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Persistence and stochastic convergence of euro area unemployment rates: evidence from LM and RALS-LM unit root tests with breaks

Persistence and stochastic convergence of euro area unemployment rates: evidence from LM and RALS-LM unit root tests with breaks*

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Abstract

The goal of this paper is to determine if the euro area (EUA) accession and membership had a significant impact on the unemployment rates of the EUA countries. The hypothesis of the paper is that there is unemployment hysteresis and EUA accession thus contributed to the economic integration and convergence of the unemployment rates in the EUA. The paper employs LM and RALS-LM unit root tests with two breaks to analyze the persistence, test the stochastic convergence and locate structural break(s) in the seasonally adjusted quarterly unemployment rates, covering the period from 1995q1 to 2016q2. The most interesting results are that: (i) there are EUA-related down breaks in unemployment rates with hysteresis, (ii) EUA-related breaks are followed by the periods of convergence to the EUA11 average, (iii) crisis-related breaks are followed by the periods of divergence and (iv) the EUA membership is not a sufficient condition for stochastic convergence.

Key words
Unemployment, Euro area, Hysteresis, Stochastic convergence, Unit root, Structural breaks

JEL classification
E24, F45, O52

1. Introduction

The euro area (EUA) represents a group of European Union (EU) member countries that have adopted euro as their national currency. It was envisioned to function as an optimal currency area (OCA), thus benefiting the member countries with full employment, low inflation and balance of payments balances (Mundell, 1961, McKinnon, 1963, Kenen, 1969). In addition, the member countries were also supposed to see the benefits of better adjustment mechanism after a shock. However, the recent financial crisis revealed that this adjustment mechanism was impaired. (De Grauwe, 2011, Krugman, 2012)

This paper contributes to the debate on the functioning of the EUA by empirically testing for the evidence on the expected EUA accession benefits. More specifically, the goal of this paper is to determine if the euro area (EUA) accession and membership had a significant impact on the unemployment rates of the EUA countries. The hypothesis of the paper is that thanks to unemployment hysteresis EUA accession contributed to the economic integration and convergence of the unemployment rates in the EUA.

The empirical literature on the persistence of shocks in the unemployment rates i.e. unemployment hysteresis in the European countries in general is rich but inconclusive (e.g. Bayer and Juessen, 2007, Monfort et al., 2016). It is thus not clear whether demand side shocks would have a permanent effect on the unemployment rates. If one assumes that EUA accession is a positive demand side shock (yielding positive employment benefits as stated earlier), and if there is an unemployment hysteresis, one can expect EUA accession to cause a positive shock represented by a structural break in the unemployment rates series and a subsequent decrease in unemployment rates. There is, however, no existing empirical literature that looks for EUA-related shocks in the unemployment rates of the EUA countries and relating it to the issue of unemployment hysteresis.

Furthermore, the issues with the EUA member countries' adjustment mechanism during the financial crisis has been elaborated quite extensively (e.g. Blanchard, 2007, De Grauwe, 2011, Krugman, 2012, Pelin et al., 2012, Estrada et al., 2013, Rey, 2015). However, stochastic convergence testing has so far, to best of our knowledge, not been used to find evidence on just how much this adjustment mechanism breakdown is EUA related. What is needed is the evidence on precisely what role the EUA membership plays or doesn't play in the convergence patterns i.e. adjustment capabilities of its member countries.

In order to fill these literature gaps this paper uses two-break LM unit root test proposed by Lee and Strazicich (2003) and RALS-LM test proposed by Meng et al. (2016). Unit root testing gives us answers on the unemployment hysteresis and stochastic divergence hypotheses, while structural break testing endogenously determines the break locations that are then further discussed in light of the EUA accession and the financial crisis.

The remainder of the paper is structured as follows; in Section 2 we provide a review of the existing literature; in Section 3 we provide data explanation and outline the used methodology; Section 4 provides the results of the analysis; Section 5 discusses the results, and finally Section 6 provides some summary remarks.

2. Literature review

Euro area (EUA) represents an integration of nineteen European Union (EU) member states that have adopted euro as their currency after fulfilling the so-called convergence criteria. All of the EU member states are the part of Economic and Monetary Union (EMU) since they all coordinate their economic and fiscal policies and share a common monetary policy.

In the economic core of EUA creation, there is a need to create a unique and integrated system that will stabilize economic shocks. In economic terms, this implies that the EUA should function as an optimal currency area (OCA)[1]. But, the recent global financial crisis (that represents a shock) has shown differently. Namely, the recent crisis in the euro area has shown that an unsustainable system has been created, which contributes to even greater differences among member states (e.g. de Grauwe (2011), Estrada et al. (2013), Marelli and Signorelli (2015)). The introduction and retention of the euro thus becomes the main center of the debate among economists and politicians across the EU, but also wider[2].

[1] According to the theory of the OCA (Mundell, 1961, McKinnon, 1963, Kenen, 1969), the optimal currency area is one that can at the same time achieve full employment, low inflation and balance of payments balances. If countries are heavily commercially linked, then there is a motivation for introducing a common currency. There are two basic criteria for countries to establish the OCA. The first is that the shocks they face are symmetrical. If they are faced with asymmetric shocks, then labor mobility should be high in the entire area (Mundell's criterion). The conditions for the functioning of the optimal currency area have been extended, for example, with the requirement that member states have a centralized fiscal system that ensures the transfer of money to shock-affected countries. More about the research on the subject of the OCA can be found in Broz (2005).

[2] The recent global financial crisis is neither the first nor the last crisis that economies face. The reason why economists find it to be intriguingly is due to the strength and duration of recent crisis. At the end of 2009, Krugman wondered why none of the economists had predicted the crisis, despite the known fact of the existence of the cycles (Krugman, 2009). Among the controversial issues, one topic that was particularly pronounced, and still is, is the issue of the euro area and its failure to function as an optimal currency area (OCA).

The EUA is only a monetary union but is not an OCA because the EUA member states are not affected by symmetric shocks (some countries were hit by crisis more than others), there is low labor mobility, countries are not involved in a common fiscal system, inflation rates are different and salaries and prices are rigid[3]. Because of the failure of the EUA to function as the OCA, the member states face difficulties in adjustment mechanism after some shock occurs (De Grauwe, 2011, Krugman, 2012). Adjustment issues are linked to different growth rates of member states, decentralized fiscal policy and the differences that exist in labor market institutions among the member states. This is particularly reflected in the differences in unemployment rates between member states and in external imbalances. If there are large differences between the labor market institutions across countries, the same shock will affect price and employment levels in each country differently and impose costs, as countries can no longer rely on their own exchange rate policy. Certain studies have shown that economies having a flexible exchange rate have been better off in crisis compared to fixed-rate economies (e.g. Pelin et al., 2012, Rey, 2015).

Prior to the crisis, most of the scientific studies on the functioning of EUA (and EU in general) have focused on monetary policy and the costs and benefits of introducing a common currency have been seen in the context of a country's successful adjustment to the fixed exchange rate. However, since the crisis the focus has turned to labor markets. These studies state that the reason for the failure of the EUA to be the OCA can be found in the mechanism of labor market institutions (ECB, 2012, Eichhorst et al., 2010). Namely, labor mobility is the prevailing adjustment mechanism. Temporary adjustments in growth lead to temporary fluctuations in relative unemployment. When job seekers move to other areas, the labor market adjusts itself towards a long-run equilibrium and, therefore, there is a convergence of regional unemployment rates (Blanchard and Katz, 1992). If labor mobility mechanism worked in EUA, unemployed people from countries that are more affected with the crisis would find jobs in countries that were less affected or not affected by crises. Over time, this would mean that countries should be returning to their natural level of unemployment, which they are not (European Commission, 2015).

In order to achieve the optimal functioning of the EUA, the convergence between European countries in real and not only in nominal terms is one of the basic aims of the EU Treaty. This is the reason why it is important to identify the policy measures that one country must

[3] If the EUA was an optimal currency area, then the member states would be affected by symmetrical shocks or, in the case of asymmetric shock, the labor market mechanisms would make it easier to adjust. In the case of the EUA, neither has happened.

implement within EU guidelines. Because of country's heterogeneity, "one size fits all" policy should be replaced with adjusted measures for groups of countries in such union. To do so, as a starting point it is important to analyze whether macroeconomic series (such as unemployment rates as an indicator of labor market functioning) for different countries converge or diverge from the most successful member country.

Our research investigates further into this subject of whether EUA functions optimally. First, is the unemployment in the EUA countries returning to its natural level? And second, is there evidence of convergence of the unemployment rates between the EUA countries. The existing literature on the subject is extensive and briefly analyzed in the remaining part of the literature review.

Regarding the return of the unemployment to its natural level, the debate is not new. Namely, Friedman (1968) suggested that unemployment is a stationary process (so-called NAIRU[4] hypothesis). According to him the shifts caused by a monetary policy or some other sources from the demand side have only short-run impacts on unemployment which returns to its natural rate, determined by the supply side of the economy[5]. On the other hand, Blanchard and Summers (1986) stress the hysteresis hypothesis which states that unemployment rates might be permanently affected by the cyclical fluctuations in the labor market causing them to be non-stationary. Demand influences unemployment which then influences the natural rate of unemployment. Most of the earlier research, using various unit root tests, was not able to reject the hysteresis hypothesis (e.g. Neudorfer et al. (1990) for Austria, Jaeger and Parkinson (1994) for the UK, USA, Canada and Germany, Mitchell (1993) for selected OECD countries).

After controlling for the structural breaks using Perron's (1997) test on the Central and Eastern European unemployment rates, Léon-Ledesma and MacAdam (2004) conclude that evidence on hysteresis hypothesis weakens. Arestis and Mariscal (1999) rejected hysteresis hypothesis for the majority of the analyzed OECD countries using Lumsdaine and Papell's (1997) methodology, an extension of Zivot and Andrews (1992) unit root test methodology with structural breaks. Papell et al. (2000) also rejected the unit root null in 10 OECD countries after controlling for the structural changes.

[4] Original meaning is „non-accelerating inflation rate of unemployment", but today called in short just „natural rate of unemployment".

[5] Phelps (1994) augments this theory by suggesting that there may be some permanent changes to the natural rate of unemployment but they are rare and occasional. Most of them are temporary which would make unemployment stationary process with a presence of few structural breaks.

Using panel unit root tests in selected OECD countries Song and Wu (1997, 1998) as well as Lee et al. (2001) rejected the hysteresis hypothesis. On the other hand, Chang et al. (2005) confirmed hysteresis hypothesis for 8 out of 10 European countries using the seemingly unrelated regressions augmented Dickey-Fuller test (SURADF) by Breuer et al. (2001).

More recent non-linear approaches have also been showing some mixed results. Alonso and Sanzo (2011) find evidence on hysteresis for Italy, France and the US using a non-linear, regime switching approach. Chang's (2011) results of a stationarity test with a Fourier function also support hysteresis hypothesis for the most of the analyzed OECD countries from 1960 to 2009. Meng et al (2017) using various linear and non-linear unit root tests, with and without structural breaks find permanent effects of shocks to unemployment in 11 out of 14 analyzed OECD countries. Lee (2010) on the other hand finds evidence that supports natural rate of unemployment hypothesis for 23 of 29 OECD countries using non-linear panel unit root test.

The results on the hysteresis hypothesis are obviously not conclusive, but as Ball (2009) concludes, it is clear that some form of hysteresis exists. He suggests that when hysteresis exists, it is dangerous for central banks to focus policy too heavily on inflation since they might create a needlessly high unemployment in the process of achieving their inflation targets. However, if natural rate of unemployment is independent of monetary policy, focusing on inflation can at worst exacerbate short-run unemployment movements. This issue is obviously of great importance for the analysis of the unemployment rates in the context of the EUA accession which requires its potential member states to target their inflation rates at most at the HICP[6] reference value[7]. So one would expect, if the hysteresis holds, to find breaks in unemployment rates series around the time of EUA accession driving the unemployment rates up (due to requirements of lower inflation). If there is no hysteresis, it is less likely there would be any significant breaks around that time.

Regarding the existing research on convergence, there are empirical studies which support the evidence of convergence of unemployment rates convergence after or due to EUA accession. However, the extensive literature on economic convergence in the EU focuses mostly on per capita income or other related income and productivity measures. For example, Pesaran (2007) states that the question of output per capita convergence has played a central role surrounding the European integration and its sustainability. The main reason for the non-convergence results

[6] Harmonized Index of Consumer Prices

[7] HICP reference value is calculated as the unweighted arithmetic average of the similar HICP inflation rates in the 3 EU member states with the lowest HICP inflation plus 1.5 percentage points.

appears to be highly persistent country specific unobserved factors. GDP per capita convergence in the 28 EU member states is analyzed by Simionescu (2015), and the overall convergence hypothesis is rejected. However, four convergence clubs are identified with a clear difference between the founding EU member states and CEEC economies. Carvalho and Harvey (2005) identified two convergence clubs in euro zone area for real GDP per capita: club of low-income countries (Greece, Portugal, Spain) and high-income countries' club (Austria, Finland, and 5 core economies). Brada et al. (2005) concluded that there are limited advantages offered by EMU accession, studying the real GDP and monetary aggregate convergence in CEEC. These results are also supported in Monfort, Cuestas, and Ordóñez (2013).

However, the convergence analysis can be extended to other areas of economics such as unemployment (Quah, 1996). In order to test the convergence hypothesis, Bayer and Juessen (2007) applied unit root tests on the relative unemployment rate of the country (Germany) and found a strong evidence of convergence of its federal states.

Monfort et al. (2016) used cluster analysis to examine the convergence patterns of income inequality, absolute redistribution, and unemployment. They point out that the expected outcome after years of economic integration was convergence to a single cluster. But results, however, uncover a variety of groups, implying that economic integration has not led to real economic convergence.

Such results are also supported by Soukiazis and Castro (2005), who examined how the Maastricht obligations and the Stability Pact restrictions have affected the process of real convergence for living standards, productivity, investment and unemployment among the European countries. They used panel data estimation techniques to detect any significant influence (favorable or not) of the Maastricht rules on real convergence.

Estrada et al. (2013) analyze the extent of macroeconomic convergence/divergence among euro area countries. They focused on four variables (unemployment, inflation, relative prices, and the current account) and seek to determinate the role played by the monetary union as a convergence factor. Authors pointed out that, especially during the last recession, the EMU has not prevented a dramatic surge in the dispersion of unemployment rates within the euro area. In fact, the increase in dispersion across EUA countries has been much larger than for noneuro countries. The results support the hypothesis that the common currency in its initial design and the lack of country-specific monetary policies or stabilizing risk-sharing devices to

accommodate country-specific shocks may have been a factor behind the large differences in unemployment performance.

As this literature review shows, the existing literature has not analyzed the stochastic convergence of the unemployment rates in the EUA in a way that consistently connects it with the monetary shocks of EUA accession and the persistence of those shocks on the unemployment rates. Our paper bridges that literature gap.

3. Data and methodology

3.1.Data

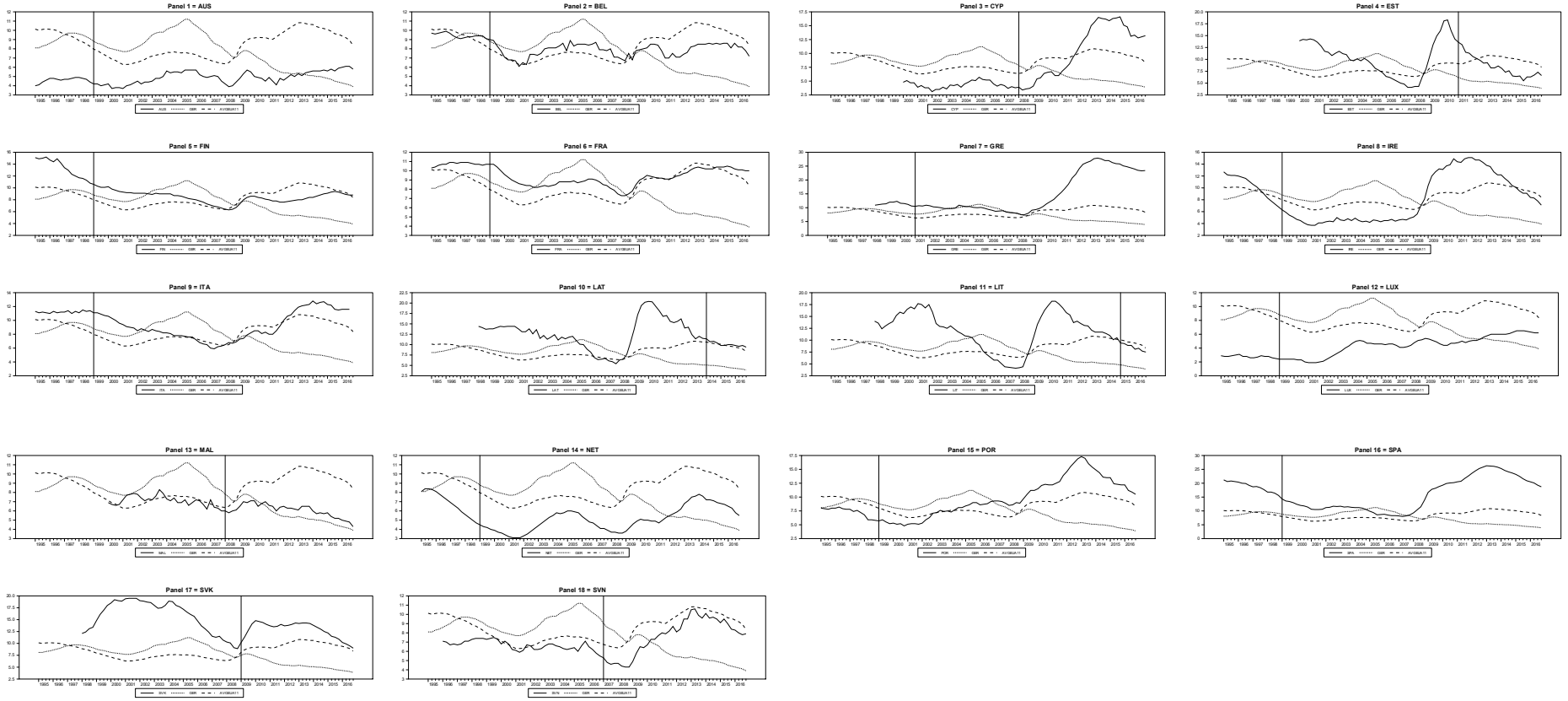
The data used in the analysis are seasonally adjusted quarterly unemployment rates from Eurostat for the nineteen EUA countries: Austria, Belgium, Cyprus, Estonia, Finland, France, Greece, Germany, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia and Spain. Depending on the data availability, the analysis covers the period from the beginning from 1995 for the first eleven euro area countries - Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain – i.e. EUA11, the beginning of 1996 for Slovenia, the first quarter of 1998 for Lithuania and Slovakia, the second quarter of 1998 for Greece and Latvia and the beginning of 2000 for Estonia, Cyprus and Malta. The data span until the end of 2016 for all of the analyzed countries.

Figure 1 presents the unemployment rates of all of the EUA countries, together with the average unemployment rate for the first eleven EUA countries and Germany's unemployment rates which will be used as a benchmark in the convergence analysis. It is visible from the graphs that all of the countries report an increase in unemployment rates due to financial crisis around 2008, in some countries this increase is more pronounced, while in the others this effect was more subtle and/or short-lived. But for the most of the countries, this effect of the financial crisis seems to have caused more permanent effect, with the exception of Germany and potentially Malta. Thus the average unemployment rate series for the EUA11 also displays a certain degree of persistence after the financial crisis. Actually, on average, the entire euro area experienced high unemployment rate growth from the beginning of the financial crisis. The vertical lines on the graphs display the accession dates of each of the countries to the EUA[8].

[8] With the exception of Germany is not individually represented in these graphs. Germany accessed the EUA at the beginning of 1995.

Except for the countries that accessed the EUA around the time of the financial crisis, all of the other countries' EUA accessions seem to have been accompanied or followed by decreases in unemployment rates. Whether EUA accession was accompanied by the breaks in the unemployment series or in their convergence patterns remains to be analyzed.

Figure 1. Unemployment rates in the EUA compared to EUA11 average and Germany



Note: The vertical lines on the graphs display the accession dates of each of the countries to the EUA

Source: Eurostat, authors' calculation

Table 1 shows descriptive statistics, namely numbers of observations, means, standard errors, minimums and maximums for all of the unemployment series. The data from the Table 1 reveal the highest mean unemployment rate and the highest maximum unemployment rate for Spain and Greece, while the lowest mean and minimum unemployment rate was noted for Luxembourg.

Table 1. Descriptive statistics

Series	Obs	Mean	Standard Error	Minimum	Maximum
AUS	88	4.88	0.62	3.70	6.10
BEL	88	8.15	0.89	6.10	9.90
CYP	68	7.65	4.63	3.10	16.60
EST	68	9.68	3.51	4.10	18.30
FIN	88	9.37	2.20	6.30	15.20
FRA	88	9.46	1.00	7.30	10.90
GER	88	7.77	1.97	3.90	11.20
GRE	75	14.69	6.92	7.50	27.90
IRE	88	8.45	3.87	3.70	15.10
ITA	87	9.56	1.96	5.90	12.80
LAT	75	12.24	3.58	5.40	20.40
LIT	76	11.73	4.01	4.10	18.20
LUX	88	4.16	1.40	1.90	6.50
MAL	68	6.57	0.80	4.30	8.30
NET	88	5.42	1.45	3.10	8.40
POR	88	9.45	3.31	4.80	17.30
SPA	88	16.30	5.68	8.00	26.30
SVK	76	14.53	3.11	8.90	19.50
SVN	84	7.13	1.47	4.30	10.60
AVGEUA11	88	8.45	1.42	6.30	10.83

Source: authors' calculation

3.2.Methodology

The analysis in this paper consists of two parts. First, we analyze the unemployment rates of the 19 EUA countries. We look for the persistence of their means and potential break locations in order to detect whether EUA accession might have had some permanent effects on the unemployment rates of its member countries. To accomplish this, unit root testing with structural breaks is used on the natural logarithms of each country's unemployment rates.

Second, we test the divergence hypothesis, i.e. whether there is a divergence of the EUA countries (i) from the average of the first eleven member countries, and (ii) from Germany as the best-performing economy of the group. To test this hypothesis, we use the approach by Bernard and Durlauf (1995, 1996) who suggested that if there is a stochastic convergence across different countries, the variables of interest, e.g. unemployment rates, should not differ arbitrarily and hence the relative unemployment rates should be stationary. Following their approach, we define two variables of the relative unemployment rate. First is the relative unemployment rate of country i ($lnavg\_u_{it}$) as the natural logarithm of the ratio of the country i's unemployment rate (U_{it}) and the average unemployment rate of the first eleven EUA countries (avg_u_t). The second variable is defined as the relative unemployment rate of country i ($lnger\_u_{it}$) i.e. as the natural logarithm of the ratio of the country i's unemployment rate (U_{it}) and the unemployment rate of Germany ($U_{GER,t}$) as a benchmark.[9]

$$lnavg\_u_{it} = ln\frac{U_{it}}{avg\_u_t} \tag{1}$$

$$lnger\_u_{it} = ln\frac{U_{it}}{U_{GER,t}} \tag{2}$$

Although technically the rejection of the divergence null hypothesis leads to the conclusion of non-divergence, we follow the phrasing of the existing literature (e.g. Pesaran, 2007) and conclude that there is a stochastic convergence if $lnavg\_u_{it}$ and/or $lnger\_u_{it}$ are stationary, which means that the shocks on country's relative unemployment rate(s) are temporary. In other words, following a shock, unemployment rate of a country i can deviate from the EUA11 average i.e. Germany's unemployment rate only temporarily.

The unit root tests used in the both parts of the analysis are two-break LM unit root test proposed by Lee and Strazicich (2003) and RALS-LM test proposed by Meng et al. (2016). In the first part of the analysis, the failure to reject the unit root null hypothesis means a failure to reject the hysteresis hypothesis. The shocks have a permanent effect on the unemployment rates. In the second part of the analysis, the failure to reject the unit root null indicates evidence against the stochastic convergence i.e. the evidence of a divergence.

Lee and Strazicich (2003) two-break LM unit root test is used as the benchmark unit root test to test the non-stationarity null hypothesis. According to the LM (score) principle, a unit root test statistic is obtained from the following regression:

[9] This approach to convergence testing was used by many researchers, e.g. Pesaran (2007), Gomes and da Silva (2009), Meng et al. (2013) and others.

$$\Delta u_t = \delta' \Delta Z_t + \emptyset \tilde{S}_{t-i} + \varepsilon_t \quad (3)$$

Where $\tilde{S}_t$ is a de-trended series $\tilde{S}_t = u_t - \tilde{\psi}_x - Z_t\tilde{\delta}, t = 2, \dots, T$, $\tilde{\delta}$ is a vector of coefficients in the regression of Δu_t on ΔZ_t and $\tilde{\psi}_x = u_1 - Z_1\tilde{\delta}$ and ε_t is the error term, assumed independent and identically distributed with zero mean and finite variance. For a Crash model which allows changes in levels at two breaks, Z_t is described by $[1, t, D_{1t}, D_{2t}]'$ where $D_{jt} = 1$ for $t \geq T_{Bj} + 1, j = 1,2$ and 0 otherwise, and T_{Bj} is the time period of the breaks. For a Trend Break model which assumes breaks in both constant and a trend with two breaks Z_t is $[1, t, D_{1t}, D_{2t}, DT^*_{1t}, DT^*_{2j}]'$ where $DT^*_{jt} = t - T_{Bj}$ for $t \geq T_{Bj} + 1, j = 1,2$ and 0 otherwise. Under the unit root null hypothesis $\emptyset = 0$ in Equation (3), the t statistic is defined as $\tilde{\tau}$ = t-statistic for the null hypothesis $\emptyset = 0$. To endogenously determine the location of the breaks ($\lambda_j = \frac{T_{Bj}}{T}, j = 1,2$) a grid search is used and a break is endogenously determined where t-test statistic is minimized.

$$LM_\tau = Inf\tilde{\tau}(\lambda) \quad (4)$$

Critical values for the Crash model are independent of the break locations, but critical values of the Trend Break model depend on the break locations. All of the corresponding critical values are found in Lee and Strazicich (2003) paper.

The reason this test is used is that it allows for breaks under both null and alternative hypothesis and its properties are unaffected by the breaks under the null[10]. As a consequence, the rejection of the null indicates evidence of a trend-stationary time series with or without breaks and, hence, stochastic convergence. And a structural break under a unit root null can be interpreted as a large permanent shock or an outlier. (Lee and Strazicich, 2003)

Additionally, Residual Augmented Least Squares–Lagrange Multiplier (RALS-LM) unit root two-break test by Meng et al. (2016) is employed. This test incorporates information on non-normal errors and is thus more powerful than the usual LM test. The transformed RALS-LM test statistic is obtained from the following regression:

$$\Delta u_t = \delta' \Delta Z_t + \emptyset \tilde{S}_{t-i} + \gamma \hat{\omega}_t + v_t \quad (5)$$

[10] Namely, compared to tests Lee and Strazicich (2003), most of the other unit root tests that allow for breaks derive their critical values assuming no breaks under the null leading to spurious rejections of the null in case of a unit root with breaks. Examples of such tests are for previously mentioned Perron (1997), Zivot and Andrews (1992) and others.

where v_t is an error term and an Equation (5) is connected to Equation (3) with $\varepsilon_t = \gamma\widehat{\omega}_t + v_t$, where $\widehat{\omega}_t$ is the RALS augmenting term that utilizes the information on non-normal errors and is uncorrelated with ε_t. More specifically, it is

$$\widehat{\omega}_t = h(\hat{\varepsilon}_t) - \widehat{K} - \hat{\varepsilon}_t\widehat{D}_2 \tag{6}$$

where $\hat{\varepsilon}_t$ is the OLS residual from the regression (3), $\widehat{K} = \frac{1}{T}\sum_{t=1}^{T} h(\hat{\varepsilon}_t)$, $\widehat{D}_2 = \frac{1}{T}\sum_{t=1}^{T} h'(\hat{\varepsilon}_t)$ and in order to capture the information on non-normal errors Meng et al. (2016) let $h(\hat{\varepsilon}_t) = [\hat{\varepsilon}_t^2, \hat{\varepsilon}_t^3]'$ where $\hat{\varepsilon}_t^2$ and $\hat{\varepsilon}_t^3$ are the second and third moment of $\hat{\varepsilon}_t$ respectively. The t statistic is defined as $\tau^*_{RALS-LM}$ = t-statistic for the null hypothesis $\emptyset = 0$.

Just like the two-break LM unit root test, RALS-LM test is also free of nuisance parameters that indicate the location of the breaks; it is free of the spurious rejections meaning that the rejection of the null can be considered as a more accurate evidence of stationarity. In addition, since the variance in the error term in Equation (5) is smaller than that in Equation (3), RALS-LM test provides some asymptotic efficiency gains with non-normal errors compared to LM test.

4. Results

4.1.The persistence and the structural breaks in the euro area unemployment rates

The results of the LM and RALS-LM unit root test analysis of the euro area unemployment rates' persistence are outlaid in Table 2. In this paper, we graphically show the results of the LM test Trend Break model with two structural breaks, since this is still a test more common in the empirical convergence literature. The results of a more recent and more powerful RALS-LM test are however also analyzed and especially pointed out if they significantly stand out from the results of the LM test.

From the LM test statistics (from both Crash and Trend Break models) it can be concluded that the stationarity null hypothesis is rejected for all of the EUA countries suggesting that the shocks to the unemployment rates tend to be persistent, thus supporting the hysteresis hypothesis. This is what graphical depiction of the natural logarithms of EUA countries' unemployment rates also suggests (Graph 2). However, RALS-LM test does not support these findings for Estonia, Finland, France and Lithuania and, to a lesser extent, Austria, Belgium, Greece, Latvia, Luxembourg, Portugal, Slovenia, and Slovakia. The conducted unit root tests thus robustly fail to reject the stationarity hypothesis only for the seven EUA countries: Cyprus, Germany, Ireland, Italy, Malta, Netherlands, and Slovakia. For them, the shocks to their unemployment rates appear to have a more permanent effect.

The analysis of the structural breaks presented in Table 2 is organized in a way that first the breaks that are around (+/- 2 years) the one or more of the important dates listed in column two of Table 2 are discussed (these breaks are shaded in the table). Afterwards, the other breaks are also briefly analyzed. The breaks are called either the up-breaks (if what follows is a period of higher unemployment rates) or down-breaks (if the following period is characterized by on average lower unemployment rates).

In the beginning, a couple of limiting factors to this analysis should be stressed. First, some countries had accessed the EUA at the time of the financial crisis, either just before (like Slovenia), during (Cyprus, Malta, Slovakia) or just as the recovery started to kick in (Estonia). It is, hence, not possible to distinguish in which way the breaks derived by the analysis for these countries are related to the EUA accession. And as it is shown in Table 2, except for Slovenia which had a down-break in 2007, at the time of the EUA accession, it is not clear-cut if these

breaks distinguish higher or lower unemployment rates after the break period. This is possibly due to contradicting influences of EUA accession versus the effects of the crisis.

Furthermore, Latvia and Lithuania are also specific since their EUA accession occurred near the end of the sample period. Given the used methodology disregards the first and the last part of the sample when looking for the breaks, it was methodologically impaired from finding breaks around the time of their EUA accessions, even if they in reality exist.

Analysis of the shaded break locations in Table 2 yield some interesting observations. First, the EUA accession seems to be accompanied mostly by the down-breaks in the most of the (remaining) analyzed countries – more specifically, eleven of them. These down-breaks are statistically significant in Belgium, France, Germany, Netherlands, Portugal, Slovenia and Spain, and found but not statistically significant for Austria, Finland, Ireland, and Luxembourg. There are no up-breaks relating to the EUA accession. However, the up-breaks seem to be located in the vicinity of the dates of the euro adoption. This is the case for Belgium, Germany, Luxembourg, Netherlands and Portugal, and an insignificant break for Ireland. There are also statistically significant down-breaks in the vicinity of the EU and/or ERM II accession dates for Latvia, Malta, Slovakia and a statistically insignificant break for Lithuania. There are only four countries that did not show any breaks surrounding the important EU and EUA related dates – Greece, Ireland, Italy (due to big shocks relating to the financial crisis) and previously mentioned Lithuania.

In addition to the break points situated around the important EU, EUA, ERM II accession dates or the euro adoption dates, the majority of breakpoints are understandably located in the period of financial crisis. Most of the countries have up-breaks (fifteen out of nineteen) at the beginning of the financial crisis and some of them down-breaks (eight out of nineteen) near the end. For Greece e.g., the 2012 break corresponds to the year of their elections and austerity bailout. There are some other interesting election-related breakpoints worth mentioning. For example the Austria 2006 down-break related to the election of Alfred Gusenbauer and the formation of the grand coalition. The similar situation can be observed for Germany that had also had a down-break near 2005 when Angela Merkel was elected, and another grand coalition came to power.

Table 2. Unit root test and structural break test results for the natural logarithms of unemployment rates in the EUA

Variable	Important dates	Test	Crash model	Break(s)		Trend Break model	Break(s)			
			Statistic	Constant	Constant	Statistic	Constant	Trend	Constant	Trend
LN_AUS	EU 1995	LM	-2.67	1998:03	2007:03	**-3.18**	**2000:03**		**2006:02**	
	EUA 1999q1			-0.06	-0.12**		**-0.00**	**-0.00**	**-0.03**	**-0.04*** **
	Euro 2002q1	RALS-LM	-2.90	2000:01	2011:03	-6.64***	2009:03		2011:04	
				-0.13	0.17		0.09*	-0.15***	-0.06	0.20***
LN_BEL	EU 1951	LM	-2.35	1999:04	2002:03	**-3.80**	**1999:03**		**2001:04**	
	EUA 1999q1			-0.11**	0.06		**-0.02**	**-0.05****	**-0.03**	**0.07*** **
	Euro 2002q1	RALS-LM	-3.37	2008:02	2010:04	-5.44***	2004:02		2011:01	
				0.13***	-0.16***		0.12**	0.02	-0.07	0.08***
LN_CYP	EU 2004	LM	-1.27	2009:01	2011:03	**-2.84**	**2009:02**		**2013:01**	
	EUA 2008q1			0.25***	0.13*		**-0.01**	**0.09*** **	**0.05**	**-0.05***
	Euro 2008q1	RALS-LM	-2.92	2009:01	2010:02	-3.30	2010:03		2011:04	
				-0.21***	0.31***		-0.07	0.17***	-0.04	0.00***
LN_EST	EU 2004	LM	-1.43	2008:02	2009:04	**-2.94**	**2008:01**		**2010:03**	
	EU 2011q1			0.37***	0.18**		**-0.23*** **	**0.24*** **	**-0.04**	**-0.30*** **
		RALS-LM	-6.58***	2008:02	2011:04	-4.22**	2008:01		2010:01	
	ERMII 2004q2			0.34***	0.04		-0.19***	0.20***	-0.15**	0.00***
LN_FIN	EU 1995	LM	-0.85	1997:02	2008:03	**-2.24**	**1997:01**		**2009:01**	
	EUA 1999q1			-0.05**	0.05**		**-0.01**	**-0.01**	**0.09*** **	**0.03*** **
	Euro 2002q1	RALS-LM	-4.12*	2008:04	2009:04	-5.45***	2008:02		2009:03	
				0.08***	-0.05**		-0.05***	0.09***	0.03**	-0.08***

LN_FRA	EU 1951	LM	-1.04	1999:04	2008:03	**-2.28**	**1999:04**		**2009:01**	
	EUA 1999q1			-0.04**	0.03*		**-0.03***	**-0.02****	**0.05*****	**0.01*****
	Euro 2002q1	RALS-LM	-4.15**	2008:04	2009:04	-5.36***	2008:02		2009:04	
				0.05***	-0.04***		-0.03**	0.07***	-0.02	-0.06***
LN_GER	EU 1951	LM	-0.77	2002:03	2010:04	**-1.99**	**1999:04**		**2004:03**	
	EUA 1999q1			0.05**	-0.05**		**-0.03***	**-0.00**	**0.04***	**-0.03*****
	Euro 2002q1	RALS-LM	-3.52	2008:01	2008:03	-3.13	2000:03		2005:02	
				0.01	0.11***		-0.02	-0.00	0.02	-0.05***
LN_GRE	EU 1981	LM	-0.67	2009:04	2011:03	**-2.83**	**2007:04**		**2012:02**	
	EUA 2001q1			0.08**	0.11***		**-0.05***	**0.03***	**0.0556****	**-0.03****
	Euro 2002q1	RALS-LM	-5.64***	2008:03	2009:01	-1.51	2008:02		2012:04	
				0.07***	-0.16***		-0.05	0.07***	0.07*	-0.13***
LN_IRE	EU 1973	LM	-0.59	2008:03	2010:03	**-2.22**	**1999:03**		**2008:04**	
	EUA 1999q1			0.16**	0.08		**-0.03**	**0.01**	**0.22*****	**0.05***
	Euro 2002q1	RALS-LM	-2.90	2008:02	2008:04	-3.57	2007:03		2009:03	
				0.18***	0.21***		-0.13***	0.17***	-0.02	-0.13***
LN_ITA	EU 1951	LM	-0.76	2009:02	2011:04	**-2.82**	**2006:03**		**2012:02**	
	EUA 1999q1			0.06**	0.08***		**-0.02**	**-0.00**	**0.00**	**0.01**
	Euro 2002q1	RALS-LM	-3.30	2007:02	2011:03	-3.65	2005:03		2007:01	
				0.07**	0.09***		-0.07**	0.08***	-0.02	-0.06***
LN_LAT	EU 2004	LM	-1.39	2006:04	2008:03	**-3.05**	**2005:04**		**2009:01**	
	EUA 2014q1			0.02	0.31***		**-0.02**	**-0.07***	**0.24*****	**0.05**
		RALS-LM	-4.56**	2008:03	2009:01	-4.14*	2007:03		2010:01	
	ERMII 2005q2			0.32***	0.36***		-0.18***	0.09***	0.06	-0.23***

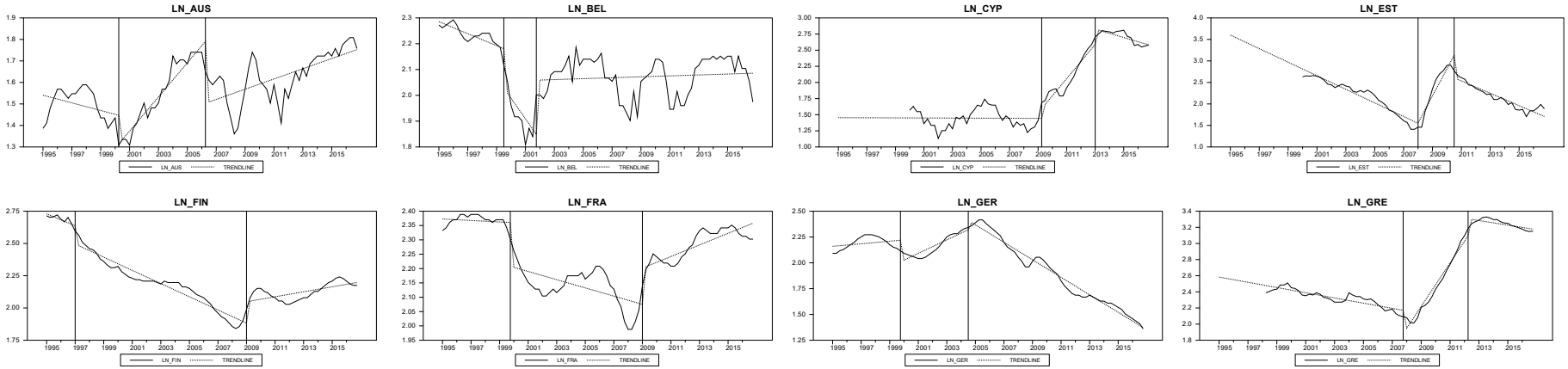
LN_LIT	EU 2004	LM	-1.09	2007:01	2008:04	**-2.14**	**2005:03**		**2009:01**	
	EUA 2015q1			-0.04	0.26***		**-0.07**	**-0.04**	**0.21*** **	**0.03**
		RALS-LM	-7.22***	2008:02	2009:04	-5.21***	2008:01		2010:02	
				0.37***	0.10*		-0.13**	0.15***	0.05	-0.28***
LN_LUX	EU 1951	LM	-1.24	2002:01	2004:01	**-2.65**	**2000:02**		**2003:02**	
	EUA 1999q1			0.11**	0.06*		**-0.01**	**0.01**	**0.09** **	**0.01**
	Euro 2002q1	RALS-LM	-1.97	2000:03	2010:03	-3.91**	2001:04		2004:01	
				-0.15***	0.07**		-0.15***	0.12***	0.06**	-0.13***
LN_MAL	EU 2004	LM	-3.32	2009:01	2015:01	**-4.58**	**2001:03**		**2008:04**	
	EUA 2008q1			0.09**	-0.06		**0.02**	**-0.09**	**0.01**	**0.07*** **
	Euro 2008q1	RALS-LM	-2.21	2003:02	2006:04	-3.15	2010:03		2011:04	
				0.09**	0.15***		-0.20**	0.19***	0.06	0.00***
LN_NET	EU 1951	LM	-0.75	1997:03	1999:03	**-1.46**	**2002:02**		**2008:03**	
	EUA 1999q1			-0.06*	-0.05		**0.07***	**0.04*** **	**-0.03**	**0.02***
	Euro 2002q1	RALS-LM	-2.23	2009:01	2010:01	-2.59	2001:03		2004:02	
				0.10***	-0.10***		-0.09***	0.10***	-0.00	-0.07***
LN_POR	EU 1986	LM	-0.78	1998:01	2014:02	**-2.67**	**1999:02**		**2012:02**	
	EUA 1999q1			-0.15***	-0.06*		**-0.07** **	**0.01**	**0.06***	**-0.02**
	Euro 2002q1	RALS-LM	1.38	1999:02	1999:04	-3.96*	2001:03		2013:01	
				-0.10**	0.17**		-0.08**	0.05***	0.02	-0.08***
LN_SVK	EU 2004	LM	-1.22	2006:01	2008:03	**-1.92**	**2005:03**		**2009:02**	
	EUA 2009q1			-0.07*	-0.04		**0.01**	**-0.07*** **	**0.11*** **	**0.05** **
	Euro 2009q1	RALS-LM	-3.09	2008:04	2009:02	-3.65	2004:01		2008:03	
	ERMII 2005q4			-0.10***	0.16***		-0.11***	0.15***	0.08***	-0.15***

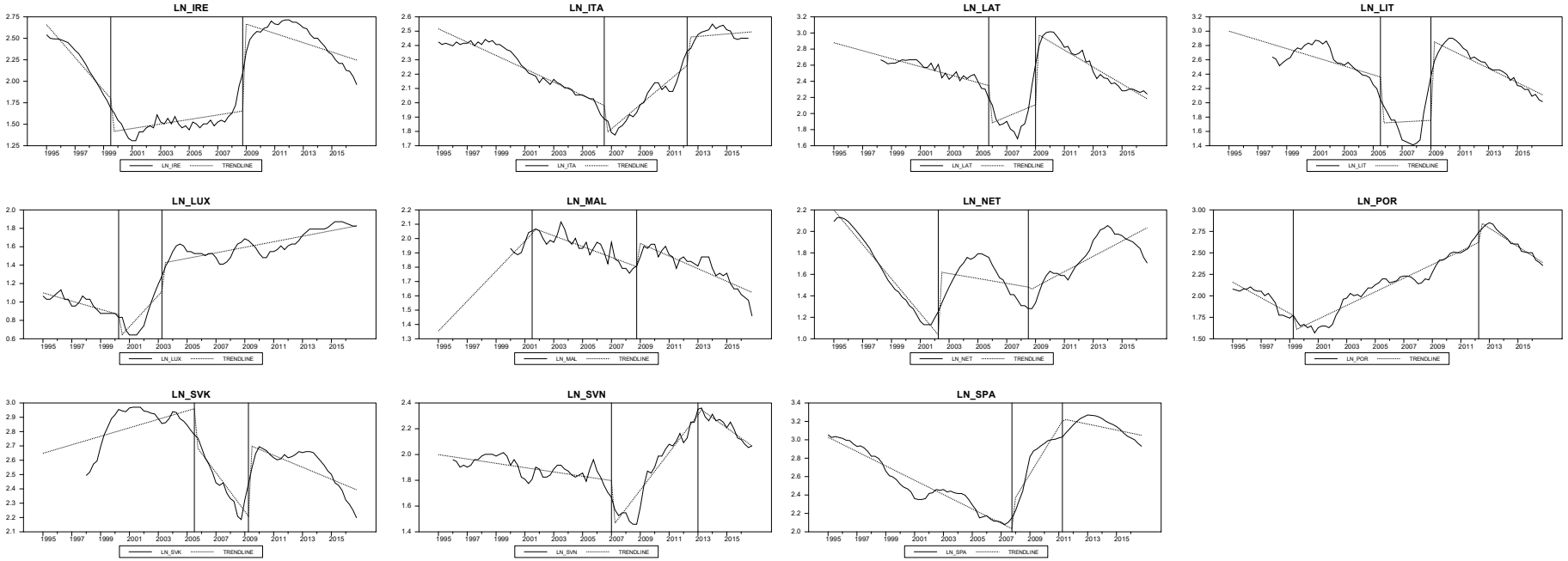
LN_SVN	EU 2004	LM	-1.54	2009:01	2012:02	**-3.22**	**2007:01**		**2013:01**	
	EUA 2007q1			0.16***	0.13***		**-0.11****	**0.00**	**0.03**	**-0.04****
	Euro 2007q1	RALS-LM	-2.43	2008:04	2012:04	-4.54**	2008:02		2013:01	
				0.14***	0.13***		-0.06	0.06***	0.02	-0.13***
LN_SPA	EU 1986	LM	-0.59	1998:04	2008:01	**-1.87**	**2007:04**		**2011:02**	
	EUA 1999q1			-0.09**	0.11***		**0.00**	**0.10*****	**0.04**	**-0.07*****
	Euro 2002q1	RALS-LM	-6.83***	2008:03	2009:01	-3.64	2007:03		2009:02	
				0.10***	-0.15***		-0.08***	0.12***	0.02	-0.08***

Notes: *, **, *** denote 10%, 5% and 1% significance respectively. The shaded break dates are located +/- 2 years from one or more of the important dates in the second column.

Source: authors' calculation

Figure 2. Natural logarithms of EUA countries' unemployment rates and the break dates





Source: authors' calculation

4.2. The stochastic convergence analysis

In this section, stochastic convergence analysis is conducted on two relative unemployment rate variables. The first is the relative unemployment rate of country i to the average unemployment rate of the first eleven EUA countries ($lnavg\_u_{it}$). The second variable is the relative unemployment rate of country i to the unemployment rate of Germany ($lnger\_u_{it}$). These two analyses are conducted and reported separately in the following two subsections.

4.2.1. Convergence to the average EUA11 unemployment rate

Results of the unit root tests conducted on the relative unemployment rates variables $lnavg\_u_{it}$ are presented in Table 3. The LM test rejected the unit root null hypothesis for all of the EUA countries except for Belgium which suggests that on average in the observed time period there was a divergence of the individual countries' unemployment rates from the EUA11 average, Belgium being the exception. RALS-LM test results, however, show that at the 10% significance level the divergence hypothesis is also rejected for additional eleven countries – Austria, Cyprus, Estonia, Finland, France, Germany, Latvia, Lithuania, Malta, Netherlands and Slovenia. As noted in the Methodology, the failure to reject the null in the remaining 7 out of 19 countries suggests on average the divergence of their unemployment rates from the EUA11 average at the 10% significance level. It is interesting to note that out of eleven first EUA countries, five of them diverge from the EUA11 average – Ireland, Italy, Luxembourg, Portugal and Spain.

The analysis of structural breaks presented in Table 3 provides some further insights into the subject. First, most of the countries (twelve out of nineteen[11]) present with the structural breaks around the periods of EU accession, EUA accession or euro adoption. In addition, five[12] of the countries that have accessed the EUA in the periods relating to the financial crisis (as noted earlier) so their breaks can hardly be distinguished as the breaks relating to the EUA accession. And finally, only four of the countries (Austria, Germany, Ireland and Spain) do not have breaks that can be related to one or more of these events.

It is interesting to note that EUA accession-related breaks are all statistically significant and most are followed by more or less long periods of convergence[13] of individual unemployment

[11] Belgium, Cyprus, Finland, France, Greece, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands and Portugal
[12] Cyprus, Estonia, Malta, Slovakia and Slovenia
[13] The convergence trend here is loosely defined if there is a down-break when $lnavg\_u_{it}$ is positive, i.e. if there is an up-break when $lnavg\_u_{it}$ is negative. The divergence trend is defined in the opposite way.

rates to the EUA11 average (Finland, France, Greece, Italy, Latvia, Luxembourg, Netherlands, and Portugal). Only Belgium seems to diverge from the EUA11 average when euro is introduced. In addition, the few breaks relating to the EU accession (for Cyprus, Lithuania, Malta and insignificant for Latvia) are also followed by a period of convergence.

On the other hand, financial crisis seems to have been the 'culprit' for structural breaks in most of the countries. The financial crisis breaks are related to divergence periods in ten out of eleven countries[14]. Only Italy's financial crisis break is followed by a convergence period. The reason for this is that before this break, Italy's relative unemployment was negative suggesting lower unemployment than the average. After the break around 2010, its unemployment rate started to increase, thus converging to an average. However, since this shock was obviously very persistent, this increase of unemployment rate soon translated into the divergence (Graph 3).

Around 2012 and 2013 there was a pronounced decrease in the average EUA11 unemployment rate due to recovery, and that period coincides with breaks in eight countries – Austria, Belgium, Finland, Germany, Ireland, Lithuania, Luxembourg, Netherlands, and Spain – that were followed by a convergence period. The only exception is Germany who still continued to diverge, but the rate of divergence slowed down.

Additional break periods should be pointed out since they are found in several countries, namely Austria, Belgium, Germany, Ireland, Malta and Spain. All of these countries except for one had one or more significant down-breaks (only Ireland had an up-break) somewhere in the period between 2005 and 2007. At that time the average unemployment rate in the EUA11 was increasing due to the growth deceleration from the first half of 2005 (EC, 2005) meaning that the countries with down-breaks suddenly started performing significantly better than the average of EUA11. For Austria, it was a period after some significant tax cuts (EC, 2005) and around the time of 2006 elections. For Germany as well, it was the already mentioned 2005 elections that were almost continuously followed by decreasing unemployment rates.

[14] Not counting the countries that accessed EUA around that time.

Table 3. Unit root test and structural break test results for the relative unemployment rates $lnavg\_u_{it}$

Variable	Important dates	Test	Crash model	Break(s)		Trend Break model	Break(s)			
			Statistic	Constant	Constant	Statistic	Constant	Trend	Constant	Trend
LNAVG_AUS	EU 1995	LM	-1.25	2007:03	2009:04	**-5.12**	**2006:03**		**2012:01**	
	EUA 1999q1			-0.10**	-0.11***		**0.00**	**-0.07*** **	**0.04**	**0.01**
	Euro 2002q1	RALS-LM	-2.26	2007:03	2011:02	-6.74***	2007:02		2012:03	
				-0.12***	-0.15***		0.09***	-0.17***	-0.06*	0.12***
LNAVG_BEL	EU 1951	LM	-2.68	2008:03	2010:04	**-5.75****	**2006:04**		**2012:02**	
	EUA 1999q1			-0.15***	-0.11***		**0.03**	**-0.03*** **	**-0.03**	**0.05*** **
	Euro 2002q1	RALS-LM	-1.62	2001:03	2008:03	-5.49***	2007:01		2012:02	
				0.13***	-0.14***		0.10***	-0.06***	-0.04	0.10***
LNAVG_CYP	EU 2004	LM	-1,73	2001:04	2010:04	**-3.38**	**2009:02**		**2013:02**	
	EUA 2008q1			-0.24***	0.10		**-0.04**	**0.06*** **	**0.07**	**-0.04***
	Euro 2008q1	RALS-LM	-2.83	2009:01	2010:02	-4.17*	2005:04		2011:04	
				0.26***	-0.19***		0.17**	-0.04	-0.17**	0.12***
LNAVG_EST	EU 2004	LM	-1.43	2008:02	2009:04	**-2.62**	**2008:01**		**2010:04**	
	EU 2011q1			0.33***	0.17**		**-0.18****	**0.17*** **	**0.05**	**-0.24*** **
		RALS-LM	-4.30**	2008:02	2011:04	-3.38	2007:03		2010:01	
	ERMII 2004q2			0.30***	-0.10*		-0.00	0.08**	0.11	-0.28***
LNAVG_FIN	EU 1995	LM	-0.88	2004:02	2014:01	**-3.18**	**1999:03**		**2012:02**	
	EUA 1999q1			-0.04*	0.05**		**0.03***	**0.01***	**-0.02**	**0.01**
	Euro 2002q1	RALS-LM	-1.36	1996:04	2009:01	-4.04*	2001:03		2013:01	
				0.00***	0.05**		-0.02	0.01	-0.02	0.05***
LNAVG_FRA	EU 1951	LM	-0.65	1999:01	2007:03	**-1.98**	**1998:04**		**2011:03**	
	EUA 1999q1			0.02	-0.04**		**0.04*** **	**-0.02*** **	**-0.01**	**0.01**
	Euro 2002q1	RALS-LM	-1.42	2003:04	2004:03	-4.33*	2000:04		2013:04	
				-0.03**	0.03**		0.03**	-0.03***	-0.02	0.02***

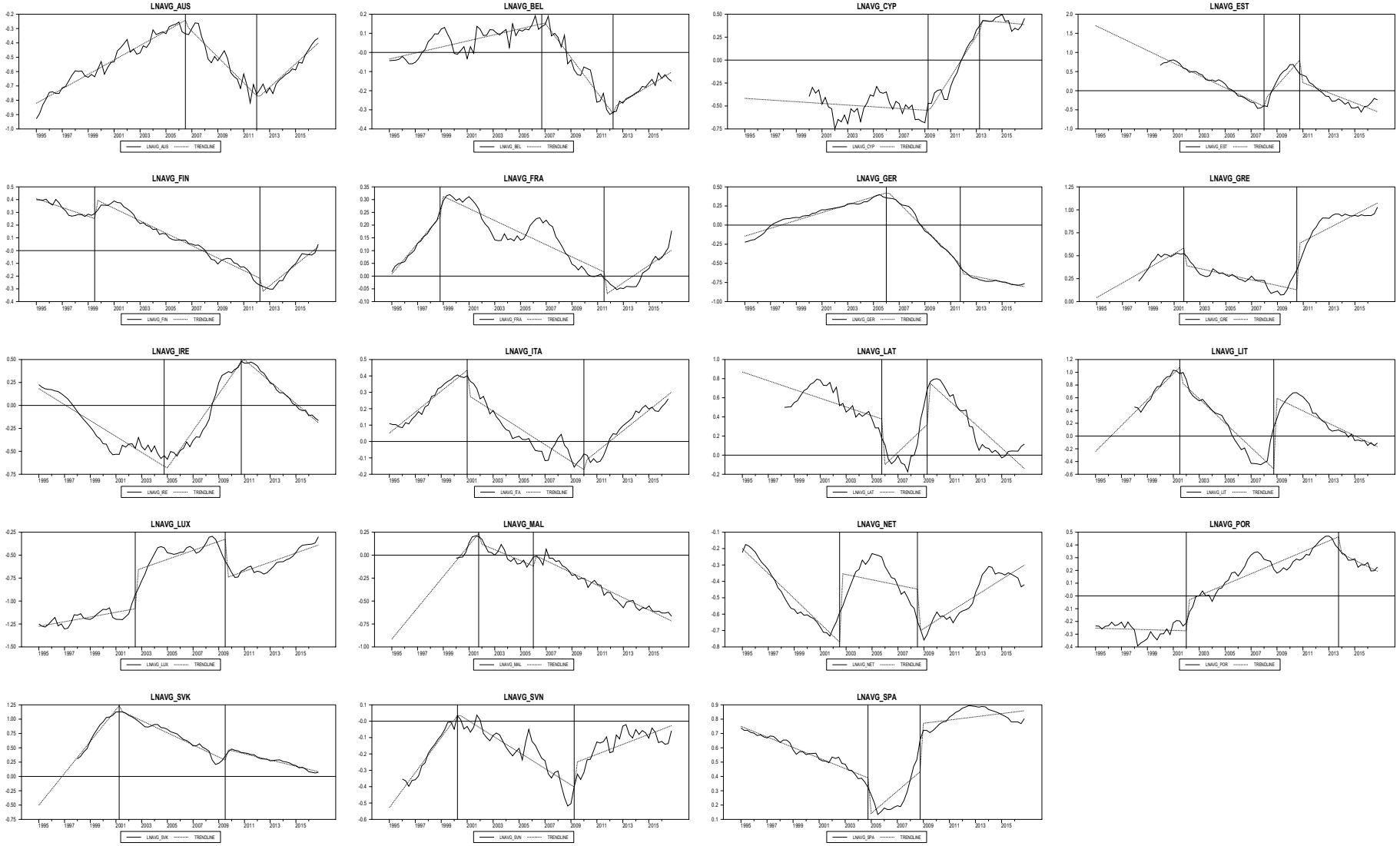
LNAVG_GER	EU 1951	LM	-0.43	2007:04	2010:01	**-2.18**	**2006:01**		**2011:04**	
	EUA 1999q1			-0.03	-0.04*		**0.03****	**-0.06*****	**-0.03****	**0.02*****
	Euro 2002q1	RALS-LM	-2.67	2005:03	2008:02	-4.57**	2006:03		2012:03	
				-0.05***	-0.06***		0.03**	-0.06***	-0.02	0.03***
LNAVG_GRE	EU 1981	LM	-0.78	2009:04	2011:03	**-1.90**	**2001:04**		**2010:03**	
	EUA 2001q1			0.07**	0.07**		**-0.01**	**-0.05*****	**0.06***	**0.06*****
	Euro 2002q1	RALS-LM	-1.86	2003:04	2008:01	-3.86	1999:04		2008:03	
				0.07**	-0.10***		-0.04	-0.04***	-0.02	0.06***
LNAVG_IRE	EU 1973	LM	-0.67	2006:04	2008:04	**-2.11**	**2004:04**		**2010:04**	
	EUA 1999q1			0.07*	0.14***		**-0.08****	**0.07*****	**0.01**	**-0.07*****
	Euro 2002q1	RALS-LM	-1.53	2008:02	2008:04	-2.58	2006:03		2010:04	
				0.13***	0.16***		-0.15***	0.11***	-0.01	-0.10***
LNAVG_ITA	EU 1951	LM	-0.85	2002:02	2004:02	**-2.48**	**2001:01**		**2010:01**	
	EUA 1999q1			-0.05*	-0.05**		**-0.01**	**-0.04*****	**-0.02**	**0.04*****
	Euro 2002q1	RALS-LM	-2.68	2007:02	2008:02	-3.76	2000:04		2010:03	
				0.07***	-0.11***		0.05**	-0.04***	-0.02	0.05***
LNAVG_LAT	EU 2004	LM	-1.41	2006:02	2009:01	**-2.28**	**2005:04**		**2009:02**	
	EUA 2014q1			-0.06	0.19***		**-0.06**	**-0.02**	**0.13****	**-0.04***
		RALS-LM	-0.63	2008:03	2012:02	-4.14**	2007:03		2009:03	
	ERMII 2005q2			0.29***	-0.21***		-0.12*	0.02	-0.00	-0.14***
LNAVG_LIT	EU 2004	LM	-1.11	2005:02	2008:03	**-1.80**	**2001:03**		**2008:04**	
	EUA 2015q1			-0.14***	0.21***		**0.09**	**-0.11*****	**0.14****	**0.07****
		RALS-LM	-5.74***	2008:02	2009:04	-4.22*	2007:04		2010:02	
				0.32***	0.10*		-0.06	0.07**	0.08	-0.21***
LNAVG_LUX	EU 1951	LM	-1.23	2002:01	2009:01	**-2.93**	**2002:03**		**2009:03**	
	EUA 1999q1			0.10**	-0.09**		**0.01**	**0.06*****	**-0.05**	**-0.07*****
	Euro 2002q1	RALS-LM	-1.79	2000:03	2011:03	-2.72	2001:04		2004:02	
				-0.12***	-0.09***		-0.08**	0.08***	0.03	-0.10***

LNAVG_MAL	EU 2004	LM	-2.56	2008:04	2011:02	**-4.52**	**2001:04**		**2006:01**	
	EUA 2008q1			-0.04	-0.11**		**0.03**	**-0.09*** **	**0.04**	**0.03****
	Euro 2008q1	RALS-LM	0.49	2006:04	2010:01	-5.84***	2006:03		2007:02	
				-0.09**	0.18***		0.21***	-0.17***	-0.15***	0.05**
LNAVG_NET	EU 1951	LM	-1.04	1997:03	2002:04	**-1.76**	**2002:03**		**2008:03**	
	EUA 1999q1			-0.04*	0.06**		**0.03**	**0.03****	**-0.06****	**0.00**
	Euro 2002q1	RALS-LM	-3.20	2009:01	2010:01	-4.52**	2005:03		2009:01	
				0.08***	-0.09***		0.00	-0.00	0.03	0.06***
LNAVG_POR	EU 1986	LM	-1.29	2002:01	2004:01	**-2.84**	**2002:01**		**2013:04**	
	EUA 1999q1			0.08**	0.05*		**0.06***	**0.04*****	**-0.02**	**-0.04*****
	Euro 2002q1	RALS-LM	-1.78	1998:01	2002:03	-3.80	1999:04		2013:01	
				-0.14***	0.08**		0.09**	0.02*	0.04	-0.08***
LNAVG_SVK	EU 2004	LM	-0.83	2000:01	2008:03	**-2.89**	**2001:02**		**2009:03**	
	EUA 2009q1			0.09**	-0.08*		**0.03**	**-0.11*****	**0.09*****	**0.02*****
	Euro 2009q1	RALS-LM	-3.18	2008:02	2008:04	-2.50	2001:01		2013:04	
	ERMII 2005q4			-0.13***	0.11***		0.05	-0.07***	-0.03	0.00***
LNAVG_SVN	EU 2004	LM	-1.74	2005:01	2007:01	**-3.51**	**2000:02**		**2009:02**	
	EUA 2007q1			-0.08**	-0.10**		**-0.02**	**-0.02***	**0.05**	**0.03*****
	Euro 2007q1	RALS-LM	-1.68	2005:02	2007:01	-4.15*	2005:01		2005:04	
				-0.11**	0.18***		0.12***	-0.07***	0.03	0.08***
LNAVG_SPA	EU 1986	LM	-0.74	2008:01	2010:04	**-2.46**	**2004:04**		**2008:04**	
	EUA 1999q1			0.09***	0.03		**-0.05****	**0.00**	**0.06****	**0.01**
	Euro 2002q1	RALS-LM	-3.13	2008:03	2009:01	-3.57	2007:02		2009:02	
				0.11***	-0.08***		-0.04	0.08***	-0.01	-0.06***

Notes: *, **, *** denote 10%, 5% and 1% significance respectively. The shaded break dates are located +/- 2 years from one or more of the important dates in the second column.

Source: authors' calculation

Figure 3. Relative unemployment rates $lnavg\_u_{it}$ and the break dates



4.2.2. Convergence to Germany's unemployment rate

Results of the unit root tests conducted on the relative unemployment rates variables $lnger\_u_{it}$ are presented in the Table 4. The LM test failed to reject the divergence null hypothesis for all of the analyzed countries at the 5% significance level. At 10% Austria and Belgium seem to stochastically converge to Germany. RALS-LM test results, however, again provide some rejections of the null i.e. at the 10% significance offer a proof of stochastic convergence of the following ten countries to Germany – Austria, Belgium, Estonia, Finland, France, Italy, Lithuania, Luxembourg, Slovakia and Slovenia. The RALS-LM results do appear surprising, but it should be accentuated once again that technically, the rejection of the divergence null implies that there was no divergence of their unemployment rates and not necessarily that their levels of unemployment rates literally converged. It is interesting to note that seven of these countries plus Germany showed in the previous section stochastic convergence to the average EUA11 unemployment rate at 10% significance using RALS-LM test[15]. Also, out of eleven first EUA countries, for only four of them divergence hypothesis couldn't be rejected at 10% significance – Ireland, Nederland, Portugal and Spain.

Structural break test results again show structural breaks in this relative unemployment series around the EU or EUA dates in most of the analyzed countries. The only exceptions are Ireland and Spain. The interesting finding is that, when countries accessing EUA around the time of financial crisis are excluded, EUA related structural breaks are found only in the (remaining) eleven countries that were the first to accept Euro as their currencies[16]. And all of the breaks were followed by the period of convergence of their unemployment rates to Germany's (i.e. relative unemployment rates moving towards 0).

Depending on their relative position to Germany, the countries that presented with the EU-related breaks[17] had different patterns of convergence/divergence after the EU accession, but this was because all of them saw decreases in their relative unemployment rates.

As far as the financial crisis is concerned, all of the countries that present with a crisis-related break (seventeen out of eighteen[18]) experienced a period of increasing relative unemployment rates. A big part of that trend is definitely Germany's constantly decreasing unemployment rates during that period. The end of the financial crisis also marked some breaks in the relative

[15] The exceptions are Italy, Luxembourg and Slovakia.
[16] Austria, Belgium, Finland, France, Greece, Italy, Luxembourg, Netherland and Portugal
[17] Cyprus, Latvia, Lithuania, Malta, Slovakia and Slovenia
[18] All except Malta

unemployment series in nine countries[19] with most of them followed by the slowdown of divergence from Germany and some of them even reversing the trend to convergence.

And finally, as expected, there were more than a few up-breaks relating to the already mentioned period between 2005 and 2007 in seven countries[20], all of them being followed by the period of convergence from the negative relative unemployment rates. This effect is again mostly (but certainly not exclusively) due to decreasing unemployment rates in Germany.

[19] Cyprus, France, Greece, Ireland, Malta, Netherland, Portugal, Slovenia and Spain
[20] Belgium, France, Ireland, Luxembourg, Malta, Portugal and Spain

Table 4. Unit root test and structural break test results for the relative unemployment rates $lnger\_u_{it}$

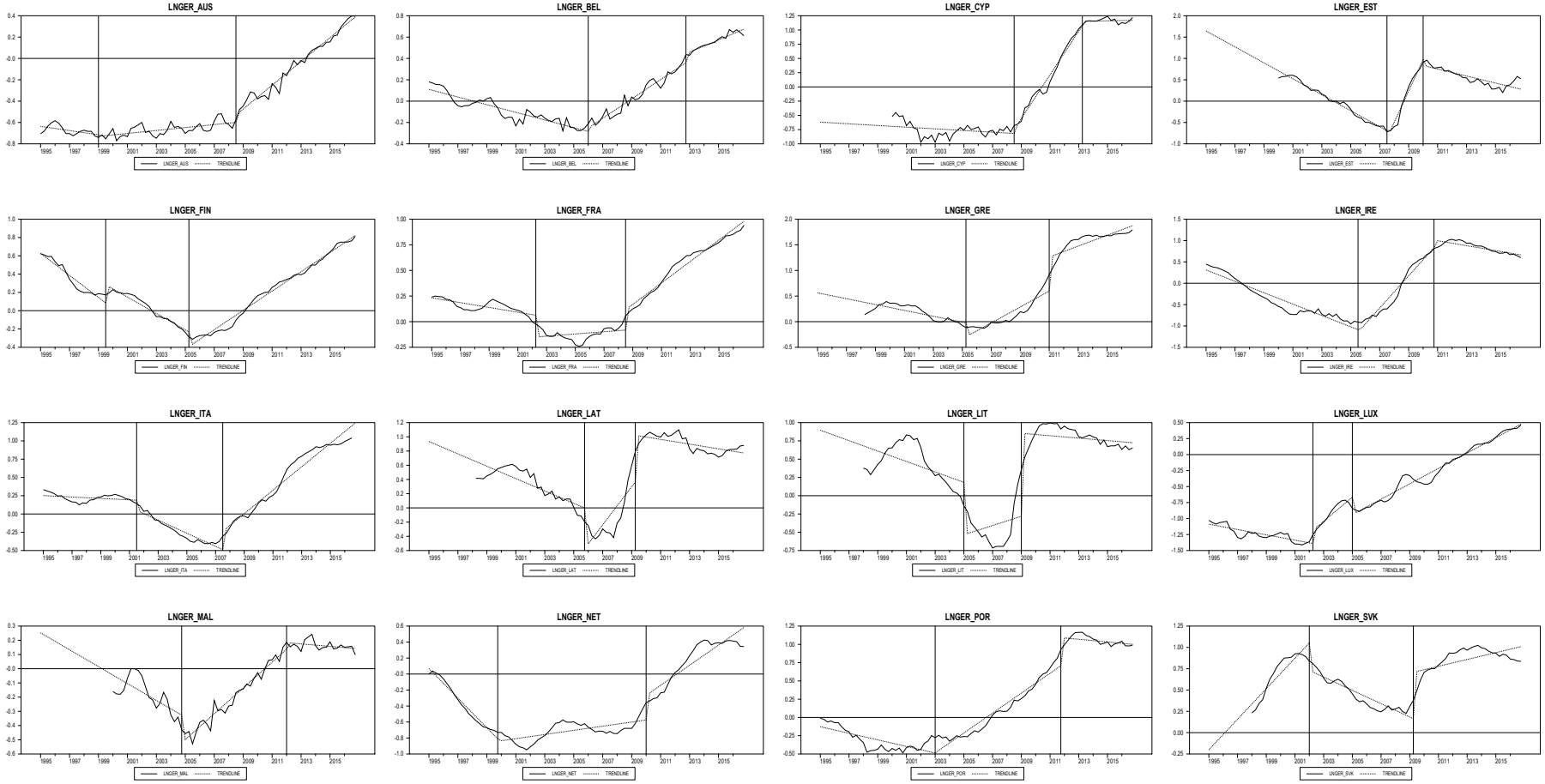
Variable	Important dates	Test	Crash model	Break(s)		Trend Break model	Break(s)			
			Statistic	Constant	Constant	Statistic	Constant	Trend	Constant	Trend
LNGER_AUS	EU 1995	LM	-1.71	2000:01	2011:03	**-5.56***	**1999:01**		**2008:03**	
	EUA 1999q1			-0.13***	0.18***		**0.03**	**-0.03****	**0.08****	**0.03*****
	Euro 2002q1	RALS-LM	1.21	2010:04	2011:03	-4.53**	2008:01		2009:04	
				0.11***	0.22***		-0.16***	0.16***	-0.09***	-0.13***
LNGER_BEL	EU 1951	LM	-1.27	2008:02	2011:02	**-5.42***	**2006:01**		**2012:04**	
	EUA 1999q1			0.16***	0.10**		**0.07***	**0.03*****	**-0.04**	**0.06*****
	Euro 2002q1	RALS-LM	-1.30	2004:01	2008:02	-5.20***	2006:02		2012:02	
				-0.12***	0.15***		-0.10**	0.07***	-0.04	0.07***
LNGER_CYP	EU 2004	LM	-0.94	2001:04	2010:04	**-3.46**	**2008:03**		**2013:02**	
	EUA 2008q1			-0.26***	0.16**		**-0.07**	**0.15*****	**0.07**	**-0.10*****
	Euro 2008q1	RALS-LM	-2.68	2009:01	2010:02	-2.60	2010:03		2011:04	
				-0.18***	0.28***		-0.21***	0.17***	0.00	0.00***
LNGER_EST	EU 2004	LM	-1.04	2008:02	2009:04	**-3.17**	**2007:03**		**2010:01**	
	EU 2011q1			0.43***	0.19**		**-0.16****	**0.20*****	**0.13****	**-0.26*****
		RALS-LM	-5.71***	2008:02	2011:04	-3.60	2007:03		2010:01	
	ERMII 2004q2			0.38***	0.14**		-0.22***	0.20***	-0.09	0.00***
LNGER_FIN	EU 1995	LM	-0.53	2008:03	2010:04	**-2.23**	**1999:03**		**2005:02**	
	EUA 1999q1			0.04*	0.05*		**0.04****	**0.02****	**-0.05****	**0.04*****
	Euro 2002q1	RALS-LM	-3.22	2000:01	2014:01	-8.21***	2000:04		2005:02	
				-0.06***	0.05**		-0.00	0.04***	-0.03*	0.04***
LNGER_FRA	EU 1951	LM	-0.53	2001:04	2011:03	**-2.03**	**2002:02**		**2008:03**	
	EUA 1999q1			-0.06**	0.05**		**-0.01**	**-0.00**	**0.01**	**0.04*****
	Euro 2002q1	RALS-LM	0.34	2003:04	2006:04	-4.19*	1999:01		2005:01	
				-0.06***	0.06***		0.02	0.00	-0.03	0.05***
LNGER_GRE	EU 1981	LM	-0.55	2009:04	2011:03	**-1.65**	**2005:02**		**2011:01**	

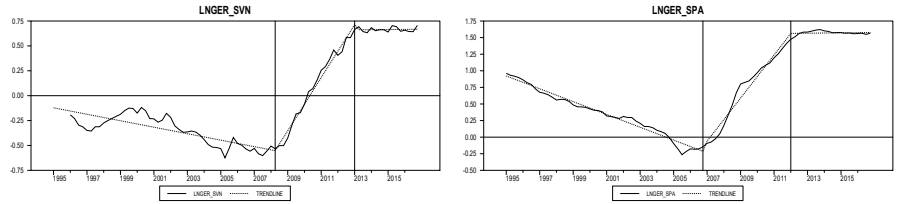
	EUA 2001q1			0.11**	0.13***		**-0.02**	**0.02**	**0.09****	**0.02**
	Euro 2002q1	RALS-LM	-2.20	2004:01	2009:01	-3.08	2008:02		2013:03	
				-0.11***	-0.10***		-0.02	0.08***	-0.05	0.00***
LNGER_IRE	EU 1973	LM	-0.51	2006:04	2008:04	**-1.93**	**2005:03**		**2010:04**	
	EUA 1999q1			0.11*	0.20**		**-0.09****	**0.13*****	**0.03**	**-0.08*****
	Euro 2002q1	RALS-LM	-3.90	2008:02	2009:04	-2.96	2005:04		2011:03	
				0.23***	-0.11**		-0.05	0.13***	0.11***	-0.09***
LNGER_ITA	EU 1951	LM	-0.52	2009:04	2011:04	**-1.76**	**2001:03**		**2007:03**	
	EUA 1999q1			0.07**	0.10***		**-0.01**	**-0.02****	**-0.01**	**0.07*****
	Euro 2002q1	RALS-LM	-2.01	2009:02	2010:02	-6.43***	2007:01		2010:02	
				0.07**	-0.10***		-0.05**	0.06***	-0.02	0.04***
LNGER_LAT	EU 2004	LM	-1.04	2002:02	2008:03	**-2.43**	**2005:04**		**2009:02**	
	EUA 2014q1			-0.21***	0.30***		**-0.07**	**0.00**	**0.12***	**-0.02**
		RALS-LM	-0.98	2008:03	2013:02	-3.19	2007:03		2010:01	
	ERMII 2005q2			0.28***	0.17**		-0.25***	0.18***	0.07	-0.22***
LNGER_LIT	EU 2004	LM	-0.86	2002:01	2008:03	**-1.81**	**2005:01**		**2009:01**	
	EUA 2015q1			-0.18**	0.25***		**-0.07**	**-0.02**	**0.15****	**0.03**
		RALS-LM	-5.78***	2008:02	2009:04	-3.44	2008:01		2013:04	
				0.38***	0.09		-0.05	0.12***	-0.10*	0.00***
LNGER_LUX	EU 1951	LM	-1.12	1998:02	2008:01	**-3.02**	**2002:02**		**2005:01**	
	EUA 1999q1			-0.07*	0.11**		**0.03**	**0.09*****	**-0.05**	**-0.03****
	Euro 2002q1	RALS-LM	-0.41	2000:03	2004:04	-4.91**	2000:02		2001:03	
				-0.13***	-0.08**		0.13***	-0.08***	-0.05	0.15***
LNGER_MAL	EU 2004	LM	-1.59	2002:01	2003:04	**-4.38**	**2004:04**		**2012:01**	
	EUA 2008q1			-0.08*	-0.12**		**-0.03**	**-0.04****	**-0.05**	**0.02**
	Euro 2008q1	RALS-LM	-2.26	2006:04	2011:03	-2.36	2001:02		2005:03	
				-0.13**	0.22***		-0.14**	0.11***	0.02	0.00***
LNGER_NET	EU 1951	LM	-0.53	1997:03	2011:03	**-1.67**	**1999:04**		**2010:01**	

	EUA 1999q1			-0.07*	0.09**		**0.00**	**0.04*** **	**-0.02**	**0.04*** **
	Euro 2002q1	RALS-LM	-3.77	2009:02	2010:01	-3.30	2008:04		2013:03	
				0.07***	-0.10***		-0.07***	0.08***	0.03	-0.06***
LNGER_POR	EU 1986	LM	-0.66	1997:01	2008:02	**-2.18**	**2003:01**		**2011:04**	
	EUA 1999q1			-0.09**	0.09**		**0.02**	**0.04*** **	**0.06***	**-0.00**
	Euro 2002q1	RALS-LM	3.33	1997:03	1998:02	-3.75	2006:01		2012:04	
				-0.03	0.17***		-0.02	0.06***	-0.00	-0.06***
LNGER_SVK	EU 2004	LM	-0.86	2002:04	2005:01	**-1.87**	**2002:01**		**2009:02**	
	EUA 2009q1			-0.08**	-0.08*		**0.00**	**-0.09*** **	**0.08** **	**0.06*** **
	Euro 2009q1	RALS-LM	-3.82	2003:03	2007:03	-4.59**	2008:03		2013:04	
	ERMII 2005q4			-0.08**	0.09**		-0.14***	0.06***	-0.07**	0.00***
LNGER_SVN	EU 2004	LM	-0.83	2010:01	2012:02	**-2.67**	**2008:02**		**2013:01**	
	EUA 2007q1			0.12**	0.14***		**-0.04**	**0.08*** **	**0.03**	**-0.08*** **
	Euro 2007q1	RALS-LM	-2.78	2005:02	2005:04	-4.50**	2008:03		2013:01	
				-0.08*	-0.18***		-0.16***	0.13***	0.00	-0.13***
LNGER_SPA	EU 1986	LM	-0.49	2007:04	2011:02	-2.34	2006:04		2012:01	
	EUA 1999q1			0.12**	0.08*		-0.03	0.12***	0.03	-0.08***
	Euro 2002q1	RALS-LM	-3.04	2005:03	2009:01	-3.00	2007:02		2009:01	
				0.12***	-0.11***		-0.10***	0.15***	-0.01	-0.08***

Source: authors' calculation

Figure 4. Relative unemployment rates $lnger\_u_{it}$ and the break dates





Source: authors' calculation

5. Discussion

The results of the analysis have provided quite strong evidence on the persistency of shocks in unemployment rates in most of the EUA countries, which adds to the, still not conclusive, findings on the hysteresis hypothesis in the existing literature. This paper supports the existing literature on the European unemployment rates that stresses the existence of at least some form of hysteresis exists unemployment hysteresis in the European Union (e.g. Ball, 2009, Gali, 2015).

Hysteresis hypothesis goes hand in hand with both supply but also demand side shocks having a more permanent effect on the unemployment rates. However, RALS-LM test was able to provide evidence of stationarity for seven EUA countries, supporting the NAIRU hypothesis which suggests that only supply side shocks can have a permanent effect on the countries' unemployment rates. Interestingly, in our analysis, the countries with non-stationary unemployment rates series experienced both EUA-related structural break and crisis-related break. On the other hand, except for Netherlands, countries that were found stationary did not have an EUA-related break. Our results thus seem to support the economic theory. Furthermore, in all of the countries that experienced an EUA-related break, what followed was a period of decreasing unemployment rates. This result is interesting for two reasons. First, understanding the persistency of member countries' unemployment rates helps policy makers assess how effective their policies can be. The unemployment in countries with non-stationary unemployment rates i.e. unemployment hysteresis might be managed more effectively from the demand side then the countries with stationary unemployment rates. And second, these results are interesting for the countries planning to join the EUA. Namely, if the shocks to their unemployment rates tend to be persistent, they can expect to have a significant and relatively permanent decrease of their unemployment rates following the EUA accession. On the other hand, countries with stationary unemployment rates should not expect some significant or permanent effects from the EUA accession.

The analysis of the stochastic convergence of individual unemployment rates to the EUA11 average or to Germany provided some mixed results, with LM test results mostly leading to conclusions of divergence, and RALS-LM more prone to rejecting the divergence hypothesis than the LM test. However, none of the tests was able to reject the divergence null hypothesis for Ireland, Greece, Portugal, and Spain. It is interesting that the divergence is most pronounced in the four countries that were in the EUA form the very beginning.

This suggests that EUA membership is not a guarantee for a convergence as it was envisioned when created.

On the other hand, majority of countries presented with an EUA-related break in the relative unemployment rate series $lnavg\_u_{it}$ and those breaks were followed almost exclusively by the periods of convergence to the EUA11 average! So even though the EUA membership is not a guarantee for a long-term convergence of the EUA member states' unemployment rates, it appears to provide the initial boost.

As far as convergence to Germany is concerned, the EUA-related breaks (again followed by the convergence period) were found only in the first countries that adopted the euro. Quite possibly due to Germany's extraordinary performance since the middle of the 2000s, none of the newer member states managed to achieve significant break towards their convergence.

Finally, the analysis resulted in many breaks relating to the period of the financial crisis. The crisis-breaks were, as expected, followed by the periods of increasing unemployment rates. Recoveries, on the other hand, were marked by the down-breaks. These results were expected and very robust. There were, however, also breaks in the relative unemployment rates series that robustly marked the periods of divergence following the crisis-breaks and periods of convergence after the recoveries. These results are opposite from how the EUA was envisioned. The results fall in line with the literature stating that EUA fails to function as predicted by the OCA theory and member states face difficulties in adjusting after a shock such as the financial crisis occurs (De Grauwe, 2011, Krugman, 2012).

6. Conclusion

It can be concluded that the hypothesis that there is an unemployment hysteresis and that EUA accession thus contributed to the economic integration and convergence of the unemployment rates in the EUA is only partially proven. First, the results of the analysis have provided evidence of unemployment hysteresis in most of the analyzed countries. In addition, those countries were also characterized by the EUA-related down-breaks in unemployment rates. There were also the EUA-related breaks in the relative unemployment rates series which were followed by the periods of convergence in all of the countries for which the breaks were found. These are all the findings that support the hypothesis of the paper.

However, the analysis also resulted in some evidence against the hypothesis of the paper. First, we found evidence in favor of the NAIRU hypothesis in several countries using the RALS-LM unit root test, and there were hence no EUA-related down-breaks in unemployment rates in those countries. Second, since Ireland, Greece, Portugal, and Spain, four of the first countries to adopt euro, are robustly shown to diverge from both the EUA11 average and form Germany, one can conclude that the EUA membership is not a sufficient condition for stochastic convergence. And third, there are significant robust divergence patterns in most countries following the financial crisis, which is an argument against successful economic integration that EUA membership was supposed to provide. These results are mostly consistent with the existing empirical literature which suggests that EUA is not performing as an OCA.

This study contributes by filling the gap in the existing empirical literature by providing an analysis of the stochastic convergence of the unemployment rates in the EUA in a way that consistently connects it with the monetary shocks of EUA accession and the persistence of those shocks on the unemployment rates.

There are, however, certain limitations to the study that should be stressed. One limit of the research is conditioned by the time period considered in the analysis. Namely, for some countries locating the structural break around the EUA accession date was impossible because it was too close to the beginning or the end of the sample period, and methodologically, these parts of the samples were disregarded when performing a grid search for a break. Another unavoidable limitation is EUA accession of certain countries around the time of the crisis which made it impossible to discern, using this methodology, if the structural breaks were EUA- or crisis-related.

Finally, there are several implications of our study for the economic policy. First, our results imply that in the most of the EUA countries, due to unemployment hysteresis, alongside supply-side policies, well thought out demand side policies should be effective at battling high unemployment rates. Second, for countries outside the EUA, the EUA accession is likely to reduce the unemployment rates and induce convergence if their unemployment rates are non-stationary. So it is a goal worth pursuing. However, solely reliance on the EUA membership for sustained stochastic convergence to Germany or EUA11 average would be misguided.

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