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Do Balkan economies catch up with EU? New evidence from panel unit root analysis

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Abstract This paper explores empirically the issue of income convergence for the Balkans over the period 1994–2011 and the investigation relies on income differentials from both the averages of the European Union's-15 (EU-15) and the European Union's-24 (EU-24) as well as within the Balkan group. The adopted methodology deploys the non stationary panel unit root framework to cope with the problem of limited sample providing more reliable insight and, in particular, the analysis uses the univariate and panel minimum Lagrange Multiplier (LM) unit root tests, suggested by Lee and Strazicich (2003, 2004) and Im et al. (2005), that accounts for one and two endogenously determined structural breaks. The overall evidence is in favor of catching up with the EU benchmark cases as well as in favor of convergence within the Balkan area. However, disparities for some countries are confirmed.

Keywords Convergence · Panel unit root test · Structural breaks · Balkan countries

JEL Classification C23 · C24 · O47 · O52

1 Introduction

In 1989, the changes in the socialistic regimes of Central Eastern Europe (CEE) affected the future of the Balkan countries. Until the mid-1990s, many countries in

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the Balkan area witnessed significant growth; however, after 1995 the considerable decline of Total Factor Productivity (TFP) growth and the persistently-high current account deficits raised increasing concerns about the macroeconomic stability and the growth performance of the area, this fact being especially negative for the countries aiming at the accession to the European Union (EU). In fact, as the Eastern Enlargement moved on and the states of CEE were directed to the path of the European Monetary Union (EMU), there has been noticed a strong interest towards the European future of the Balkans from both the academic community and the European Commission (Thessaloniki and Brussels reunions 2003). However, their remained differences underlined the importance of looking backwards to their economic and political progress (Amplatz 2003; Gros and Steinherr 2004). In addition, there is a considerable European attention on income convergence in the Balkans since there is still a lot to be done in these economies to converge with western standards (Cavenaile and Dubois 2011).

More specifically, the transition process from centrally-planned economies to post-communist markets and their accession to the EU through the adoption of western-style's political and economic systems were the two dominant political and socio-economic processes that characterized the region (Amplatz 2003; Gros and Steinherr 2004; Monastiriotis and Petrakos 2010). In this context, during the last two decades many changes in economic organizational level have occurred. However, the reborn nationalism of the past within the Balkans resulted in conflicts especially among the nations of the former Yugoslavia and formed an unstable environment (Rafailidis 1994; Katsovska-Maligoudi 2004). This fact was only the beginning of a long period of deindustrialization and economic reconstruction that changed a lot the organization of the economic activity (Monastiriotis and Petrakos 2010). The Balkan economies, during the first years of their transition were characterized by increasing inflation and unemployment. Nowadays, in the context of national convergence programs in CEE countries, despite the tendency of rapid growth as well as the controlled decreasing inflation, unemployment keeps on being in high levels. Obviously, the converging process cannot be similar to the western evolution of the 1960s, thus the convergence period can be possibly shorter (Lucian 2010).

So far, the issue of economic growth remains of primary importance for the national economic policies and attracts continuously the academic interest. This scientific area has been thoroughly investigated both in theoretical and empirical context. More particularly, the inherited to growth concept of convergence, since the eighteenth century, has been further analyzed relating its central aspect to whether the differences among countries or regions decrease over time. Gerschenkron (1952) underlined that the main motive for convergence is the advantage of backwardness. Later, Solow (1956), intending to form a mathematical approach for convergence, related his growth model with the notion of convergence implying that countries with lower initial income levels tend to grow faster than countries with relatively higher initial income levels. Abramovitz (1986) defined the term "convergence" as "catch up effect" by setting two groups of countries, the leaders and the followers. He claimed that the followers attempt to approach the leaders under certain conditions. According to the hypothesis of convergence, the investigation faced a dual question of whether poor economies are able to reach the economic level of the richer ones or they are convicted to fall into the poverty trap (Quah 1996). Therefore, the notion of convergence is related to the implications of per capita income differences across countries and their reduction over time (Bourguignon and Morrison 2002). Analyzing real convergence, Orłowski et al. (2000) affirmed that it is translated as "*a gradual reduction of (Gross Domestic Product) GDP gaps between less developed economies (or regions) and the more developed ones*".

Bernard and Durlauf (1995) defined the possible definitions of convergence in a stochastic environment as follows:

Assume the following model for the individual output series:

$$a\ (L)Y_{i,t} = b_i + e_{i,t} \tag{1}$$

where a(L) has one root on the unit circle and $e_{i,t}$ is a mean zero stationary process. This equation includes both a linear deterministic and a stochastic trend in output.

In Eq. (1), the countries i and j converge if the long-term output for both countries at time t is given by:

$$\lim_{T\to\infty} E\left(y_{i,t+T} - y_{j,t+T}|I_t\right) = 0 \tag{2}$$

The $y_{i,t+T}$ and $y_{j,t+T}$ must be cointegrated with a cointegrating vector [1, −1]. Otherwise, the $y_{i,t+T}$ and $y_{j,t+T}$ are cointegrated with a cointegrating vector [1, −α] and the time trends are common:

$$\lim_{T\to\infty} E\left(y_{i,t+T} - ay_{j,t+T}|I_t\right) = 0 \tag{3}$$

The countries i and j have a common trend if the long-term forecasts of output are proportional at time t.

The above definitions are related to the notions of absolute and conditional convergence. The case of absolute convergence is described by Eq. (2) while Eq. (3) stands for conditional convergence. If the countries have identical structural characteristics (technology, policies, population growth, saving rate), they converge conditionally towards their own long term equilibrium level (Romer 1986; Lucas 1988; Galor 1996).

The relevant empirical literature was enriched as the new growth theory showed up. Baumol (1986), De Long (1988), Barro (1991), Barro and Sala-i-Martin (1992, 1991, 1995), Mankiw et al. (1992) representing the neoclassical approach supported the view that poor economies tend to grow faster than the rich ones and provided both theoretical and empirical evidence. However, the majority of the relevant research efforts on convergence appeared the last decades when larger data sets became available (Baumol 1986). In these pioneering works, the testing procedure for convergence was based on cross country regressions. Barro and Sala-i-Martin (1992) suggested the well known b-convergence methodology which relies on a cross sectional regression of the average growth rate of per capita output over an extended time horizon. Nevertheless, this regression received strong criticism (Evans 1998; Evans and Karras 1996) based on the fact that the b-convergence regression provides biased conclusions. The criticism of Quah (1993, 1996) for these regressions pointed out the importance of time series properties. Bernard and Durlauf (1995, 1996) adopted these properties and examined convergence as a stochastic process. In the context of time series analysis, Nahar and Inder (2002) suggested a testing procedure for convergence based on time polynomials. The use of unit root tests on time series was also criticized for their power (Haldrup and Jansson 2006). This fact led to the use of combined cross section and time series information that improved a lot the power of these tests under a panel data framework (Evans 1996) expanding them to analyze convergence.

Other researchers supported that convergence may take place at different rates according to certain conditions and suggested the use of non linear specifications such as Threshold Autoregressive (TAR) and Momentum Threshold Autoregressive (MTAR) (Beyaert and Camacho 2008). Some others (Le Pen 2011; Holmes et al. 2013) have used the pair—wise approach, suggested by Pesaran (2007). According to this method, all possible bivariate relations are considered while any problematic choice of every single country isn't involved and cointegration does not have to be a prerequisite for convergence to be confirmed.

In this paper, we aim at exploring the issue of convergence within the group of Balkan economies and detecting possible catching-up effects with the EU. In particular, the analysis addresses the following issues: Firstly, the convergence process is examined under the stochastic framework. Given that univariate unit root tests have been criticized for low power, especially when limited data samples are used, a battery of panel unit root tests is applied. Secondly, the robustness of the stochastic convergence results is analyzed accommodating for cross correlations and heterogeneity among the panels. A third contribution lays in the use of the univariate and panel minimum Lagrange Multiplier (min LM) unit root tests, suggested by Lee and Strazicich (2003, 2004) and Im et al. (2005), which explore endogenously for possible structural breaks. To this point, we should mention that the existence of significant structural changes, if ignored, may provide misleading inference in favor of rejecting the null hypothesis of a unit root that is lack of convergence. More particularly, Strazicich et al. (2004), referring to the Solow model, interpreted breaks in the deterministic components as permanent changes in country specific compensating differentials sourcing from e.g. different relative levels of technology. A broken deterministic term probably reflects an exogenous event and could be thought as representing for instance, a change in the political and economic environment due to structural reforms in the political and legal system or a change in the economic policy.

The time period under our investigation is characterized by numerous important facts emerging from internal conflicts as well as economic and political instability in the Balkan area. On the other hand, there had been some economic and institutional reforms supported by the EU to enhance the process of recovery in the region and ease the future integration within the EU. The majority of the relevant research efforts used samples that comprised only a limited number of countries from the Balkan group (Baldwin et al. 1997; Bjorksten 2000; Breuss 2001; Doyle et al. 2001; Lejour et al. 2001; Martín et al. 2001; Sarajevs 2001; Marini 2003; Fidrmuc and

Korhonen 2004; Kutan and Yigit 2004; Zbigniew and Prochniak 2004, 2007; Figuet and Nenovsky 2006; Bonetto et al. 2009; Del Bo et al. 2010; Szeles and Marinescu 2010). A final contribution could be the enrichment of the relevant literature in terms of a more complete data set since it comprises all, in terms of data availability, economies in the Balkan Peninsula.

The remainder of the paper is structured as follows. Section 2 provides a short description of the examined Balkan area and refers to the empirical efforts on convergence over the area. Section 3 illustrates the background of the adopted empirical methodologies. Section 4 presents the data sample used and Sect. 5 analyzes and discusses the results of the empirical analysis. Finally, Sect. 6 summarizes our analysis and concludes.

2 A brief inspection of the Balkan economies

The Balkan region, located in the Southeastern part of Europe, has been isolated from the rest of the Europe for a long time due to the sociopolitical facts that have taken place in the area. It was considered as a region without defined borders and the crossroad of both eastern expansionism and west imperialism. Balkans kept on being an unstable region for centuries without any special development opportunities and since then, remains economically heterogeneous (Rafailidis 1994; Katsovska-Maligoudi 2004; Tzortzis 2010; Monastiriotis and Petrakos 2010).

For centuries, the Balkan regions were under the rule of the Ottoman Empire (1299–1923) and the Austro-Hungarian Empire (1867–1918). The Ottoman rule in combination with the economic isolation led the region to be the least developed in Europe. The stability at all levels came to the region after World War II. Another significant era that changed a lot the political and economic background of the Balkans was the period of the Cold War (1947–1991). Although, most of the Balkan nations, as members of the Eastern Bloc,[1] were following a path of decreasing growth rates, the change of the socialistic regimes and the transition to the market economy brought up new political and economic conditions.[2] However, this occurred despite the rising nationalism which affected the region through serious conflicts among the former Yugoslavian republics within the same time period: the Croatian War for Independence (1991–1995), the Bosnian War (1992–1995) and the Kosovo War (1998). During Kosovo's War, the idea of the Stability Pact for the countries of Southeastern Europe emerged aiming at the establishment of economic and political stability and the adjustment of reforms at all levels (Papasotiriou 1994; Rafailidis 1994; Katsovska-Maligoudi 2004; Tzortzis 2010).

The established peace and the expectations for cooperation had already redefined the prospects and goals of the Balkans in relation to their European future path.

[1] USSR, Poland, East Germany, Poland, Hungary, Bulgaria, Czechoslovakia, Romania, Albania, Yugoslavia.

[2] Privatization of nationalized enterprises, protection of property rights, reforms.

Moreover, the concentration of foreign direct and portfolio investments, the internal and external migration that decreased the population in periphery at a high level and also the restructuring of industry, increased the regional disparities among the Balkan transition countries (Monastiriotis 2010, 2011). The EU provided less support to the Balkan transition countries due to the instability and their poor initial conditions. As a result, their problems enlarged and the received funds[3] seemed to have a negative impact in the transition process. (Monastiriotis 2010; Monastiriotis and Petrakos 2010). The EU efforts through the Stability Pact[4] (SP) regarding the South Eastern Europe and the Stabilization and Association Process (SAP) successfully led to the creation of a common framework for the Balkans. However, the SP lost its power when it was directed in regional level and the SAP complicated the accession process (Economides 2008; Monastiriotis 2008; Uvalic 2010). Therefore, as long as the Balkan countries stay away from the necessary conditions in order to access the EU, the financial support remains limited.

In Fig. 1, below, we illustrate the evolution of the mean GDP growth rates of the studied Balkan economies. The graph accounts for two distinct periods to permit the comparison of the studied countries before the implementation of the European support programs for the region and also their performance during the decade of 2000s when new conditions regarding the stability and also the institutional and financial regulations were established.

It is obvious that, over the period 1995–2002, the majority of the Balkan countries exhibit a considerable growth rate (except from Bulgaria, FYROM and Romania). The extreme mean growth rate in case of Bosnia and Herzegovina is overshadowed due to population movements (Bićanić et al. 2010). Regarding the second period (2003–2011) the respective rates appear slightly degraded. It is worth mentioning that, during this second period, both the individual and the average performance of the Balkan countries have been considerably improved compared to the EU averages. The new EU members (Bulgaria and Romania) as well as Albania seem to lead the Balkan group with Serbia remaining nearly at the same rates.

The observed variability in the economic performance of the Balkan countries has motivated further research on the issue of convergence in this area. In fact, since these economies are considered as transition laggards, their delay in the transition process could be justified by ethnic conflicts in this area and economic fragmentation until the late 90s. All these conditions have built non symmetrical relations with the EU and deserve further attention. Following the above, some researchers attempted to investigate the convergence hypothesis through different empirical methodologies. Sarajevs (2001) investigated a sample of eleven transition CEE economies (among them Albania, Bulgaria, Romania and Slovenia) for real income convergence with the EU-15 for the period 1991–1999. The majority of the methods performed in this paper indicated convergence with the Balkan countries of

[3] The funding distribution provides evidence that there are differences among these countries; Poland receives more funds than Bulgaria (PHARE—structural funds 2007–2013), Bulgaria receives more funds than Croatia (PHARE, IPA, structural funds), Croatia receives more funds than Serbia (under CARDS, IPA).

[4] 1999-financial and political support.

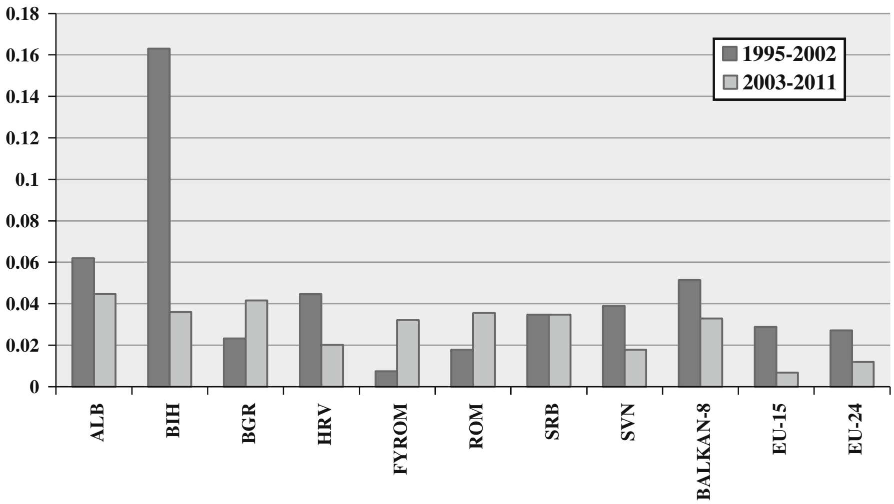

Fig. 1 Mean growth rates of the Balkan cconomies. BALKAN-8: Mean of the data sample, EU-15: Mean of the EU-15, EU-24: Mean of the EU-24, ALB: Albania, BIH: Bosnia and Herzegovina, BGR: Bulgaria, HRV: Croatia, ROM: Romania, SRB: Serbia, SVN: Slovenia

the sample converging faster to their own steady state than to the EU's average. Amplatz (2003) performed a comparative growth analysis on groups of CEE countries from 1996 to 2000. He examined β, σ and club convergence for different subgroups based on the Standard Deviation and the Markov chain probability matrices (club convergence).The sample included some of the Balkan countries[5] and the results were in favor of convergence for most CEE EU candidates, but not with Western Europe. Herz and Vogel (2003) examined 31 CEECs[6] regions and concluded in favor of divergence in the early transition period and of conditional convergence ultimately. Figuet and Nenovsky (2006), among others, analyzed three types of convergence: nominal, real and financial. Their sample included Romania and Bulgaria and they concluded that Bulgaria was advancing faster than Romania.

El Ouardighi and Somun-Kapetanovic (2007) focused on Western Balkan countries[7] and examined their convergence to the EU-24 during the period 1989–2005. The results, clearly, indicated real convergence in terms of labor productivity though in terms of per capita GDP and employment rate they were mixed. They concluded that the gap between Balkan countries and the EU remains deep and the catching up process moves really slow. Two years later, they advanced their investigation over the same sample (El Ouardighi and Somun-Kapetanovic 2009). This analysis permitted to exam both income and inequality convergence over the period 1989–2008 using per capita GDP, expressed in Purchasing Power Parity (PPP), in US dollars and in constant prices of 1990. Their findings revealed

[5] Albania, Bulgaria, FYROM, Romania and Slovenia.

[6] Central and Eastern European Countries.

[7] Albania, Bosnia-Herzegovina, Croatia, Macedonia and Serbia-Montenegro.

convergence tendency among the Balkan countries but persistence was noticed with the EU-24. They also examined the same samples in two discrete sub-periods (1996–2008 & 2000–2008) and concluded that both types of convergence occurred at a higher grade during the second half of the 1990s for the Balkans though only after 2000 for the EU-24.

Evidence of convergence has also been provided in country-case studies such that of Totev (2008) for Bulgaria as well as of Banerjee and Jarmuzek (2010) for Slovakia. Bonetto et al. (2009) used data from 21 European and Balkan countries for the period 1999–2007 to test the convergence's hypothesis. Their sample included Bulgaria, Croatia, Greece, FYROM, Romania, Serbia, and Slovenia. They used the Bayesian iterative estimation method and calculated the convergence's rates for each individual country. They found that the less developed economies (Bulgaria, Croatia, FYROM, Romania and Serbia) presented higher convergence rates and reached the half of the distance from the steady state growth in fewer years than the advanced EU ones. Rapacki and Próchniak (2009) studied the classical approach of convergence (absolute and conditional) in a sample of 27 transition countries during 1990–2005. Their results were mixed indicating that their economic growth paths differ significantly.

Szeles and Marinescu (2010) intended to examine absolute, unconditional and conditional convergence for a sample of ten CEE countries and the particular role of Romania. They found evidence for convergence with Romania enhancing the economic convergence. More specifically, absolute and conditional convergence was strongly detected when Romania participated in the sample while the unconditional one was independent of Romania's presence. Del Bo et al. (2010) presented an overview of the convergence process among European regions over the period 1995–2006 including regions of Bulgaria, Greece, Romania and Slovenia. They found evidence of absolute and conditional β convergence with an estimated speed of approximately 2 percent. To our knowledge, there is a rather limited number of empirical efforts on convergence over Balkans and in most cases the researchers used samples that included only a part of the Balkan countries.

Under a different perspective, Monastiriotis (2013) examined regional disparities among CEE countries by means of an hybrid growth model combining neoclassical approach of convergence, cumulative causation and Kuznets curve. He found partial evidence in support of all three approaches without obeying convergence rule. Smetkowski and Wójcik (2012) by means of several methods in a sample of ten CEE countries (at the NUTS3 level) concluded that during the period 1998–2005 there is a relatively weak evidence of regional convergence with the regions with lower level of development to be growing relatively faster than those with higher level of development.

3 Methodological issues

Since the pioneering works of Levin and Lin (1993, 2002), Quah (1994) and Breitung and Meyer (1994), testing for unit roots in non stationary panels became a popular tool for econometric analysis. The classical unit root tests such as Dickey Fuller and Augmented Dickey Fuller (1979, 1981) were criticized due to their low power in small samples as they have no standard distributions on whether or not deterministic terms are included in the testing procedure. Consequently, unit root tests for panel data attracted the interest of many researchers and practitioners since by letting $N \rightarrow \infty$ for fixed T they present considerably higher testing power.

Baltagi and Kao (2000) defined the work in a panel framework as a combination of the powerful parts from both cross section and time series analysis. More specifically, panel data analysis uses the increased data sample size and power derived from the cross section analysis dealing with the non stationary data of the time series analysis. Therefore, this type of analysis empowers the properties of the unit root tests, especially when the examined time series are limited. In this study, we employ a number of first generation panel unit root tests that can be divided into two distinct groups: tests which assume common unit root processes (Breitung 2000; Hadri 2000) and tests which assume individual unit root processes (Maddala and Wu 1999; Choi 2001; Im et al. 2003). All these tests assume cross sectional independence, meaning that the data are independent identically distributed (i.i.d.).

3.1 Non stationary panel unit root tests: common unit root processes

The basic assumption of a common unit root can be expressed as $\delta_i = \delta$ (where $i = 1, 2, \ldots, N$) considering b_i is identical across cross section where $i = 1, 2, \ldots, N$. Taking into account the full augmented dickey fuller (ADF) model (including an intercept and a time term):

$$\Delta Y_{it} = a_i + \delta_i Y_{i,t-1} + \sum_{k=1}^{p_i} \gamma_{i,k} \Delta Y_{i,t-k} + e_{\iota,t} \tag{4}$$

where $Y_{it} = Y_{it} - Y_{i,t-1}$, for $i = 1, \ldots, N$ countries, $t = 1, \ldots, T$ periods, we proceed with testing for unit roots:

3.1.1 Levin et al. (2002)

Based on Eq. (4), in the context of this test is developed a model of individual effects and no time trends under the assumption of homogeneity for the coefficient and with the error terms being i.i.d. $(0, \sigma^2 e)$.

The pair of the tested hypotheses is:

$$\begin{aligned} H_0 &: \delta = 0, \quad \text{unit root (non stationarity)} \\ H_1 &: \delta < 0, \quad \text{stationarity (convergence)} \end{aligned} \tag{5}$$

and the test is supported by the adjusted t-statistic:

$$t^*_\delta = \frac{t_\delta}{\sigma^*_T} - NT\hat{S}_N \left(\frac{\hat{\sigma}_\delta}{\hat{\sigma}^2_e}\right)\left(\frac{\mu^*_T}{\sigma^*_T}\right) \tag{6}$$

where t_δ = standard t-statistic based on the estimator $\widehat{\delta}$, σ_T^* = standard deviation adjustment, $\widehat{S}_N = \left(\frac{1}{N}\right)\sum_{i=1}^{N}\left(\frac{\widehat{\sigma}_{y_i}}{\widehat{\sigma}_{e_i}}\right)$, $\widehat{\sigma}_{y_i}$ =kernel estimator of long run variance μ_T^* = mean adjustment. The null hypothesis is rejected if $t_\delta^* <$ *criticalvalue* ($t_\delta^* \sim$ normal distribution).

3.1.2 *Im et al. (2003)*

Im et al. propose a test which permits heterogeneity of the dynamics and error variances across cross section units and residual serial correlation. It is based on the mean of ADF statistics computed for each individual panel unit. The IPS procedure allows heterogeneity in the short-run dynamics, in the error structure and in the form of fixed effects and linear trend terms. The tested hypotheses are:

$$H_0 : b_i = 0, \quad \text{unit root}$$
$$H_1 : b_i < 0 \quad \text{at least for an i, stationarity}$$

The alternative hypothesis H_1 allows some (but not all) of the individual panels to have a unit root test. The IPS statistic is given by the below relation

$$\bar{t}_{NT} = \frac{1}{N}\sum_{i=1}^{N} t_{i,T} \tag{7}$$

where $t_{i,T}$ is the DF statistic from the i cross section unit. The null hypothesis is rejected if $\bar{t}_{NT} < Z_{critical}$.

3.1.3 *Breitung (2000)*

In this test, it is used a model with heterogeneous trends and short run dynamics. The testing procedure is one sided and develops a t-statistic, t_B, which follows a standard normal distribution. He shows that the proposed statistic has low power in case of heterogeneous trend parameters across units. According to Breitung, we test for stationarity by estimating the persistence parameter a from the below pooled proxy equation:

$$\Delta y_{i,t}^* = a y_{i,t-1}^* + v_{i,t} \tag{8}$$

where the term a is asymptotically distributed as a standard normal, $\Delta y_{i,t}^*$ and $y_{i,t-1}^*$are transformed standardized proxies of $\Delta y_{i,t}$ and $y_{i,t-1}$. The tested hypotheses are:

$$H_0 : a = 0, \quad \text{unit root}$$
$$H_1 : a < 0, \quad \text{stationarity}$$

For determined level of significance and sample size, the null hypothesis is rejected if $t_B < Z_{critical}$

3.1.4 Hadri (2000)

This panel unit root test is based on the residuals from the individual Ordinary Least Squares (OLS) regressions of y_{it} on a constant and time trend. If we assume that the individual time series y_{it} are generated from the following model:

$$y_{it} = f_i(t) + r_{i,t} + e_{it} \tag{9}$$

where $f_i(t) =$ constant or time trend and $r_{i,t} = r_{i,t-1} + u_{i,t}$, $u_{i,t}$ is i.i.d. The e_{it} is assumed to be a stationary process and it is mutually independent from $u_{i,t}$ with residuals from the individual OLS regressions, an LM_H t-statistic can be formed by:

$$LM_H = \frac{1}{N}\left(\sum_{i=1}^{N}\left(\sum_{t} S_i(t)^2/T^2\right)/f_0\right) \tag{10}$$

where $S_i(t) =$ cumulative sums of the residuals and $f_0 =$ average of the individual estimators of the residual spectrum at frequency zero. This test presents significant distortion translated in autocorrelation when there is no unit root and appears to over-reject the null of stationarity (Hlouskova and Wagner 2006). The hypotheses tested are:

$$H_0 : \text{stationarity}$$
$$H_1 : \text{unit root}$$

in a panel of N time series. The computed statistic follows a typical normal distribution and the rejection of the null is confirmed when $LM_H < Z_{critical}$.

3.2 Non stationary panel unit root tests: individual unit root processes

The basic assumption of an individual unit root in every stochastic process can be expressed as $b_i \neq b$, where $i = 1, 2, \ldots, N$. Taking into account the full model of ADF regression (including an intercept and a time term), we have:

$$\Delta y_{i,t} = \delta + b y_{i,t-1} + \gamma t + \sum_{k=1}^{K} a_{ik}\Delta y_{i,t-k} + e_{it} \tag{11}$$

3.2.1 ADF & Phillips-Perron (PP)–Fischer Chi square

These tests, proposed by Maddala and Wu (1999) and Choi (2001), are an alternative approach of Fisher's (1932) results to derive tests that combine the *p* values from individual unit root tests as with the IPS. This is a X^2 test procedure that is based on the *p* value from any individual ADF unit root test for all cross-section units. Defining the probability values (*p* values) with p_i, we obtain:

$$-2\sum_{i=1}^{N}\log(p_i) \rightarrow x^2 \tag{12}$$

Moreover, Choi (2001) suggests that:

$$Z = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} \Phi^{-1}(p_i) \rightarrow N(0,1) \tag{13}$$

where Φ^{-1} = inverse of the standard normal cumulative distribution function. Both the asymptotic X^2 and the standard normal statistics are reported using ADF and PP individual unit root tests. The examined hypotheses are:

$$\begin{aligned} H_0 &: b_i = 0, \quad \text{unit root} \\ H_1 &: b_i < 0, \quad \text{stationarity} \end{aligned}$$

It is possible either to include or not exogenous regressors, individual intercepts and trend terms.

3.3 Min LM unit root tests

In the context of the unit roots investigation, it is important to account for structural breaks as it is well documented in literature. Perron (1989) assuming that the break point is already known or determined exogenously brought out the possibility of the break point to be determined from the data sample. According to Perron (1989), Zivot and Andrews (1992) and Perron (1997), the break point is determined endogenously. More specifically, Zivot and Andrews (1992) proposed the minimum *t* test statistic for determining break points so that the null of a unit root to be less favorable. Perron (1997) determined the break point through the maximum absolute value of the t-statistic. Vogelsang and Perron (1998) suggested the examination of the significance of the dummy variables included in the testing regression in order to detect the break points. They note that using the above ADF-type endogenous break unit root tests spurious rejections might occur and it is possible for the researcher to incorrectly conclude that a time series is stationary with break when is not (Lee and Strazicich 2004; Strazicich et al. 2004).

The relevant recent literature in order to overcome potential problems of bias and spurious rejections adopts the min LM unit root test as it was developed by Lee and Strazicich (2003). The results of this test are more revealing in our research as the rejection of the null hypothesis of unit root indicates stochastic convergence. The methodology can be described based on the LM (score) principle. The two break LM unit root test statistic of every individual can be obtained by estimating the below regression:

$$\Delta_{y_t} = d'\Delta Z_t + \varphi \widehat{S}_{t-1} + \sum \gamma_i \Delta \widehat{S}_{t-\iota} + \varepsilon_t \tag{14}$$

where Δ denotes the first difference operator, Z_t is vector of exogenous variables described by $\left[1, t, D_{1t,} D_{2t}, DT^*_{1t,} DT^*_{2t}\right]'$, with $DT^*_{jt} = t$ for $t \geq T_{B_j} + 1, j = 1, 2$, and zero otherwise, and T_{B_j} = time break. To be more specific, the regression includes the term ΔZ_t instead of Z_t and $\Delta Z_t = \left[B_{1t,} B_{2t}, D_{1t,} D_{2t}\right]'$, where $B_{jt} = \Delta D_{jt}$ and $D_{jt} = \Delta DT^*_{jt}$, $j = 1, 2$. Next, the term $\widetilde{S}_{t-1}$ is the detrended value of y_t

(Schmidt and Phillips 1992) and more particularly $\widetilde{S}_t = y_t - \widetilde{\psi}_x - Z_t\widetilde{\delta}$ (de-trended series), with $t = 2,\ldots,$ T (time parameter), $\widetilde{\delta} =$ vector of coefficients in the regression of Δy_t on ΔZ_t and $\widetilde{\psi}_x = y_1 - Z_1\delta$ (where y_1 and Z_1 are the first observations of y_t and Z_t respectively) and φ ($\varphi = 1 - \rho$) is the coefficient of $\widetilde{S}_{t-1}$. The $\Delta\widetilde{S}_{t-\iota}$ terms are included to correct for possible serial correlation (Amsler and Lee 1995), $i = 1,\ldots,k$. Finally, the term ε_t is an i.i.d. disturbance term described as, with zero mean and finite variance, that follows the classical assumptions.

The LM *t* test statistic is determined as:

$$\widetilde{\tau} = t - \text{statistic} \quad \text{for } \varphi = 0$$

and $\widetilde{\rho} = T^* \ \widetilde{\varphi}$

To detect endogenously the two breaks, meaning $\lambda_j = T_{Bj}/T,\ j = 1,2$, the min LM unit root test utilizes a complex search for the combination of the two break points:

$$\begin{aligned} LM_\rho &= \ln f_\lambda \widetilde{\rho}(\lambda) \\ LM_\tau &= \ln f_\lambda \widetilde{\tau}(\lambda) \end{aligned}.$$

According to Lee and Strazicich (2003), the critical values depend on the location of the breaks λ_j and the ones used to correspond the estimated break points. The examined hypotheses are:

$$\begin{aligned} H_0 &: \varphi = 0, \quad \text{unit root} \\ H_1 &: \varphi < 0, \quad \text{stationarity} \end{aligned}$$

The panel LM unit root test (Im et al. 2005) test statistic is obtained by taking into consideration the average of the optimal univariate LM unit root *t* test statistic which is estimated for every single country as:

$$LM_{barNT} = \frac{1}{N}\sum_{i=1}^{N} LM_i^{\tau} \tag{15}$$

4 Data

Nowadays, the term "Balkans" tends to be replaced by the term "Southeastern Europe"[8] due to internal, national and psychological reasons (Rafailidis 1994; Katsovska-Maligoudi 2004; Tzortzis 2010). According to them, "Southeastern Europe" is a geographical area wider than the Balkan one including countries, which are either fully, or partially or almost outside the Balkan Peninsula. However, for most purposes the Balkan region comprises the following countries: Albania, Bosnia & Herzegovina, Bulgaria, Croatia, FYROM, Greece, Kosovo, Montenegro, Romania, Slovenia, Serbia and a part of Turkey, that compared to the past has an extraordinary progress from isolation to openness.

[8] The term "Western Balkans" is also in use.

Our empirical analysis uses annual per capita GDP series in PPP, in US Dollars and in constant prices of 2005, derived from the World Bank's database, from 1994 to 2011. The sample comprises eight countries from the Balkan area namely, Albania, Bosnia & Herzegovina, Bulgaria, Croatia, FYROM, Romania, Serbia and Slovenia. The per capita GDP is the most common indicator used in income convergence analysis and the PPP adjustment is suggested since it provides a common background for the particular national currencies. Following Maddison (2001), this indicator is the best one for comparing the economic performance of countries in an international level. In addition, we employ three different averages, the Balkan-8, the EU-15 and the EU-24. In particular, the Balkan-8 and the EU-15 averages were computed based on data referring to per capita GDP series, in PPP, in US Dollars and in constant prices of 2005 for the 8 Balkan countries and the 15 EU member countries respectively. As for the EU-24 average, it is actually the EU-27 average, excluding Bulgaria, Romania, Slovenia since these countries are already members of the examined group to account for possible bias. All tests are applied on the natural logarithms of the per capita GDP and the analysis is performed using the E-views 7 and Gauss 10 econometric software.

5 Results

The empirical analysis is structured as follows. In the first step, we apply several conventional panel unit root tests to analyze the integration properties of the panel data set and conclude on the converging performance of the examined series. These tests have been suggested by Levin et al. (LLC) (2002), Im et al. (IPS) (2003), Breitung (2000), Maddala and Wu (1999), Choi (2001), Hadri (2000) and the univariate and panel min LM unit root tests with no breaks (Lee and Strazicich 2003; 2004; Im et al. 2005).

In the second step, we attempt to test the robustness of the results by applying a more advanced unit root testing procedure that takes into account the possible existence of structural breaks that, if ignored, may mislead the statistical inference. In particular, we apply the univariate and panel min LM unit root tests (Lee and Strazicich 2003, 2004; Im et al. 2005) that allow, endogenously, for possible shifts

Table 1 Panel unit root tests

Tests		LLC	IPS	Breitung	ADF - Fischer	PP - Fischer	Hadri
Benchmark	Balkan-8	7.85450 (1.000)	−0.54819 (0.2918)	0.40432 (0.6570)	24.8297 (0.0729)	29.6305 (0.0200)	4.45979 (0.000)
	EU-15	2.86291 (0.9979)	−1.86027 (0.0314)	1.77583 (0.9621)	26.8175 (0.0436)	22.3742 (0.1315)	4.16437 (0.000)
	EU-24	4.92635 (1.000)	−1.47277 (0.0704)	1.98189 (0.9763)	24.7622 (0.0741)	24.9960 (0.0699)	3.54423 (0.0002)

The parentheses include the p values. Probabilities for Fischer tests are computed using an asymptotic Chi square distribution. All other tests assume asymptotic normality in the level of the examined series. The final step involves the application of the same LM tests allowing for two possible level shifts.

Table 1 reports the results from six panel unit root tests (LLC, IPS, Breitung, ADF—Fischer Chi Square, PP—Fischer Chi Square) as well as one panel stationarity test (Hadri):

Based on the reported values, we notice that in the majority of the applied unit root testing procedures, the findings fail to reject the null hypothesis of a unit root, suggesting lack of convergence. Similar evidence is drawn from Hadri's stationarity test where the findings suggest rejection of the null of stationarity (the *p* value is less than 1 percent). More particularly, lack of convergence for the relative incomes is confirmed with the Balkan-8 average by LLC, IPS, Breitung, ADF Fischer and Hadri at the 5 percent level of significance. Using as benchmark the EU-15 average, lack of convergence is supported by LLC, Breitung, PP-Fischer and Hadri. Last, with the EU-24 average, similar evidence in favor of the null of a unit root is provided by all the applied tests.

Next, we continue by applying the min LM unit root testing procedures proposed by Lee and Strazicich (2003, 2004) and Im et al. (2005). Table 2, reports the LM test statistics for the involved individual panels and for the three benchmark cases (Balkan-8, EU-15 and EU-24); the last line of Table 2 reports the panel min LM value for the total panel of the countries:

Based on the reported results, we notice that, using as benchmark the Balkan-8 average, the null of a unit root is rejected only for Albania and Slovenia at the 1 percent level of significance ($LM = -4.233 < -3.63$ and $LM = -3.838 < -3.63$ respectively). Turning to the results with the two EU benchmarks, we see that the null of a unit root in both cases cannot be rejected except from Albania and Croatia. Additionally, in the case with EU-24 as benchmark, the null of a unit root is rejected again for Albania and Croatia as well as for Serbia at the 10 percent level of significance. For the rest of the countries, there is no evidence in favor of

Table 2 Min LM unit root test with no structural breaks

Benchmark Balkan countries	Balkan 8 *LM-stat*	EU-15	EU-24
Albania	−4.233***	−3.304**	−3.161**
Bosnia & Herzegovina	−0.74	−2.125	−0.626
Bulgaria	−1.865	−1.825	−1.932
Croatia	−1.475	−4.012***	−4.009***
Fyrom	−1.464	−1.012	−1.528
Romania	−2.558	−2.38	−2.696
Serbia	−2.42	−2.713	−2.913*
Slovenia	−3.838***	−1.551	−2.217
Panel LM test statistic	*−1.658***	*−1.694***	*−1.849***

The critical values for the cross section units for 1 percent, 5 percent and 10 percent are −3.63, −3.06 and −2.77 respectively. The corresponding critical values of the panel LM test for 1 percent, 5 percent and 10 percent are −2.326, −1.645 and −1.282 respectively. The lag length k is chosen using SIC test

***, **, * represent the 1 percent, 5 percent and 10 percent levels of significance convergence. This lack of stationarity might be due to the limited explanatory power of the test under the presence of significant structural breaks. In addition to the individual results, there is further overall evidence from all the panel LM statistics in favor of the rejection of the null hypothesis of a unit root.

To further investigate the robustness of the obtained results, we continue by allowing first for one and then for two level shifts (Tables 3, 4 respectively):

Using as benchmark the Balkan-8 average, the null hypothesis is rejected for Albania, Bulgaria and Slovenia at the 1 percent significance level (the respective LM values are smaller than the critical value −4.239) as well as for Serbia at the 5 percent significance level (LM = −3.983 < −3.566). Moreover, the cases of Bosnia & Herzegovina and Romania also reject the null of a unit root at 10 percent. With regard to the panel LM statistic, it indicates that the group exhibits stationarity thus, it converges to the Balkan-8 average (LM = −7.681 < −2.326). In sum, six out of eight countries converge to the Balkan-8.

As far as it concerns the catching-up with the EU-15, the null hypothesis of a unit root is rejected for Albania, Bulgaria and Croatia, at the 1 percent significance level (the respective LM statistics are smaller than the critical value −4.239) while Romania and Serbia reject the null of a unit root, at the 5 percent significance level (the respective LM statistics are smaller than the critical value −3.566). These findings present statistical evidence that these countries converge to the EU-15 average. The panel LM test statistic further indicates that the entire sample converges to the average as it is found stationary at the 1 percent level of significance (LM = −7.421 < −2.326).

Finally, concerning the EU-24, the null hypothesis is rejected for six out of eight countries in the group. In particular, lack of a unit root is supported, at the 1 percent significance level for Bulgaria, Croatia and Serbia (the respective LM values are

Table 3 LM unit root tests with one structural break

Benchmark	Balkan-8		EU-15		EU-24	
Balkan countries	LM-stat	Break points	LM-stat	Break points	LM-stat	Break points
Albania	−5.762***	2008	−4.488***	2008	−3.967**	2001
Bosnia & Herzegovina	−3.242*	1999	−2.378	2000	−2.313	2000
Bulgaria	−4.547***	1999	−5.666***	2007	−7.984***	2007
Croatia	−2.692	2006	−5.16***	2002	−4.523***	2008
Fyrom	−1.708	2006	−1.557	2000	−1.784	2004
Romania	−3.397*	2002	−3.678**	2002	−3.747**	2002
Serbia	−3.983**	2002	−4.08**	2002	−5.14***	1999
Slovenia	−4.633***	2006	2.268	2006	−3.347*	2008
Panel lm test statistic	−7.681***		−7.421***		−5.614***	

The critical values with one break for 1 percent, 5 percent and 10 percent are −4.239, −3.566 and −3.211 respectively. The corresponding critical values of the panel LM test for 1 percent, 5 percent and 10 percent are −2.326, −1.645 and −1.282 respectively. The lag length k is chosen using SIC test

***, **, * represent the 1 percent, 5 percent and 10 percent levels of significance

Table 4 LM unit root tests with two structural breaks

Benchmark	Balkan-8			EU-15			EU-24		
Balkan countries	LM-stat	Break points		LM-stat	Break points		LM-stat	Break points	
Bosnia & Herzegovina	–	–	–	−2.042	2000	2004	−1.986	2000	2004
Croatia	−2.046	1999	2002	–	–	–	–	–	–
Fyrom	−1.522	2006	2008	−1.139	2001	2007	−1.184	2001	2007
Slovenia	–	–	–	−1.723	2001	2006			
Panel LM test statistic	−2.017**			−2.522***			−3.829**		

The critical values with two breaks for 1 percent, 5 percent and 10 percent are −4.545, −3.842 and −3.504 respectively. The corresponding critical values of the panel LM test for 1 percent, 5 percent and 10 percent are −2.326, −1.645 and −1.282 respectively. The lag length k is chosen using SIC test

***, ** represent the 1 percent and 5 percent levels of significance

smaller than the critical value −4.239) providing strong evidence for convergence. Furthermore, convergence is confirmed for Albania ($LM = -3.967 < -3.566$) and Romania ($LM = -3.747 < -3.566$) at the 5 percent level of significance as well as for Slovenia ($LM = -3.347 < -3.211$) at the 10 percent level of significance. The panel LM statistic further indicates that the group is stationary and converges with the EU-24 average.

At the last step of our investigation, we proceed by testing the possibility of two structural breaks. More particularly, since the previous reported results did not confirm significant stationarity for two out of eight countries with both Balkan-8 and EU-24 and for three out of eight with EU-15, we repeat the testing procedure for these countries by allowing for two possible level shifts. The results, presented in Table 4, report the new findings only for these countries that were previously found with a unit root (no convergence):

We notice that none of them reveal new evidence of catching up with Balkan-8, EU-15 and EU-24 respectively. However, the panel LM statistic, once again, supports convergence with all three benchmarks.

Summing up, almost all the examined income differentials present a break point identified either within the period 1999–2002 or within 2006–2008. Regarding convergence to the Balkan-8, significant breaks in 1999 and 2002 have been noticed for Bosnia & Herzegovina, Bulgaria, Romania and Serbia. Albania and Slovenia also present a structural break which is located in the period 2006–2008. Moreover, the break dates for Romania and Serbia are also located within the time period 1999–2002 when testing for catching up with either EU-15 or EU-24 averages while for Bulgaria and Slovenia the break is indentified within the period 2006–2008. Albania and Croatia present also a structural break though it is identified in different years when the EU benchmarks are used. In particular for Croatia, it is the year 2002 with EU-15 benchmark and the 2008 with the EU-24 while for Albania it is the 2008 with EU-15 and the 2001 with the EU-24.

The break dates located in the first period coincide with the effect of an immigrants' wave due to Kosovo war (Albania, Serbia) and the decomposition of Bosnia & Herzegovina due to Dayton Pact (Bosnia & Herzegovina, Serbia). This was a period of a generalized change, that occured after many years in economic crisis and political instability. The detection of a significant break point around 2000 for most of the examined countries coincides also with the ending of a suffering period for the Balkans due to institutional shocks (Bicanic et al. 2010). In addition, SAAs[9] and CARD[10] initiatives along with the liberalization of trade with EU jointly improved the area's rate of development (Kondonassis et al. 2005). The institutional reforms, the privatizations and the stability after 2000 pushed towards a noticeable growth path of the region which affected severely the living standards. Regarding the break points located in the second period, 2006–2008, obviously coincide with the first years of the current global economic crisis.

All the above mentioned aspects have considerably affected the area with the individual countries to respond within a wider time period interval, each according to its peculiar characteristics regarding the level of development, the institutional and the financial status and the distance from the developed Europe.

6 Conclusions

This paper explored empirically the issue of income convergence within the group of Balkan economies as well as the catching-up of the area with the EU averages, over the period 1994–2011. The empirical investigation employed a data set for the relative income differentials from the EU-24, the EU-15 average as well as from the Balkan-8 average.

The applied econometric tools belong to the non stationary panel unit root testing framework, so as to cope with the problem of limited data for this area. More particularly, we applied univariate and panel min LM unit root testing framework for one and two, endogenously determined, structural breaks, suggested by Lee and Strazicich (2003, 2004) and Im et al. (2005). The utilized framework is superior in terms of reliability compared to the respective conventional unit root tests. Actually, the LM unit root test is comparatively more flexible for the detection of a number of breaks at unknown time and allows for structural changes under the null of unit root. According to Lee and Strazicich (2004), if such break points are ignored, in connection with stochastic non-stationarity, they may lead to size distortions.

Regarding the empirical findings for the Balkan area, there is evidence in favor of convergence within the group of the Balkan economies and catching-up effects with the EU averages. Actually, for most of the Balkan countries, there is undisputable evidence of a strong and sustainable recovery after 2000. However, since most of these countries (with the exception of Albania) were hardly hit by the recent global economic crisis, the issue of income convergence towards EU will remain under question (Sanfey 2010) and will force the region's economies to undertake further and more efficient reforms.

Concluding, the Balkan European future has to be constructed on the grounds of further reforms in political, economic and social level in order to keep on moving

[9] Stabilisation and Association Agreements.

[10] Community Assistance for Reconstruction, Development and Stabilisation.

towards the advanced EU growth rates; and more particularly, this has to be a matter of priority for the candidate countries in order to meet with the specific criteria for accession to EU. Although structural change and institutional adjustment to EU requirements are important in this process, the convergence in monetary policies (Brada and Kutan 2002) and financial systems (Bonetto et al. 2009) between the EU and the Balkan countries are considered necessary conditions. The above considerations have to be paid particular attention given that the recent crisis put a halt to the heating up after 2000 and undoubtedly will prolong significantly the region's convergence to its secular levels (Bicanic et al. 2010).

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