	-3.381**
2	-1.335	-3.389**
1	-1.316	-3.254**
Obs.	159	159

Notes: Augmented Dickey-Fuller test statistic on the residual from the OLS regression $e_t = \beta \frac{cpi}{cpi}^*_t$. The statistics are found by using the DFGLS command in STATA. The critical values for Engle-Granger cointegration test are -3.90, -3.34 and 3.04 on significance level 1, 5 and 10, respectively.

Table 6 displays the result of an error correction model using the results from the cointegration test. The error correction model is given by

$$\Delta e_t = \alpha_0 + \beta_1 \Delta \frac{cpi^*}{cpi}_t + \delta_1 \left(e_{t-1} - \frac{cpi^*}{cpi}_{t-1} \right) + \varepsilon_t.$$

Note that $\left(e_{t-1} - \frac{cpi^*}{cpi} \right)$ equals the residual from the OLS regression in step two of the Engle-Granger cointegration test. The results from the error correction model suggest how fast a deviation between the equilibrium-level between the two variables is reduced back to equilibrium. The results between Romania and Germany suggest that a deviation from the equilibrium level last month, between the nominal exchange rate and the price levels, is reduced by 4.8 percent this month. The result is significant at the one percent significance level. The similar result for Turkey-Germany is 10.6 percent, which is significant at the five percent significance level.

Table 6. Error Correction Model

	$\Delta ln \frac{RON}{EUR_t}$	$\Delta ln \frac{TRY}{EUR_t}$
$\Delta ln \frac{CPI *}{CPI}_t$	0.466**	0.583*
	(0.146)	(0.225)
$(lnE_{t-1} - ln \frac{CPI^*}{CPI}_{t-1})$	-0.048*	-0.106**
	(0.023)	(0.037)
Constant	0.003	0.003
	(0.002)	(0.005)
N	172	172

Standard errors in parentheses. $^* p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

Table 7 provides results of our estimations on half-life based on the error-correction model. The half-life for Romania-Germany and Turkey-Germany are both relatively fast with 14.1 and 6.2 months respectively. In comparison with the results based on the Dickey-Fuller test in *Table 2*, these estimations imply a much faster reduction of deviations from PPP. However, the results from the error-correction model are more comparable to the results in *Table 4*, as the error-correction model does not put any requirements on the linear relationship between the two variables. The results for Romania-Germany are quite similar, while the results from Turkey-Germany were 3.8 months in Table 4 and 6.2 months from the error-correction model.

Table 7. Half-Life Based on the Error-Correction Model

Country	**Half-life (months)**
Romania	14.1
Turkey	6.2

Notes: The table displays the half-life for deviations in the equilibrium level between price levels and nominal exchange rates in the respectively countries versus Germany. Half-Life is calculated by $\frac{ln 0.5}{\ln(1-\beta)}$, where β is the coefficient on the error-correction term in *Table 6*.

Conclusion

This paper has examined whether relative PPP has been present in Albania, Bulgaria, Croatia, FYR Macedonia, Romania and Turkey versus Germany over the period January 1999 to May 2013. The results are ambiguous. By using a Dickey-Fuller test on the real exchange rate between the pairs indicates no PPP over the period. If we are allowing for the real exchange rate to follow a trend, we find that the real exchange rate is mean reverting for Croatia-Germany, FYR Macedonia-Germany and Turkey-Germany. The economic reasoning behind allowing for a trend origin in the Balassa-Samuleson effect, however, by graphing the export as a ratio of GDP, it does not seem that the Balassa-Samuelson effect is present. Nevertheless, these results imply that Croatia, FYR Macedonia and Turkey follow the same economic cycles as Germany. This should imply that their monetary policy should be synched with the ECB in terms of shocks to their economies. However, if they enter the EMU and the trend in real exchange rates continues, they will have a higher inflation growth than Germany. Depending on the outcast for their inflation, it does not seem feasible for the Croatia, FYR Macedonia and Turkey to give up their own monetary policy just yet.

We have also investigated relative PPP by using the Engle-Granger test for cointegration. Four out of the six pairs where excluded as the price differential and the nominal exchange rate were not integrated by the same level. The Engle-Granger cointergration test suggests that PPP holds over the period for the Turkey-Germany relationship.

We have calculated the half-life for all pairs with origins in the Dickey-Fuller test for the real exchange rate without a trend and with a trend. In addition we have calculated the half-life with the origin in an error-correction model. The results are ambiguous, but the error-correction model and the Dickey-Fuller test with a trend have more rapid half-lives than the Dickey-Fuller test without a trend. An interesting topic that is not addressed in this paper is how fast a deviation from relative PPP versus the countries in EMU needs to be adjusted before a specific country is ready to enter the EMU.

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Appendix

Unit Roots

A stationary series has a probability distribution that is stable over time. A stationary process has mean, variance and covariance independent over time. Therefore, the mean and variance are constant over time. The covariance restriction implies that the covariance between two points depends only on the distance between them and not on time (Wooldrigde, 2009).

Often a non-stationary process is said to be a time series that has a unit root. Some carefulness is needed regarding this statement. A time series that grow over time violates the constant mean requirement that is necessary for a stationary series. However, the time series does not need to have a unit root. Removing the trend will make the series trend stationary if it does not have a unit root. If the series become stationary after differencing (before or after removing a time trend), the series is integrated of order one (Kennedy, 2003).

A time series that can be described by $y_t = y_{t-1} + \varepsilon_t$, has a unit root. The value of y is last period's value of y plus an error term, ε_t. We can see that the value y_t can be found by $y_t = y_0 + \sum_{i=1}^{t} \varepsilon_t$. It is therefore clear that a shock in the error term is persistent. On the contrary, if the coefficient on y_{t-1} is less than unity, the shock would not be persistent and would die out (Kennedy, 2003).

Testing for Unit Roots

We can test for unit roots using the Dickey-Fuller test by inserting the variable of interest into an AR(1) model:

$$y_t = \alpha + py_{t-1} + \varepsilon_t,$$

where y_t is the time series with the expected unit root, α is the constant and ε_t is the error term assumed to follow independent identical distributed with zero mean and independent of y_0. If $p = 1$, y_t has a unit root and follows a random walk. If in addition $\alpha \neq 0$, y_t follows a random walk with a drift. If we subtract y_{t-1} from both sides of the equation we obtain

$$\Delta y_t = \alpha + \theta y_{t-1} + \varepsilon_t$$

where $\theta = p - 1$. It is now straight forward to test H_0: $\theta = 0$ against H_1: $\theta < 0$. The null hypothesis implies that $p = 1$. Thus, the null hypothesis implies that the variable has a unit root. The alternative hypothesis implies that p is less than unity and that the variable is stationary. We do not consider values for p above unity, because it would be unreasonable as it would make the time series to explode (Wooldrigde, 2009).

If the variable has a unit root, we cannot use the central limit theorem because the probability distribution is not stable over time. Thus we cannot use the standard normal distribution. However, we can still use the regular t-statistics, but they must be compared with critical values form the Dickey-Fuller distribution (Wooldrigde, 2009).

If the data generating process is an autoregressive process of higher order than one, we can easily extend the test to include additional lags. After subtracting y_{t-1} from both sides, the augmented Dickey-Fuller test is given by

$$\Delta y_t = \alpha + \theta y_{t-1} + \gamma_1 \Delta y_{t-1} + \cdots + \gamma_p \Delta y_{t-p} + \varepsilon_t.$$

The interpretation of the results is still the same. However, the critical values for the t-statistics change (Wooldrigde, 2009).

If we expect series to follow a trend, we can include a time trend and check whether the series is trend-stationary. The augmented Dickey-Fuller test with a time trend is given by

$$\Delta y_t = \alpha + \theta y_{t-1} + \delta_1 T + \gamma_1 \Delta y_{t-1} + \cdots + \gamma_p \Delta y_{t-p} + \varepsilon_t.$$

If the series has a trend, the Dickey-Fuller test has little power for rejecting a unit root (Wooldrigde, 2009).

Spurious Regressions

The spurious regression problem occurs when two independent I(1) processes are regressed on each other. The regression will often establish a false significant relationship between the two variables (Wooldrigde, 2009). If the residual from the regression follows a random walk, the t-statistic does not have an asymptotic normal distribution (Verbeek, 2012). To see why the residual follows a random walk, consider two non-stationary variables $y_t = y_{t-1} + e_1$ and $x_t = x_{t-1} + a_t$. A regression of y on x can be written as

$$y_t = \beta_0 + \beta_1 x_1 + u_t.$$

The null hypothesis is given by $\beta_1 = 0$. Because the two variables are independent, the null should hold. The equation can be rewritten as $y_t = \beta_0 + u_t$. Under the null hypothesis $\beta_1 = 0$ and therefore $y_t = \beta_0 + u$. Because y_t follows a random walk, the null hypothesis holds if β_0 equals zero and $u_t = y_t = \sum_{j=1}^{t} e_j$. Thus u_t is a non-stationary variable (Wooldrigde, 2009).

Engle-Granger Cointegration Test

Engle and Granger (1987) cointegration test can be used to see whether there exists a relationship between two variables that are both integrated by order one. If x and y are both I(1) processes and independent of each other, then $y_t - \beta x_t$ is an I(1) process for any number of β. If the two series are not independent, $y_t - \beta x_t$ is an I(0) process. In the latter case, the two variables are cointegrated and β is the cointegration parameter (Wooldrigde, 2009). The method is therefore to run the variables through an OLS regression and obtain the residual. The residual is then tested by a Dickey-Fuller test for unit roots, but with specified critical values. Note that the residual is not allowed to follow a trend.