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Income convergence clubs in the Eurozone: a tale beyond the core/periphery divide

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Abstract

Purpose – This paper aims to examine income convergence among the Euro members from 1995 to 2021.

Design/methodology/approach – This study uses Phillips and Sul's test (2007, 2009) extended by Lyncker and Thoennessen's (2017) algorithm jointly with β and σ – convergence analysis and a traditional growth equation.

Findings – This analysis identifies three clubs of countries in terms of gross domestic product (GDP) per capita with notable disparities between and within them, which implies that the theory of optimal currency areas has not been fulfilled.

Originality/value – These results rule out the core/periphery divide as presented in the literature to date. Finally, by estimating an endogenous economic growth model, this study finds the primary factors underpinning the differences between the three stationary states: labor productivity, physical and human capital, investment and international trade.

Keywords Income convergence, Eurozone, Economic integration, OCA theory

Paper type Research paper

1. Introduction

Per capita income convergence is an economic integration objective settled in the Delors Report (1988) and the Maastricht Treaty (1992). In this paper, we analyze the per capita income convergence between the countries of the Eurozone since the launching of the euro. The creation of the euro was not based on the traditional Optimal Currency Area (OCA) criteria but rather on an exhaustive analysis of costs and benefits – documented in Delors Report (1988) and Emerson *et al.* (1992) – not devoid of social and political motivations in the background of the process. In the mid-1990s, the OCA's endogeneity thesis, according to

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which the conditions for an OCA could be satisfied ex-post (Frankel and Rose, 1998), endorsed clear support for the strategy of the euro's creators.

It was expected that the Economic and Monetary Union (EMU) would be a catalyst for the necessary institutional and structural reforms to achieve convergence in per capita income and welfare within the euro area (EA) in the following years. However, if these mechanisms do not work, reforms are halted or rolled back in countries that need them most, and real convergence fails in the whole area, at least in the medium term. Wagner (2014), among others, considers that this negative outcome is unavoidable because of the design pitfalls of the European Treaties, which, in their view, generate pernicious asymmetric incentives in the European integration process and end up creating two groups of countries the core formed by the wealthiest and most advanced economies in the area, and the periphery, made up of relatively lagging and poorer countries.

After 24 years since the establishment of EMU, the effects of the common currency should already be observed. We should be able to discern whether the alleged reforms have been accomplished and whether there has been progress in per-capita income convergence among the EA members. This study proposes to shed light on this issue and unravel whether the convergence process is single or multiple. Given that the dynamics of economic growth can exhibit multiple long-term equilibria, as extensively discussed by Berthélemi (2006), a central analysis of this work consists of detecting possible convergence clubs within the EA, each one with a different stationary state. As a second objective, we analyze the primary economic growth determinants in the Eurozone to explain the convergence dynamics performed so far among its member states as a basis to improve it in the future.

In doing so, this paper goes a step further than existing papers in several aspects. First, we use GDP per capita in purchasing power parity (PPP) as a welfare indicator instead of simple GDP per capita – the variable commonly used in previous studies – since the explicit objective of the European treaties is to reduce welfare disparities between member countries [1]. Second, we apply Phillips and Sul's (2007, 2009) log-*t* test, improved by Von Lyncker and Thoennessen (2017), in the frame of the Eurozone to identify possible income converge clubs. This method overcomes critical deficiencies of traditional tests extensively applied in the literature, and it enables us to spotlight whether the core/periphery divide, with opposing attitudes regarding structural reforms and economic behavior, has a basis or not today. Third, once it has been verified that there are several real convergence clubs, we investigate the determinants of the economic growth of the whole EA to extract the recommended economic policy measures to reduce disparities in GDP per capita and increase economic cohesion among the members of the EA.

In synthesis, we find no convergence in PPP GDP per capita in the entire Eurozone, but three clubs with different convergence processes and stationary states are detected. These results rule out the clear-cut core/periphery divide as presented to date in the literature. Finally, we find that the primary factors that explain the differences between the three stationary states are closely related to the main drivers of long-term economic growth: in particular, labor productivity, physical and human capital, investment and trade openness.

The rest of the paper is organized as follows. Section 2 reviews the recent literature; preliminary results from beta and sigma tests are presented in Section 3. The econometric methodology is explained in Section 4. The empirical results are derived and explained in Section 5. Section 6 shows our policy considerations. Finally, Section 7 concludes.

2. A synthesis of recent results on income convergence within the European union and the euro area

Most studies on convergence in per capita income in European Union (EU) and EA countries carried out to date have applied β-convergence and σ-convergence tests. Although the results are

not entirely comparable because the studies use different periods and different groupings of countries, we can draw some general conclusions. First, most works obtain convergence (beta and sigma) in per capita income in the entire EU, but not in subgroups of this area. Thus, Stanišić (2012) detects convergence in EU25 but not in EU15; Ferreiro *et al.* (2017) and Marelli *et al.* (2019) find a lack of macroeconomic convergence in the EA, and Franks *et al.* (2018) derive an absence of convergence in EA12. Second, a practically unanimous result is that Ireland and the countries that adopted the euro after 2007 – mainly the Baltic and Central and Eastern European countries – have progressed very satisfactorily toward the per capita income levels of the richest countries of the EA and the EU. See, for example, Kaitila (2014), Matkowski *et al.* (2016), Díaz del Hoyo (2017), Franks *et al.* (2018) and Suciu *et al.* (2021). In line with these latest findings, Gros (2018) concludes that convergence within the EU is more evident between the members of the East and West than between the countries of the North and South of that area.

Third, the literature offers a regularity regarding the countries of the South and Southwest of the EU: they show a clear divergence concerning the most prosperous states in the area. Convincing results in this sense are found, among others, in Díaz del Hoyo (2017), Alcidi *et al.* (2018), Alcidi (2019). Fourth, most studies after 2012 find that the global financial crisis (GFC) interrupted convergence or widened the divergence in per capita income within the EA and, mainly, between the Southern and Northern countries of the EA. Coutinho and Turrini (2020) find that the lack of convergence of countries of the South and Southwest of the EU with the EU average is attributable to macroeconomic imbalances that arose in the post-financial crisis period. More recently, Licchetta and Mattozi (2023) quantified that the negative impact of the GFC on convergence in per capita income was more intense than the impact of COVID-19 in both the EU and the EA.

Some authors have focused on the factors that positively and/or negatively influence the convergence processes within the EU and the EA. Thus, using econometric tests and regressions, Rapacki and Prochniak (2019) find that the EU enlargement significantly contributed to the economic growth of the CEE countries, facilitating their advancement toward the EU-15 development level. Boltho (2020) argues that the better performance in CEE economies is because of relatively high levels of institutional quality and a politically motivated determination in these countries to anchor them to Western economies.

Chapsa *et al.* (2019) use panel techniques to demonstrate that traditional determinants of growth promote convergence in both the Northern and Southern countries of the EA. Correia and Martins (2019) show that the Macroeconomic Imbalances Procedure imposed by the European Commission on the countries of the south of the EA moved them away from their convergence path with the wealthiest economies of the EA. These findings agree with Coutinho and Turrini (2020) that the economic non-convergence of the Southern countries of the EA with the EA average would be attributable to the macroeconomic imbalances that arose in the post-crisis period. Moreover, these authors provide evidence for the growth-enhancing and convergence roles of investment, human capital and trade in goods and services in the EA and the EU.

Finally, some recent works detect various clusters within the EU that are converging toward diverging stationary states. Thus, Glawe and Wagner (2021) detect four clubs in per-capita income in the EU; the first three have trends close to each other and above the EU average, and the fourth shows a trend clearly below the EU average [2]. These results lead the authors to propose a multi-speed Europe with two main groups: a set of economies composed approximately by the countries of the core (grossly Club 1), which, in their opinion, are ready and will undertake the necessary reforms and another group of states that would wish to remain in the EU but progressing more slowly (Clubs 2, 3 and 4).

3. Preliminary results from beta and sigma tests

To analyze, in a preliminary approach, whether convergence in per capita income of the Eurozone countries has taken place since the mid-1990s, we estimate the cross-sectional absolute beta convergence equation for the EA, using data from 1995 to 2021, following the methodology of Barro and Sala-i-Martin (1992):

$$\frac{1}{T}\ln\left(\frac{y_{i,T}}{y_{i,0}}\right) = \alpha + \beta ln(y_{i,0}) + \epsilon_i \quad (1)$$

where $y_{i,T}$ represents the per capita GDP at constant PPP prices for 2021, obtained from the World Bank, $y_{i,0}$ denotes the per capita GDP at the beginning of the period in 1995 under the same conditions, and $\in_i$ is the error term. This equation postulates a negative relationship between the average per capita real GDP growth between 1995 and 2021 and each country's per capita GDP level in 1995. Results, presented in Table 1, show an absolute beta convergence coefficient among the EA equal to –2.37 % over the 1995–2021 period. This result reveals that, in general, since 1995, poorer EA countries have exhibited faster growth than richer ones.

Figure 1 presents the graphical representation of the estimated equation. The slope of the curve measures the average speed at which the gaps between national levels of per capita income and the supposedly unique steady state for all countries close, indicating that progress to the stationary state is plodding (1.4% per year).

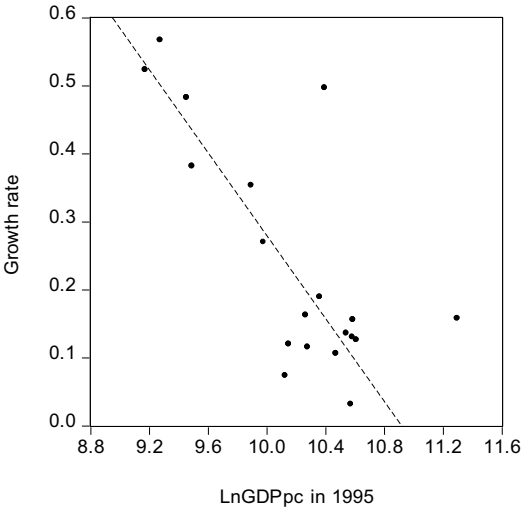
To illustrate how the degree of divergence between the per capita incomes of the EA countries has evolved, we have estimated the sigma convergence. Using annual data, Figure 2 portrays the coefficient of variation of per capita real GDP from 1995 to 2021. This coefficient decreased substantially from the start to the end of the period, but the pace of sigma convergence slowed remarkably after the GFC. Increases in divergence are apparent in both the two years following the outbreak of the GFC and the year following the COVID-19 crisis, which is in line with Licchetta and Mattozi (2023).

At first sight, both the beta and sigma tests point to some progress in the convergence of per capita income within the EA in the period analyzed. However, these two types of tests, widely used in the literature on the topic at hand, need to be revised. The beta convergence test discerns whether the worst countries -in our case, GDP per capita – are progressively reducing the gap, separating them from countries in better positions, without detecting whether they share the same long-run path. As far as σ-convergence is referred, it focuses on the reduction over time of the dispersion of the variable under study across countries. Although frequently applied, these approaches are not free from criticism, based on the absence of one-to-one correspondence between the values of their respective indicators and the degree of convergence (see, for instance, Quah, 1993).

Table 1. Eurozone cross-section regression absolute β-convergence

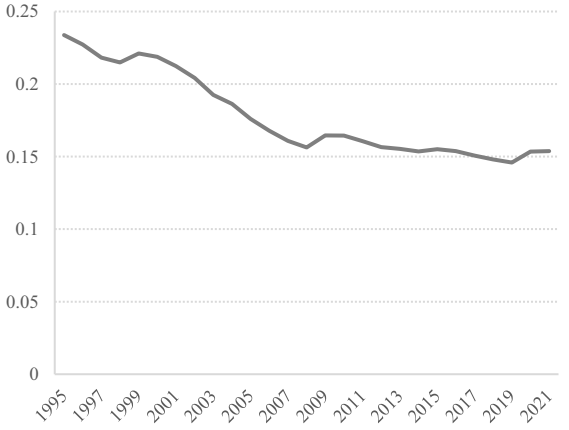
	Coefficient
α	2.659*** (0.521)
$Ln(y_{i,0})$	−0.237*** (0.051)
N	38
White test (p-value)	0.691
Adjusted R-Squared	0.533
Speed of convergence	0.014

Notes: ***Significance at 1%; **significance at 5%; *significance at 10%; period from 1995 to 2021
Source: Authors' own creation



Note: Period from 1995 to 2021
Source: Authors' own creation

Figure 1. Absolute β-convergence for the Eurozone



Note: Period from 1995 to 2021
Source: Authors' own creation

Figure 2. σ- Convergence for the Eurozone

For those reasons, we suspect that under an apparent convergence in per capita GDP within the region, different groups of countries converge toward multiple stationary states. As Bartkowska and Riedl (2012) point out, detecting convergence clubs is linked to conditional convergence and involves identifying clusters of countries sharing the same

steady state. More recent contributions show that the proper procedure for this purpose relies on applying semiparametric methodologies. To name a few, Corrado *et al.* (2018) propose a multiple pairwise comparison method based on recursive bootstrapping combined with Monte Carlo simulations, and Kar *et al.* (2019) apply the Phillips and Sul (2007 and 2009) test to identify convergence clubs in 217 countries with different degree of development.

4. Methodology

This study investigates the presence of convergence clubs in per capita income within the EA using Phillips and Sul's (2007, 2009) *log-t* test, improved by Von Lyncker and Thoennessen (2017) (referred to as PSLT). This method addresses limitations associated with β and $\sigma-$ convergence tests. Following a methodology akin to Glawe and Wagner (2021), our analysis extends the time sample and innovates in several vital aspects. First, the focus shifts from the EU to the EA, emphasizing the implications of results on area stability and the future of the single currency. Second, GDP per capita in PPP units is used instead of simple GDP per capita, aligning with the EU's foundational aim to enhance and homogenize the relative well-being of citizens. Third, an equation grounded in contemporary economic growth theories is estimated to identify primary drivers of GDP per capita growth in the Eurozone, aiming to discern factors contributing to the subdued growth in lagging countries and derive policy recommendations for improvement.

The PSLT methodology introduces a novel "*log-t*" regression test to assess convergence within a nonlinear time-varying factor model. This method is distinctive for accommodating diverse agent behaviors without assuming trend stationarity or stochastic non-stationarity, enhancing robustness against series stationarity properties.

Unlike previous approaches that categorize individuals into convergence subgroups based on predetermined criteria, PSLT uses a data-driven algorithm for identifying convergence clusters. This innovative approach avoids predefined sample separation and uses the relative transition parameters mechanism introduced by Phillips and Sul (2007) to cluster individuals based on similar transition paths.

Moreover, PSLT has advantages over stochastic-convergence tests relying on unit root and cointegration tests, which may be weak in detecting asymptotic co-movement. Unlike tests assuming that non-convergence implies divergence, the PSLT method explicitly identifies countries exhibiting divergence.

The convergence detection procedure involves assessing convergence among panel members by identifying convergence clubs and divergent groups. The initial model is a one-factor factorial model examining per capita GDP (X_{it}) for countries ($i = 1,\ldots, N$) over time ($t = 1,\ldots, T$). Our sample comprises all EA members, irrespective of their membership year, for 1995–2021, which is the most extended sample size to have a balanced panel suitable for this methodology. The model includes an idiosyncratic systematic component (α_i) measuring the distance between the common factor and the systematic part of X_{it}. Phillips and Sul (2007) modified the model by allowing the idiosyncratic systematic element to evolve over time and incorporating a random component, enabling consideration of the possibility of a country's convergence toward the common factor. The adapted model is designed to capture the evolution of X_{it} relative to the common factor by incorporating the parameter α_i and a random element ε_{it} The model is as follows:

$$X_{it} = \alpha_{it}\mu_t + \varepsilon_{it} = \left(\alpha_{it} + \frac{\varepsilon_{it}}{\mu_t}\right)\mu_t = \beta_{it}\mu_t \tag{2}$$

According to Model (2), the term β_{it} stands for the distance of country i from the common factor. If β_{it} tends toward the same constant for all countries in the panel, it can be concluded that these countries are converging. However, the model has more unknowns than there is data available, as both β_{it} and μ_t are unobservable. To address this issue, Phillips and Sul (2007) suggest using the "relative transition path," which is reflected in the evolution over time of the "relative transition coefficient," defined as follows:

$$h_{it} = \frac{X_{it}}{N^{-1}\sum_{i=1}^{N} X_{it}} = \frac{\beta_{it}}{N^{-1}\sum_{i=1}^{N} \beta_{it}} \tag{3}$$

Each value of h_{it} represents the relative distance of each country from a common mean. Convergence of countries toward this mean is indicated if h_{it} tends toward 1 for all countries.
To develop a procedure for testing convergence that considers the possibility of convergence subgroups, it is necessary to assume a specific structure for the loading coefficients β_{it}. Phillips and Sul (2007) chose a semi-parametric specification for this structure, known as a decay model:

$$\beta_{it} = \beta_i + \frac{\sigma_i \epsilon_{it}}{L(t)t^b} \tag{4}$$

The decay model includes the parameter β_i, which represents the value that β_{it} would reach in the long run. It also includes an idiosyncratic scaling parameter called σ_i and a slow function of time called $L(t)$, such as the logarithmic function $\log(t)$. The parameter b represents the rate at which panel heterogeneity decays [3].
The null and alternative hypotheses are as follows:

$$H_0 : \beta_i = \beta \ \forall \ i \ and \ b \geq 0$$

$$H_A : \begin{array}{l} 1.\ \beta_i \neq \beta \ \forall \ i \ or \ b < 0 \\ 2.\ \beta_i \neq \beta \quad for \ some \ i, \ and \ b \geq 0 \end{array}$$

If the null hypothesis is not rejected, global convergence will occur for all panel members. If the first alternative hypothesis is accepted, it would indicate absolute divergence, and if the second alternative hypothesis is accepted, it would suggest the presence of convergence clubs. Phillips and Sul (2007) use the previous equations to infer the model, which can be used to test for convergence practically:

$$\left[log(H_1/H_t) - 2log\left(log\left(t+1\right)\right)\right] = \widehat{p} + \widehat{q} log\left(t\right) + \widehat{u}_t \tag{5}$$

$$for \ t = [rT], \ [rT]+1, \ldots, \ T$$

In this model H_t is the cross-section variance and the fitted coefficient of $\log(t)$ is represented by $\widehat{q} = 2\widehat{b}$, where $\widehat{b}$ is the estimated value of the decay parameter in equation (4). It is worth noting that this estimate begins at $t = [rT]$, where r is a value between 0 and 1 and T is an integer.

The procedure involves testing the null hypothesis (H_0:$b \geq 0$) in equation (5) using a robust t-statistic called the "log-t statistic," which is calculated with a HAC estimate of the standard deviation of $\widehat{q}$ to account for heteroscedasticity and autocorrelation. If $t\widehat{q} < -1.65$,

the null hypothesis of convergence is rejected at the 5% significance level. If not dismissed, overall convergence is concluded among all group members. If the null hypothesis of absolute convergence is not accepted, the presence of convergence clubs is explored using a clustering algorithm by Phillips and Sul (2007, 2009) in four stages. Post-identification of convergence clubs, a merging process inspired by Von Lyncker and Thoennessen's (2017) methodology, is used to potentially combine subgroups into larger clubs, addressing the possibility of an overestimation in the initially identified clubs [4].

Additionally, to interpret the estimated value of q in the context of detecting convergence in our analysis, it is important to consider the relationship between q and b. Specifically, $\widehat{q} = 2\widehat{b}$, where $\widehat{b}$ is the estimated value of the decay parameter in equation (4). The interpretation of $\widehat{q}$ is as follows:

- If $\widehat{q}$ is significantly above 2, absolute convergence is detected between the converging units.
- If $\widehat{q}$ is significantly above 0 but not significantly above 2, conditional convergence is detected between the converging units.
- If $\widehat{q}$ is not significantly different from 0 but the log-*t* test still detects convergence, the convergence process is very slow.

5. Clusters in GDP per capita within the euro area

Table 2 presents convergence results among the EA countries using PSLT methodology.

The results shown in the first row of Table 2 indicate that the hypothesis of convergence in GDP per capita for the whole group or Eurozone countries is highly rejected by the *log t*-test since the log-*t* statistic is clearly under −1.645. However, three convergence clubs are detected. Club 1 is formed by Luxembourg, Lithuania and Ireland, with a *log-t* test statistic well above the critical value of −1.645. The parameter $\widehat{q}$ is estimated at 0.125, so, this convergence club constitutes a conditional convergence group. In Club 2, it is estimated at 0.41, which indicates conditional convergence, i.e. convergence in growth rate. Club 3 is made of Finland, France, Greece, Italy, Spain, Cyprus, Slovenia, Portugal, Estonia and

Table 2. Convergence clubs in per capita PPP GDP (2017, constant prices, international $)

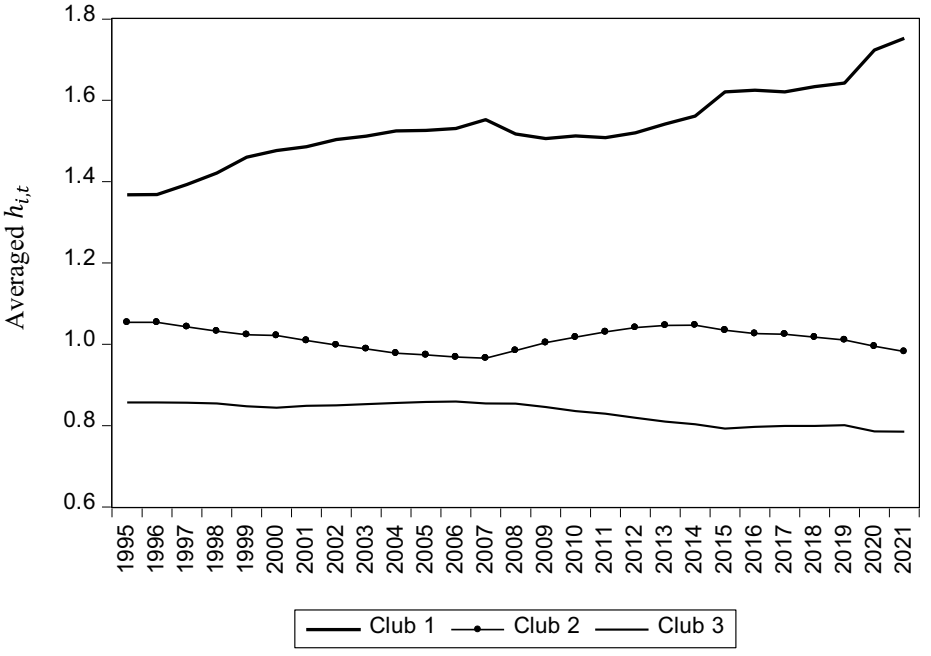
	Countries	Estimated coefficient $\widehat{q}$	*Log-t* statistic	S.E.	*p*-value	Estimated rate of decay $\widehat{b}$
Whole Eurozone group		−0.0522	−10.903	0.0047	0.0000	–
Club 1	Luxembourg, Ireland and Lithuania	0.125	1.281	0.098		0.062
Club 2	Austria, Belgium, Germany, Malta, The Netherlands and Slovakia	0.412	4.093	0.101		0.206
Club 3	Finland, France, Greece, Italy, Spain, Cyprus, Slovenia, Portugal, Estonia and Latvia	0.023	0.203	0.114		0.011

Note: Period from 1995 to 2021
Source: Authors' own creation

Latvia. As the parameter $\widehat{q}$ of this cluster is very low (0.023), its members progress very slowly following a conditional path.

Extensive research has explored economic convergence, revealing varied paces across countries or regions, notably evident in the divide between Northern and Southern nations. Studies within the EU by Bartkowska and Riedl (2012), Von Lyncker and Thoennessen (2017) and Glawe and Wagner (2021) support this observation. Contrastingly, our research on the Eurozone reveals a more complex narrative. Disparities persist but exhibit a diffuse pattern, deviating from stark geographical distinctions noted by other scholars. This shifts the focus away from a predominant geographical element, highlighting a multifaceted dynamic that underscores the intricate nature of economic convergence within the Eurozone. Notably, Eastern countries show significant progress, challenging traditional classifications, with some core countries such as Finland and France not exhibiting better evolution than certain peripheral nations like Italy, Spain, Greece, or Portugal. Meanwhile, wealthier countries such as Belgium, Germany or Austria maintain their advantageous positions.

The relative transition paths of each country within its club, as well as the average relative transition path of each club in comparison to the entire Eurozone, reveal the intricate forces shaping the Eurozone's economic landscape and the diversity in the convergence process. These differences are observed by examining the h_{it} values on the *y*-axis, representing the steady state of each country's economy. This enables the observation of the distance between these steady states and determining whether conditional convergence is occurring. Figure 3 illustrates the notable differences between the trajectory of Club 1 and Clubs 2 and 3. Additionally, the path of



Note: Period from 1995 to 2021
Source: Authors' own creation

Figure 3. Per capita GDP: Relative transition path compared to the Eurozone mean

Club 2 has decreased since 2015 and tends, as Club 3, toward a per capita GDP level below the EA average.

The analysis of relative transition paths in Figures 4–6 provides valuable insights into the dynamics of each country within its club. In Club 1, convergence occurs between Luxembourg, a well-positioned country that has worsened recently, and two worse-positioned countries that have remarkably improved, particularly Ireland since 2014. Club 2 consists of countries initially far apart, with four out of six countries having a better and more stable initial position but worsening over time. However, Malta and the Slovak Republic show opposite evolutions, moving from a less favorable situation to a better one. In Club 3, comprising peripheral countries with Finland and France, convergence results from all countries moving to a steady state at 80% of the mean EA. Most members worsen over time, but Estonia and Latvia, initially below the mean, improve their relative positions over the years.

In short, within the Eurozone, three clusters of countries exhibit per capita income trajectories leading to distinct stationary states, with Club 1's trajectory notably different from the other two. Club 3 is particularly concerned as its members' income levels slowly approach a stationary level significantly lower than the EA average despite relative progress among Eastern European countries within this cluster.

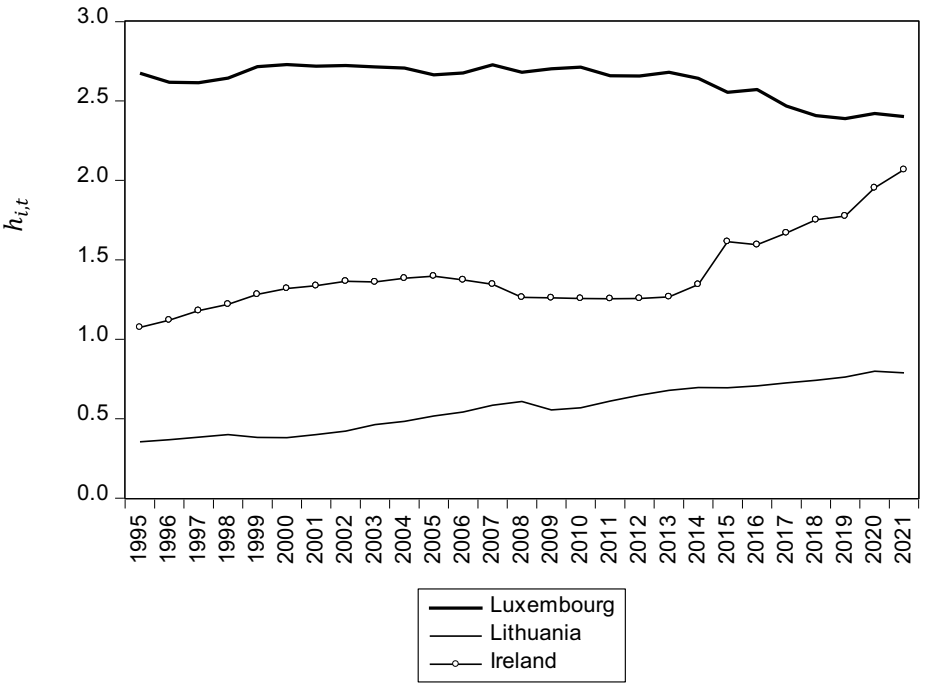


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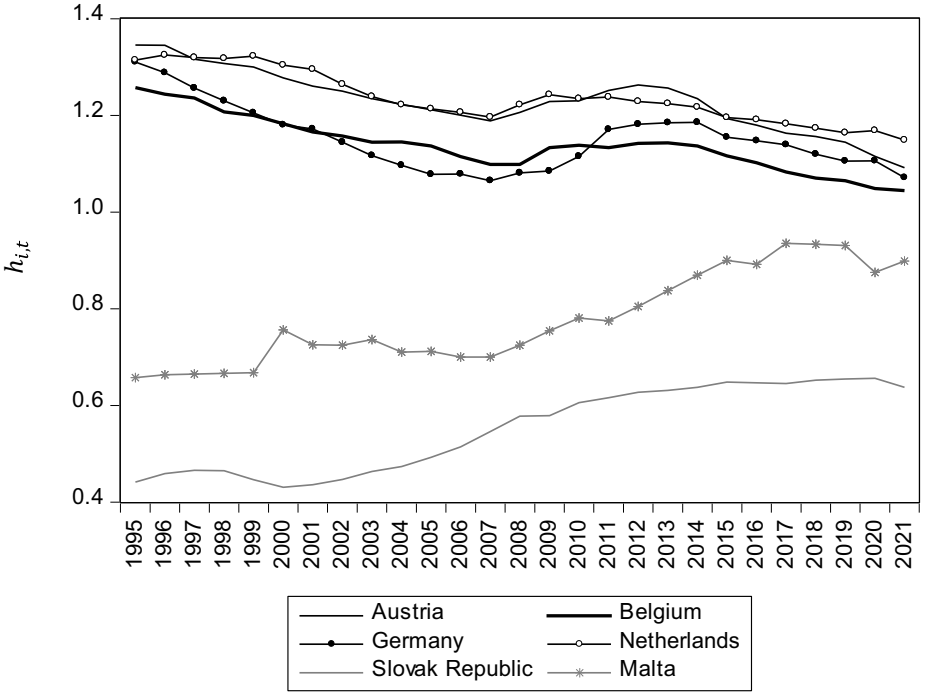
Figure 4. Per capita GDP: relative transition paths of each country within its club – Club 1



Note: Period from 1995 to 2021
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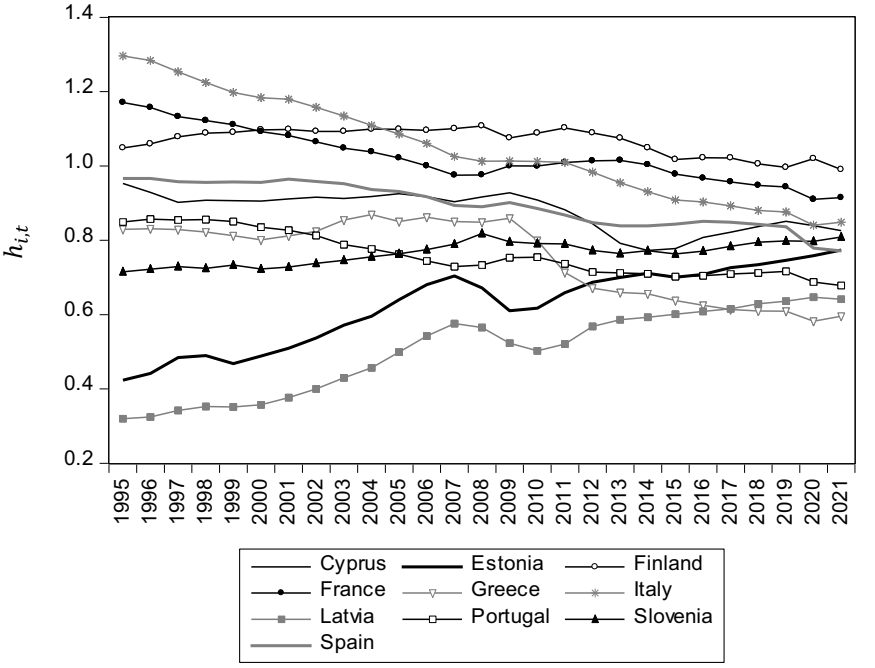
Figure 5. Per capita GDP: relative transition paths of each country within its club – Club 2

The relatively weak performance of Club 3 in income convergence within the Eurozone is attributed to the evolution of economic growth determinants. These countries should have capitalized on the decline in real interest rates following the introduction of the euro, leading to a lack of expected productivity catch-up. However, Díaz del Hoyo *et al.* (2017) highlight that the absence of real convergence is not solely because of the euro's launch but instead rooted in long-standing structural weaknesses and idiosyncratic features of Southern and Eastern Eurozone countries dating back decades.

While the PSLT methodology offers advantages, it does not delve into the underlying determinants impacting the growth process and convergence dynamics across the Eurozone. To address this limitation, we use a combination of cluster analysis and economic growth estimations using the conditional beta-converge approach. While not explicitly assigning member countries to specific groups, this approach provides insights into growth dynamics and income convergence, contributing to our understanding of factors that countries need to address for improved convergence toward higher income levels and well-being.

To unravel the relevance of the main economic growth drivers, we estimate the following model based on the endogenous economic growth theory [5]:



Note: Period from 1995 to 2021
Source: Authors' own creation

Figure 6. Per capita GDP: relative transition paths of each country within its club – Club 3

$$\Delta lny_{i,t} = \alpha + \beta_1 lny_{i,t-1} + \beta_2 ln\ RLP_{i,t} + \beta_3 \ln LF_{i,t} + \ + \beta_4 \ln Early_{i,t} + \beta_5 \ln inv_{i,t} + \beta_6 \ln Trade_{i,t} + \beta_7 \ln VA_{i,t} + \beta_8 GR_{i,t} + \varepsilon_{i,t} \quad (6)$$

where $\Delta lny_{i,t}$ is the growth rate of country i at time t. $y_{i,t-1}$ is the GDP per capita of country i at time $t-1$. Both were extracted from the World Bank and constant US dollars in PPP. A negative relationship between the lagged values of GDP per capita and the annual growth rates would reveal a catching-up process in the Eurozone. However, as we have already verified, the economies may converge to different stationary states since the growth equation addresses structural economic differences between countries, which are controlled by including determinants of economic and institutional nature. $RLP_{i,t}$ is the Real Labor Productivity index per person employed from Eurostat. $LF_{i,t}$ is the percentage of the labor force with advanced education, which accounts for the human capital in each country. $Early_{i,t}$ is the number of early leavers from education and training as a percentage of the population of age 19–24 years, also from Eurostat. $inv_{i,t}$ stands for the gross fixed capital formation as a percentage of GDP. $Trade_{i,t}$ is the sum of exports and imports of goods as a percentage of GDP, both from the World Bank. $VA_{i,t}$, the Voice and Accountability indicator from the World Bank WGI indicators, accounts for the impact of institutions on economic growth.

The theory of economic growth demonstrates that $RLP_{i,t}$, $LF_{i,t}$ $Trade_{i,t}$ and $VA_{i,t}$ impact positively on growth and that $Early_{i,t}$ influences negatively economic growth. Labor

productivity has been widely highlighted as the most important catalyst for economic growth. $GR_{i,t}$ is a dummy variable that addresses the effect of the Great Recession on convergence. It takes the value one during the years that, according to Eurostat, country i remained in this recession and zero otherwise. Finally, $\varepsilon_{i,t}$ is the error term with the usual statistical properties.

We have implemented a two-stage Seemingly Unrelated Regression (SUR) approach, akin to the two-stage least squares (2SLS) method, to address the endogeneity of lagged per capita GDP (GDP $t-1$). In the first stage of this method, the endogenous regressor (GDP_{t-1}) is regressed on all exogenous variables. The adjusted values from this regression, which replace the endogenous lag of GDP per capita in $t-1$, are then included in the final model. In the second stage, the resulting equation is estimated by SUR rather than OLS, leveraging SUR's ability to account for cross-correlation between error terms across equations. This cross-correlation arises when economic shocks or other unobserved factors simultaneously impact multiple cross-sectional units, a common occurrence within the Eurozone, given the economic interconnectedness of member states. By accounting for these correlations, SUR provides more efficient estimates than OLS (Zellner, 1962). This method is particularly suitable given the characteristics of the Eurozone data, where cross-sectional dependence is a crucial concern because of shared economic dynamics and external influences.

Furthermore, our two-stage process also effectively deals with endogeneity, which arises when lagged GDP per capita is correlated with the error term. In the first stage, the endogenous variable is regressed on exogenous predictors to obtain adjusted values, effectively purging the regressor of its endogenous component (Wooldridge, 2010). This approach is similar to 2SLS, a widely recognized method for addressing endogeneity (Stock and Watson, 2014). However, instead of relying on OLS for the second stage, we apply SUR to retain the efficiency gains associated with accounting for cross-sectional dependence. To further ensure robustness, we use clustered standard errors, which are designed to handle potential autocorrelation and heteroscedasticity within clusters (Cameron and Miller, 2015). Clustered standard errors are particularly useful in our panel data set, as they help mitigate the impact of autocorrelation and heterogeneity within cross-sectional units over time.

In sum, this approach, which combines 2SLS, SUR estimation and clustered standard errors, provides a robust and innovative estimation method compared to traditional approaches used in the existing literature. This methodology effectively addresses the challenges of both endogeneity and cross-sectional dependence, ensuring more reliable and efficient estimates of the growth equation.

Table 3 presents growth equation results for the entire Eurozone, excluding Luxembourg, because the high number of cross-border workers distorts the potential economic growth of this country [6]. All the explanatory variables exhibit the correct sign and are statistically significant. The negative relationship between lagged GDPs per capita and annual growth rates – jointly with the explanatory power of the rest of the variables – supports the hypothesis of conditional convergence in the Eurozone. This ratifies again convergence by groups of countries moving toward distinct stationary states. All explanatory variables, in line with Miron *et al.* (2022), indicate that the macroeconomic environment, labor productivity, human capital, investment and international trade are crucial drivers of economic growth and convergence in the Eurozone. The highly significant dummy variable, *GR*, aligns with changes in convergence trajectories and transition paths observed post-financial crisis in Figures 3–6.

The estimation of our economic growth equation reaffirms the crucial role of various factors in the growth and convergence process of Eurozone countries, aligning with previous studies that are not explicitly based on econometric estimations. Notably, Buti and Turrini (2015) suggest economic policies focused on improving labor quality, promoting

Table 3. Growth equation for the Eurozone as a whole, except Luxembourg

Unbalanced panel (cross-section SUR unbalanced approximation)	Coefficients
α	−0.176*** (0.066)
$lny_{i,t-1}$	−0.041*** (0.002)
ln $early_{i,t}$	−0.002* (0.001)
ln $RLP_{i,t}$	0.053*** (0.009)
ln $LF_{i,t}$	0.037*** (0.009)
ln $inv_{i,t}$	0.053*** (0.003)
ln $trade_{i,t}$	0.014*** (0.001)
D ($VA_{i,t}$)	0.016** (0.002)
$GR_{i,t}$	−0.037*** (0.002)
N	317
Adjusted R-squared	0.692
Prob(F-statistic)	0.000
	Averaged GDPpc PPP at the beginning and end of the period
Club 1	*1995*: 41,211.5 $
	2021: 85,828.4 $
Club 2	*1995*: 31,675.9 $
	2021: 48,695.7 $
Club 3	*1995*: 25,753,6 $
	2021: 38,934,1$

Notes: ***Significance at 1%; **significance at 5%; *significance at 10%; dependent variable = $\Delta lny_{i,t}$ period =1995–2021 [7]. Clustered standard errors and covariances
Source: Authors' own creation

technological progress, increasing R&D expenditures and fostering sound institutions for sustainable real convergence and resilience to adverse shocks in EA countries.

6. Policy considerations

The outcomes of this research carry significant implications for policymaking and directly impact the economic management of the Eurozone. As stressed above, several studies propose, in qualitative assessment, policy actions based on the factors that promote economic growth and convergence. This paper goes a step further by estimating the quantitative relevance of each factor in EA economic growth, as reflected in the results presented in Table 3. Moreover, this section unravels the growth factors in which each country has the most significant gaps and deficiencies. This last aspect helps us to find out, for each country in Club 3, the most appropriate growth-stimulating measures to improve their situation within their club or to move toward a higher-ranking club.

To determine the growth-stimulating factors in which Club 3 countries have more outstanding deficiencies, we calculate performance indicators for each explanatory variable with data from more than the last observed year, from 2005 to 2021. In our analysis, for each sample country, we computed each determinant's cumulative annual growth rate in equation (6). Then we computed the differences between the cumulative rates of each country of Club 3 and the averages of the corresponding cumulative rates of Clubs 1 and 2 countries, excluding Luxemburg, which form the reference area (R countries). Having undertaken this process for each growth determinant, we can identify the determinants that need improvement to facilitate the convergence of the economically underperforming Eurozone countries toward the more

prosperous ones. For example, for Finland, the figures corresponding to the *RLP* determinant indicate that the accumulated growth in labor productivity from 2005 to 2021 was 1.07 percentage points lower than the growth of that variable in the reference area. The results are presented in Table 4.

In synthesis, the indicator in which the Club 3 countries have the best situation is the growth rate of young people who leave their studies and training: half of the Club members have a figure lower than that of the reference countries: Greece, Cyprus and Portugal stand particularly out in this regard. The need to raise the growth rate of labor productivity is high in all Club 3 countries except Estonia and Latvia. The convenience of increasing human capital by providing higher education to the working population is high in all countries except France and Slovenia. All countries except Finland and France should have to adopt specific plans to increase investment. A majority of Club 3 countries must dedicate resources to increase the degree of trade openness by promoting both the growth of exports and imports of goods. Finally, the improvement of institutional quality, represented by the Voice and Accountability indicator in our growth equation, is an essential factor in all countries to raise long-term growth levels, as demonstrated, for example, by Glawe and Wagner (2021) and García-Solanes *et al*. (2023).

7. Concluding remarks

Economic convergence between the countries of the Economic and Monetary Union (EMU) remains a crucial goal for European authorities. It was expected that the single currency adoption would incentivize the participating economies to carry out the necessary reforms to make them more similar in terms of economic structures, which in turn would lead EMU to satisfy – endogenously – the OCA criteria. However, the facts proved this expectation wrong, and EMU has not led to a gradual reduction in the income gaps of the Member States, nor has it created a trend toward a unique steady state. However, the euro is not to blame for this lack of income convergence because the disparity in economic and institutional structures is deeply rooted in Member States long before the implementation of the single currency. Income convergence in the EA slowed significantly following the GFC.

Applying an innovative methodology to detect convergence clubs, in this study, we demonstrate the existence of three internal diverging trends shaping three income clubs with

Table 4. Cumulative average annual rate of each growth determinant in Club 3 countries relative to all other countries, except Luxembourg

Country	*Early*	*RLP*	*LF*	*Inv*	*Trade*	*VA*
Finland	2.741	−1.073	−0.409	0.405	−1.586	−0.078
France	1.444	−0.953	0.436	0.875	−1.010	−1.578
Greece	−4.144	−2.628	−0.387	−2.575	1.778	−0.699
Italy	0.282	−1.605	−0.199	−0.194	−0.231	0.388
Spain	−1.419	−0.835	−0.195	−2.167	−0.372	−0.542
Cyprus	−3.449	−0.623	−0.058	−0.424	0.866	−2.005
Slovenia	12.704	−0.147	0.181	−1.457	0.059	−9.809
Portugal	−7.075	−0.768	−0.179	−0.597	0.201	−0.634
Estonia	3.279	0.823	−0.050	−0.601	−0.859	1.314
Latvia	−0.431	1.305	−0.125	−1.849	−0.119	1.095

Note: Period from 1995 to 2021
Source: Authors' own creation

a composition that highlights the following peculiarities: first, the CEE countries exhibit a continuous approach to relatively more wealthy countries regardless of the club in which they are located. Second, the Southern countries have systematically underperformed relatively to the Eurozone average, with Portugal and Greece seeming caught in a lower-income trap. Third, countries such as France and Finland, which have generally been considered a core part of the Eurozone, are, in fact, in Club 3 and do not present a better evolution than some peripheral countries such as Italy and Spain. These findings call into question the traditional net division between two groups of countries, core and periphery, to which very different economic and institutional structures are attributed. Disparities are still present, but patterns are making the grouping of countries more diffuse than the stark divide previously highlighted by other scholars.

Once proved that convergence is conditional and multifaceted, our results in estimating an economic growth equation in the Eurozone provide evidence for the critical growth-enhancing role of real labor productivity, human capital, openness to international trade and highly productive investment expenditures. Based on these estimations, we identify the economic growth factors to which the authorities of each country should pay more attention. In the case of the countries in Club 3, they should make substantial efforts to increase the growth rate of labor productivity and their stock of human capital by providing higher education to the working population (except in France and the Slovak Republic). They should also strive to accomplish investment plans and increase trade openness.

Apart from these measures being the responsibility of national governments, European authorities have a wide field of action to promote the income convergence of Member States. The European Commission has launched a three-pronged financing agenda, in this respect, based on three pillars: a renewed commitment by national authorities to undertake structural reforms in both the goods and labor sectors, a flexible interpretation of fiscal responsibility giving favorable treatment to public investments aimed at strengthening economic growth and boosting investment via new resources, especially under the aegis of the current European New Generation Funds.

Notes

1. GDP per capita in PPP is a better indicator of well-being because it captures the true purchasing power (in terms of homogeneous shopping baskets) of citizens across different countries. Simple GDP per capita loses rigor if the shopping basket prices evolve differently across countries.
2. Club 1 is composed of Denmark, Ireland and Sweden. Club 2 is made of Austria, Belgium and Germany. The members of Club 3 are Finland, France and the United Kingdom. Club 4 consists of the rest of the EU countries (mainly countries in the center and south of the EU), except Bulgaria and The Netherlands, which are the two divergent countries.
3. For details see García-Solanes, Beyaert and López Gómez (2023).
4. See Phillips and Sul (2007, 2009) and Von Lyncker and Thoennessen (2017).
5. All these variables are expressed in logarithms in order to facilitate their interpretation and reduce possible correlations between them.
6. The exclusion of Luxembourg in the estimates of EA and EU growth equations is rather common practice. For example, in Díaz del Hoyo *et al.* (2017) and Licchetta and Matozzi (2023), among others.
7. All variables have been tested with the Bai and Ng test (2004) and CIPS test and no signs of non-stationarity have been detected except in VA with CIPS test, for this reason it is differentiated.

References

Alcidi, C. (2019), "Economic integration and income convergence in the EU", *Intereconomics*, Vol. 54 No. 1, pp. 5-11.

Alcidi, C., Núñez Ferrer, J., Di Salvo, M., Musmeci, R. and Pilati, M. (2018), "Income convergence in the EU: a tale of two speeds", *Centre for European Policy Studies (CEPS)*, 9 January 2018.

Barro, R.J. and Sala-I-Martin, X. (1992), "Convergence", *Journal of Political Economy*, Vol. 100 No. 2, pp. 223-251.

Bartkowska, M. and Riedl, A. (2012), "Regional convergence clubs in Europe: identification and conditioning factors", *Economic Modelling*, Vol. 29 No. 1, pp. 22-31, doi: 10.1016/j.econmod.2011.01.013.

Berthélemi, J.-C. (2006), "Convergence clubs and multiple equilibria: how did emerging economies escape the under-development trap", *Revue D'Économie du Developpment*, Vol. 5 No. 14, pp. 5-41.

Boltho, A. (2020), "Southern and Eastern Europe in the Eurozone: convergence or divergence?", *Baltic Journal of Economics*, Vol. 20 No. 1, pp. 74-93.

Buti, M. and Turrini, A. (2015), "Three waves of convergence. Can Eurozone countries start growing together again?, VoxEU", available at: https://voxeu.org/article/types-ez-convergence-nominal-real-and-structural

Cameron, A.C. and Miller, D.L. (2015), "A practitioner's guide to cluster-robust inference", *Journal of Human Resources*, Vol. 50 No. 2, pp. 317-372.

Chapsa, X., Athanasenas, A.L. and Tabakis, N. (2019), "Real convergence in EU-15: a comparative analysis of North versus South Europe", *European Research Studies Journal*, Vol. XXII No. 3.

Corrado, L., Stengos, T., Weeks, M. and Yazgan, M.E. (2018), "Robust tests for convergence clubs", Cambridge Working Papers in Economics, Nr 1873.

Correia, L. and Martins, P. (2019), "The European crisis: analysis of the macroeconomic imbalances in the rescued euro area countries", *Journal of International Studies*, Vol. 12 No. 2.

Coutinho, L. and Turrini, A. (2020), "Real convergence across the euro area", *Intereconomics*, Vol. 55 No. 5, pp. 301-311.

Díaz del Hoyo, J.L., Dorrucci, E., Heinz, F.F. and Muzicarova, S. (2017), "Real convergence in the euro area: a long-term perspective", European Central Bank, Occasional Paper Series, no 203/December.

Emerson, M., Gros, D., Italianer, A.P.-F. and Reichenbach, H. (1992), *One Market, One Money: An Evaluation of the Potential Benefits and Costs of Forming an Economic and Monetary Union*, Oxford University Press.

Ferreiro, J., Gálvez, C., Gómez, C. and González, A. (2017), "Economic crisis and convergence in the eurozone countries", *Panoeconomicus*, Vol. 64 No. 2, pp. 223-244.

Frankel, J.A. and Rose, A.K. (1998), "The endogeneity of the optimum currency area criteria", *The Economic Journal*, Vol. 108 No. 449, pp. 1009-1025.

Franks, J., Barkbu, B., Blavy, R., Oman, W. and Schoelrmann, H. (2018), "Economic convergence in the euro area: coming together or drifting apart? IMF working paper 28/10", January 2018.

García-Solanes, J., Beyaert, A. and López Gómez, L. (2023), "Convergence in formal and informal institutions and long-run economic performance in the euro area", in Dallago, B. and Casagrande, S. (Eds), *The Routledge Handbook of Comparative Economic Systems*, Routledge International Handbooks, Chapter 13, pp. 256-279.

Glawe, L. and Wagner, H. (2021), "Convergence, divergence, or multiple steady states? New evidence on the institutional development within the European union", *Journal of Comparative Economics*, Vol. 49 No. 3, pp. 860-884.

Gros, D. (2018), "Convergence in the European union: inside and outside the Euro contribution by Daniel Gros", Director of CEPS Informal meeting of Economic and Financial Affairs Ministers Sofia, 27-28 April 2018.

Kaitila, V. (2014), "Transnational income convergence and national income disparity: Europe 1960-2012", *Journal of Economic Integration*, Vol. 29 No. 2, pp. 343-371.

Kar, S., Roy, A. and Sen, K. (2019), "The double trap: Institutions and economic development", *Economic Modelling*, Vol. 76, pp. 243-259, doi: 10.1016/j.econmod.2018.08.002.

Licchetta, M. and Mattozi, G. (2023), "Convergence in GDP per capita in the euro area and the EU at the time of COVID-19", *Intereconomics*, Vol. 58 No. 1, pp. 43-51.

Marelli, E.P., Parisi, M.L. and Signorelli, M. (2019), "Economic convergence in the EU and Eurozone", *Journal of Economic Studies*, Vol. 46 No. 7, pp. 1332-1344.

Matkowski, Z., Prochniak, M. and Rapacki, R. (2016), "Real income convergence between central eastern and western Europe: past, present and prospects", Econstor, Paper presented at the 33rd CIRET, Copenhagen, Denmark, Sept. 14-17, 2016.

Miron, D., Holobiuc, A.-M., Cojocariu, R.-C. and Budacia, A.E. (2022), "Real convergence in the euro area: mirage or reality?", *Journal of Competitiveness*, Vol. 14 No. 1, pp. 100-117.

Phillips, P.C. and Sul, D. (2007), "Transition modeling and econometric convergence tests", *Econometrica*, Vol. 75 No. 6, pp. 1771-1855.

Phillips, P.C. and Sul, D. (2009), "Economic transition and growth", *Journal of Applied Econometrics*, Vol. 24 No. 7, pp. 1153-1185.

Quah, D. (1993), "Galton's fallacy and tests of the convergence hypothesis", *The Scandinavian Journal of Economics*, Vol. 95 No. 4, pp. 427-443.

Rapacki, R. and Prochniak, M. (2019), "EU membership and economic growth: empirical evidence for the CEE countries", *The European Journal of Comparative Economics*, Vol. 16 No. 1, pp. 3-40.

Stanišić, N. (2012), "The effects of the economic crisis on income convergence in the European union", *Acta Oeconomica*, Vol. 62 No. 2, pp. 161-182.

Stock, J.H. and Watson, M.W. (2014), *Introduction to Econometrics*, Pearson Education, pp. 978-1292071312.

Suciu, M.C., Petre, A., Istudor, L.G., Mituca, M.O., Stativa, G.A., Mardarovici, D. and Cotescu, R.G. (2021), "Testing real convergence as a prerequisite for long run sustainability", *Sustainability*, Vol. 13 No. 17, p. 9943.

Von Lyncker, K. and Thoennessen, R. (2017), "Regional club convergence in the EU: evidence from a panel data analysis", *Empirical Economics*, Vol. 52 No. 2, pp. 525-553.

Wagner, H. (2014), "Can we expect convergence through monetary integration? (new) OCA theory versus empirical evidence from European integration", *Comparative Economic Studies*, Vol. 56 No. 2, pp. 176-199.

Wooldridge, J.M. (2010), *Econometric Analysis of Cross Section and Panel Data*, MIT Press.

Zellner, A. (1962), "An efficient method of estimating seemingly unrelated regressions and tests for aggregation bias", *Journal of the American Statistical Association*, Vol. 57 No. 298, pp. 348-368.

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