The Journal of Economic Asymmetries 32 (2025) e00419

Contents lists available at ScienceDirect

The Journal of Economic Asymmetries

journal homepage: www.elsevier.com/locate/jeca

Does economic convergence diverge along the income distribution? Evidence from a decile-based analysis

Marco Amendola

Department of Industrial and Information Engineering and Economics, University of L'Aquila, Via Giuseppe Mezzanotte, L'Aquila, 67100, Italy

ARTICLE INFO

JEL classification:
D31
O15
O40
O47

Keywords:
Decile convergence
β-convergence
σ-convergence
Income inequality

ABSTRACT

This paper contributes to the literature on economic convergence by exploring an overlooked aspect: the potential heterogeneity of convergence processes across different segments of the income distribution. While previous analyses have typically focused on per capita income or GDP, this study adopts a more granular perspective by examining convergence at per capita income deciles. Drawing on data from 25 countries spanning 1980 to 2019, the analysis reveals a distinct pattern of divergence in the convergence process: higher-income deciles exhibit stronger convergence than lower-income ones, with this divergence widening in recent decades. These findings highlight the uneven nature of economic convergence, demonstrating that reducing cross-country income disparities is especially challenging for low-income groups — those most in need of improved well-being and economic catch-up.

1. Introduction

Global economic disparities continue to be one of the most persistent challenges in contemporary policy debates. Understanding the mechanisms behind the reduction or persistence of these disparities is essential to address issues related to long-term growth, income inequality, and global welfare. In this context, economic convergence – the process through which economic disparities between countries or regions narrow over time – has attracted significant attention in recent decades. This has resulted in a rich body of theoretical and empirical research employing diverse definitions, methodologies, and applications (see Johnson & Papageorgiou, 2020, for a recent review).

The study of economic convergence raises several fundamental questions, such as: do poorer countries (or regions) grow faster than richer ones, effectively catching up over time? If so, at what rate can inequality gaps be expected to close? Is convergence a pervasive process or does it occur in the form of convergence clubs, with groups converging internally but not across each other? What underlying forces drive these processes and what policies could accelerate the transition? Economic convergence has also attracted significant interest from scholars in growth theory, serving as a valuable empirical lens for testing alternative growth models (Durlauf et al., 2005).

Historically, much of the literature has examined convergence through the lens of average income or GDP (e.g., Barro, 1991, 2015; Barro & Sala-i Martin, 1992; Baumol, 1986; Mankiw et al., 1992; Phillips & Sul, 2009). While these studies have provided valuable insights into the existence, pace, and scope of convergence, they have largely overlooked how convergence, if present, unfolds across and impacts different segments of the income distribution. This paper argues that focusing on this aspect of the convergence process is crucial, as it could offer critical insights into the nature of convergence, its welfare implications, and its relationship with trends in inequality.

E-mail address: marco.amendola2@univaq.it.

https://doi.org/10.1016/j.jeca.2025.e00419
Received 9 December 2024; Received in revised form 19 March 2025; Accepted 14 April 2025
Available online 2 May 2025

Average convergence, defined here as convergence in per capita income (or GDP), can, in principle, emerge through two distinct pathways. On the one hand, it may reflect a relatively uniform convergence process across all segments of the income distribution. This outcome aligns with predictions from neoclassical growth models, which, when extended to account for idiosyncratic shocks, suggest convergence of entire income distributions rather than merely their averages (Benabou, 1996). On the other hand, convergence may be driven by uneven dynamics, where certain segments – such as higher-income groups – catch up, while others fall behind. In such cases, relying solely on average convergence analyses can lead to misleading conclusions about the nature and inclusivity of the convergence process.

The distinction between these two pathways is especially important in today's context of high and rising within-country income inequality (Chancel & Piketty, 2021). China offers a striking example: while the country has experienced remarkable economic growth in recent decades, inequality has simultaneously skyrocketed, with the benefits of growth disproportionately concentrated at the top of the income distribution. Similar patterns are evident in many other "converging countries", raising critical questions about the nature, inclusiveness, and distributional impacts of growth and convergence (Kuznets, 1955; Milanovic, 2016). In particular: is the convergence process uniform across different segments of the income distribution? If not, how does it vary? Which segments of the income distribution experience faster closure of cross-country income gaps?

Addressing these questions requires moving beyond average-based convergence analyses and examining the dynamics of convergence across the entire income distribution (Bishop et al., 1992). This paper adopts such an approach by extending the standard β-, σ-, and log-t-convergence frameworks to analyze cross-country convergence in (pre-tax) per capita income across income deciles. In doing so, it establishes a connection between within-country inequality trends and cross-country convergence, allowing investigating whether convergence occurs uniformly across the income distribution or if distinct *income-class convergence clubs* emerge. To my knowledge, this is the first study to explore the convergence process through this lens.

The findings underscore the importance of adopting this granular perspective. Analyzing data from 25 countries over the period 1980–2019, the study reveals a distinct pattern of divergence within the convergence process: higher-income deciles demonstrate markedly stronger convergence compared to low-income groups. This suggests that narrowing cross-country income disparities is particularly challenging and slow for the bottom segments of the income distribution — those for whom catching up in well-being is most urgent. Simulations of alternative scenarios also reveal that achieving equitable convergence across the income distribution necessitates reducing within-country income inequality in low-income, highly unequal converging countries. This highlights the potentially crucial role of policy in fostering more inclusive growth, ensuring that the benefits of economic progress are more evenly distributed across all income groups in these economies.

The remainder of the paper is structured as follows. Section 2 sets the stage for the analysis by reviewing the related literature and discussing how this paper contributes to the existing body of work. Section 3 describes the data sources and trends in income inequality. Section 4 details the methodologies employed, while the results of the analysis are presented and discussed in Section 5. Section 6 concludes.

2. Related literature

The literature on economic convergence primarily differentiates between two key concepts: β-convergence and σ-convergence (Barro & Sala-i Martin, 1990; Barro et al., 1991; Sala-i Martin, 1996; Monfort, 2008).

β-convergence occurs when poorer countries (or regions) experience higher growth rates than richer ones, effectively "catching up" over time (Barro & Sala-i Martin, 1992; Mankiw et al., 1992). This concept finds a solid theoretical foundation in the Solow growth model, where diminishing returns to capital imply that economies growth faster at low level of capital accumulation (Solow, 1956). β-convergence is said absolute (or unconditional) if it is assumed that all economies converge to the same steady-state level of income in the long run. In contrast, β-convergence is conditional if different economies converge to distinct steady-state levels, shaped by country-specific structural factors, such as saving rates, human capital, fertility rates, and institutional quality (Barro, 2015; Barro et al., 1991; Mankiw et al., 1992).

While β-convergence captures growth differentials, σ-convergence focuses on the dispersion of income levels, investigating whether measures of income dispersions across economies decline over time. As shown in the literature, the two concepts are clearly related, with β-convergence being a necessary but not sufficient condition for achieving σ-convergence (Barro & Sala-i Martin, 1990, 1992; Furceri, 2005; Sala-i Martin, 1996). Idiosyncratic shocks can, in fact, temporarily increase income disparities, even among converging economies (Sala-i Martin, 1996). Additionally, in the case of conditional β-convergence, economies may be converging towards different steady states, which does not necessarily lead to a reduction in overall income dispersion over time (Monfort, 2008; Young et al., 2008). Several scholars have thus argued that σ-convergence offers a clearer framework for analyzing convergence trends, as it directly reflects changes in income variability across economies without relying on the estimation of any specific model (e.g., Friedman, 1992; Quah, 1993). Other scholars, argued that both metrics of convergence are independently valuable as they offer complementary insights (e.g., Sala-i Martin, 1996).

From an empirical perspective, numerous studies have examined cross-country β-convergence in per capita income or GDP, demonstrating that while absolute convergence often appears within specific subsets of countries, it tends to disappear in larger, more diverse datasets, where it may reemerge as conditional convergence (e.g., Barro, 1991, 2015; Barro & Sala-i Martin, 1992; Baumol, 1986; Mankiw et al., 1992). Evidence of absolute β-convergence has been frequently observed at the sub-national level, across various institutional contexts, such as U.S. states, European regions, Japanese prefectures, and Canadian provinces (Barro & Sala-i Martin, 1990; Barro et al., 1991; DeJuan et al., 2012; Sala-i Martin, 1996). This can be attributed to the greater plausibility of homogeneous steady states at more localized levels. Quite surprisingly, a β-convergence rate of approximately 2% per year –

whether absolute or conditional – has emerged as a robust and consistent regularity in the literature, earning it the moniker of an "iron law" of economic convergence (Barro, 2015; Sala-i Martin, 1996).

Consistent with a σ-convergence process, several seminal studies have documented long-term reductions in per capita income dispersion at the sub-national level in the United States, Europe, and Japan (e.g., Barro & Sala-i Martin, 1990; Barro et al., 1991; Sala-i Martin, 1996). However, more recent decades have exhibited less consistent patterns. For instance, Monfort (2008) notes that the regional convergence process among EU-15 regions, which had been progressing for decades, began to stagnate in the mid-1990s. Boyle and McCarthy (1999) investigates σ-convergence at the country level, finding convergence among high- and upper-middle-income countries but divergence among low-income countries. More recently, Ram (2018) identified a clear pattern of divergence in the dispersion of per capita GDP across a dataset of 110 countries from 1960 to 2010.

Recent years have seen the development and application of novel techniques to study convergence (see Johnson & Papageorgiou, 2020). Among these, the log-t test introduced by Phillips and Sul (2007) has gained significant attention. As discussed in more detail in Section 4.3, the log-t test is a time-series approach that evaluates convergence by testing for a reduction in the variance of the logarithm of the variable of interest – such as per capita income – relative to the sample average. Thus, the log-t test can be viewed as a test of σ-convergence (Johnson & Papageorgiou, 2020). Key advantages of the log-t test include its capacity to account for substantial heterogeneity in transitional dynamics and its use of a simple algorithm to endogenously identify convergence clubs. Phillips and Sul (2009) apply the test to three different panels, finding evidence of convergence across 48 U.S. states and 18 Western OECD countries, but no convergence across a large sample of 152 countries, where club convergence is emerging. Similarly, Bartkowska and Riedl (2012) apply the log-t test to 206 EU regions over the period 1990–2002, uncovering evidence of club convergence with six distinct clusters. Initial levels of human capital and per capita income emerge as critical factors shaping the composition of these clubs. Borsi and Metiu (2015) apply this test to the 27 EU countries finding no evidence of overall convergence in per capita income over the period 1995–2010. Evidence of club convergence is found, with clubs mainly shaped by the geographic location. Similar results are found by Von Lyncker and Thoennessen (2017) at the EU regional level.

Pesaran (2007) proposed a pairwise stationarity test on log per-capita output gaps, concluding in favor of convergence if a sufficiently high proportion exhibit stationary behavior. Applying this method to a broad country sample, he found no evidence of output convergence but observed convergence in growth rates. Similarly, Deckers and Hanck (2014) found no pairwise convergence among 51 countries. At the regional level, Le Pen (2011) found no support for convergence in European NUTS2 regions, while Mello (2011) reported convergence among U.S. states. In contrast, Holmes et al. (2014) rejected convergence across U.S. states using Pesaran's standard approach but found evidence when allowing for a weaker form of pairwise convergence – that is allowing for an unknown cointegrating vector – or when analyzing convergence across U.S. Metropolitan Statistical Areas. Their findings also suggest that geographical and economic distance weaken convergence. Finally, Arvanitopoulos et al. (2021) rejected pairwise regional convergence in Greece but identified cluster convergence, primarily driven by accessibility, sectoral specialization, labor market dynamics, market potential, and specific locational characteristics.

While convergence has predominantly been studied through the lens of per capita income or GDP, increasing attention has also been directed toward other variables. Notable examples include labor productivity (Bhattarai & Qin, 2022; Rodrik, 2013), cost of living indices (Phillips & Sul, 2007), house price (Holmes et al., 2011; Tsai, 2018), ICT development (Saba & David, 2020), per capita emissions (Aldy, 2006), and energy intensity (Liddle, 2010; Markandya et al., 2006).

A key area of interest for this study is the convergence in income inequality, which investigates whether economies are becoming more similar over time in terms of income distribution. One of the earliest contributions to this field, Benabou (1996), tested for β-convergence in the Gini index across countries. The study found clear evidence of absolute β-convergence, along with a reduction in cross-country dispersion in both the Gini index and income quintile shares, thereby supporting the presence of σ-convergence in inequality. Ravallion (2003) confirmed the evidence of β-convergence in the Gini index and extended the analysis to decile income shares, concluding that the Lorenz curve as a whole exhibits signs of convergence. More recently, Chambers and Dhongde (2017) examined β- and σ-convergence in decile income shares using a sample of over 60 countries from 1985 to 2011. Their findings confirmed convergence across all deciles, though weaker evidence was observed in developed countries, where σ-divergence emerged in several middle and top deciles. At the sub-national level, Tselios (2009) identified regional inequality convergence within European Union regions, while Lin and Huang (2012) confirm this evidence for U.S. states.

This literature offers essential context for the present analysis. Cross-country convergence for low-income groups may be stronger if, ceteris paribus, inequality decreases over time in poorer and more unequal nations. Conversely, convergence rates may weaken for these income groups when the catch-up process is accompanied by rising inequality. This interdependence highlights a clear connection between within-country inequality dynamics and convergence across different income distribution segments.

Yet, it is important to emphasize that, while complementary, the objectives of this literature differ from those of the current analysis. Convergence in inequality examines whether countries are becoming more equal internally over time, focusing on within-country income distributions. In contrast, this paper investigates cross-country convergence in income levels, aligning with the traditional economic convergence literature. By extending the traditional convergence analysis at different segments of the income distribution, the adopted approach is conceptually more similar to the work of Bishop et al. (1992), who analyzed convergence in income across deciles between the South and non-South regions of the United States. Using census data, they defined decile-level convergence as the reduction of statistically significant income differences to statistical insignificance over time. Their findings demonstrated convergence across all deciles within a decade (1969–79), with the notable exception of the bottom decile.

Table 1
List of countries included in the analysis.

Countries				
Austria	Belgium	China	Croatia	Czech Republic
Denmark	Finland	France	Germany	Greece
Hungary	Ireland	Italy	Korea	Netherlands
New Zealand	Norway	Poland	Portugal	Spain
Sweden	Switzerland	Thailand	United Kingdom	U.S.

Table 2
Percentage income share across deciles: 2019 vs. 1980.

Decile	2019		1980		Δ
	Mean	Sd	Mean	Sd	
Bottom 20	2.65	0.69	3.12	0.86	−0.47
3th	4.58	0.92	5.22	1.29	−0.64
4th	5.78	0.90	6.41	1.33	−0.63
5th	7.00	0.86	7.64	1.27	−0.63
6th	8.28	0.78	8.93	1.22	−0.66
7th	9.76	0.68	10.47	1.08	−0.72
8th	11.72	0.49	12.45	1.01	−0.73
9th	14.95	0.69	15.62	1.53	−0.67
Top 10	34.96	4.71	29.72	7.14	5.24

3. Data

Income share data for various deciles are collected from the World Income Inequality Database (WIID). This database provides comprehensive information on income and wealth distribution across countries and over time, having been extensively used by several scholars in recent years to analyze global inequality trends (e.g., Chancel & Piketty, 2021; Chancel et al., 2022).

The data analyzed in the paper span from 1980 to 2019 and include 25 countries, primarily advanced economies.[1] Although the WIID covers a wider range of countries, the sample considered in the analysis is more selective. Countries exhibiting prolonged, suspiciously constant decile income shares are excluded, as this is interpreted as a sign of potentially unreliable data. Consequently, the final sample consists of the countries listed in Table 1.

Table 2 shows the sample averages of income shares, measured as a percentage of pre-tax national income, held by various deciles in 1980 and 2019.[2] The data spotlight a well-known pattern of income concentration: by 2019, the richest half of the population held over 80% of pre-tax national income, with more than one-third concentrated in the top decile alone. A clear trend emerges over these four decades, showing an increase in income concentration within the top 10% of earners (+5.2 pp). This wealthiest decile is the only group to have significantly increased its income share, while all other income groups saw reductions. Notably, the bottom 20% experienced an absolute decline of 0.47 percentage points, translating to a 15% decrease in their income share. These differences are statistically significant, as indicated by standard tests or by simple comparing distributions over time (see Fig. 1). In fact, these tendencies are widespread across countries, regarding both poorer and richer ones, as illustrated in Fig. 2, which displays variations in decile income shares across nations ranked by their initial per capita income. A closer examination of these trends reveals that while the redistribution of income shares from the bottom to the top decile is widespread, it has been somewhat more pronounced in poorer economies. For instance, the largest increases in the top decile's income share have occurred in countries like China, Hungary, and Poland. Notably, the United States ranks fourth in this regard, aligning with well-documented trends of rising income concentration in the country over the past decades (e.g., Piketty & Saez, 2003).

Fig. 3 illustrates the evolution of the average decile shares over time. The income concentration within the top decile rose consistently in the decades preceding the global financial crisis, stabilizing in its aftermath. Conversely, the lower income deciles exhibited a mirrored trend, with their shares contracting during the pre-crisis period and leveling off in subsequent years.

These findings align with global trends highlighted, for instance, by Chancel and Piketty (2021), which document a decline in within-country inequality between 1910 and 1980, followed by a sharp rise from 1980 to 2020. Concurrently, Chancel and Piketty's work highlights a substantial reduction in between-country inequality over the past four decades. The rest of the paper complements these evidence by investigating whether and at what pace per capita income in each decile is converging across countries. The next sections detail the analysis.

[1] The analysis is limited to 2019 to avoid capturing distortions caused by the Covid-19 pandemic shock.
[2] The two lowest income deciles are combined into a single 'bottom 20%' category, as income shares in the lowest decile are often very small.

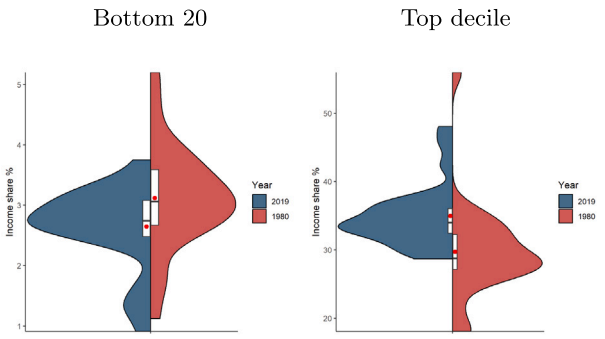

Fig. 1. Violin plot showing income share of the bottom 20% and top decile in 2019 and 1980.

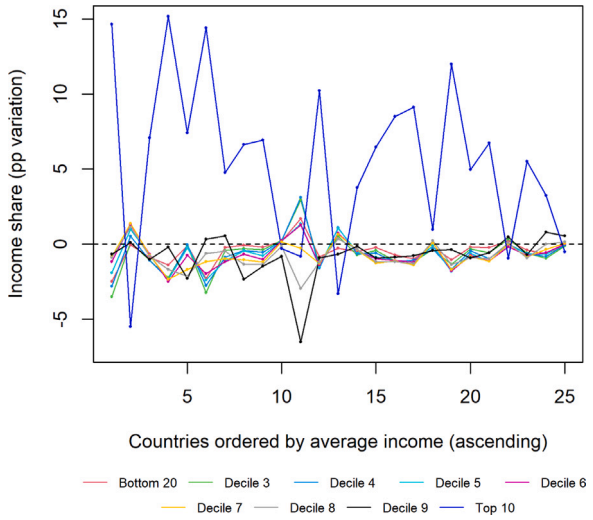

Fig. 2. Changes in decile shares across countries from 1980 to 2019. Countries are ranked by ascending per capita income in 1980, with poorer countries on the left and richer countries on the right.

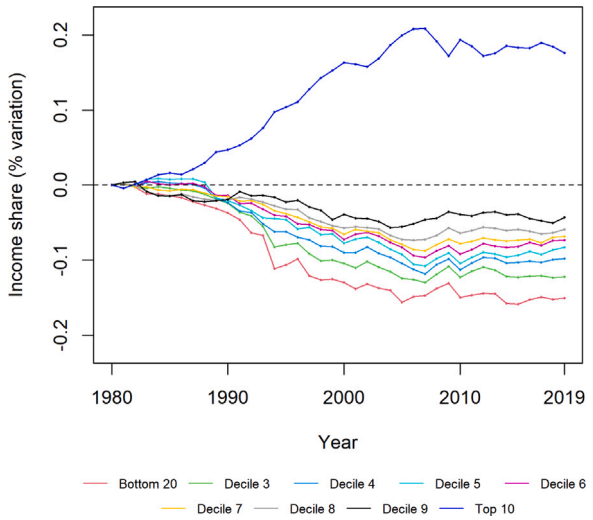

Fig. 3. Percentage variation over time in the average income shares.

4. Methods

4.1. β-Convergence

Empirically, β-convergence can be detected by regressing the average annual growth rate of per capita income (or GDP), observed over a specified time span, on the initial (log) per capita income level. Such a univariate regression framework is sufficient to identify absolute β-convergence. For conditional β-convergence, a multivariate regression is necessary in order to include variables capturing relevant country-specific characteristics (Barro et al., 1991; Mankiw et al., 1992). Alternatively, a panel data approach can be adopted to model time-invariant unit-specific characteristics (Caselli et al., 1996; Islam, 1995).[3]

The paper focuses on examining absolute β-convergence across the 25 countries included in the sample. However, unlike previous studies that concentrate exclusively on average income, I explore the convergence process in per capita income at the decile level. Specifically, for each decile $d = 1, \dots, 10$, the following equation is estimated (Barro & Sala-i Martin, 1990; Barro et al., 1991; Sala-i Martin, 1996):

$$\frac{1}{T} \cdot log\left(\frac{y^d_{i,t_0+T}}{y^d_{i,t_0}}\right) = a^d - \left(\frac{1 - e^{-\beta^d \cdot T}}{T}\right) \cdot log(y^d_{i,t_0}) + \epsilon_{i,t_0+T} \tag{1}$$

where i denotes the country, t_0 is the initial period, T is the length of the time span considered, and y^d represents the per capita income for decile d. This latter variable is computed as follows: $y^d_{i,t} = s^d_{i,t} \cdot y_{i,t} \cdot 10$, where y is the per capita income, expressed in constant prices and adjusted for Purchasing Power Parity (PPP), and s^d denotes the income share of decile d.

Eq. (1) is estimated using non-linear least squares, as proposed by Barro and Sala-i Martin (1990), among others. The key coefficient of interest is β^d, which signals the presence of absolute convergence dynamics at the decile d in case of positive and statistically significant value. A higher β^d suggests a faster convergence rate for the specific income decile under analysis.

4.2. σ-Convergence

Several metrics have been proposed in the literature to assess σ-convergence (Monfort, 2008), among which the two most commonly adopted are: (i) the standard deviation (or variance) of the logarithm of per capita income, and (ii) the coefficient of variation of per capita income.

From the literature, it is well-known that the two metrics do not always yield fully consistent results. For example, Dalgaard and Vastrup (2001) observed opposing σ-convergence outcomes depending on the specific metric used, attributing this discrepancy to the differing weights the metrics assign to individual countries' growth. Similarly, Ram (2018) found evidence of σ-divergence regardless of the metric chosen but noted that the rate of divergence was significantly higher when income dispersion was measured using the standard deviation of log-income.

These two metrics are calculated for each income decile as follows:

$$\sigma^{SD,d}_t = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(log\, y^d_{i,t} - log\, \bar{y^d_t}\right)^2} \tag{2}$$

$$\sigma^{CV,d}_t = \frac{\sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(y^d_{i,t} - \bar{y^d_t}\right)^2}}{\bar{y^d_t}} \tag{3}$$

where N is the sample size, and $\bar{y^d_t}$ is the average income level in decile d at time t. σ-convergence occurs when these metrics decrease over time, whereas an increase indicates σ-divergence.

4.3. Log-t-convergence

The log-t test, proposed by Phillips and Sul (2007), evaluates convergence within a flexible time-series framework that accommodates heterogeneity in transition dynamics. The test is based on a dynamic factor model in which the variable of interest, y, is expressed as:

$$log\, y_{i,t} = \delta_{i,t}\mu_t \tag{4}$$

where $\delta_{i,t}$ is a time-varying, unit-specific component that captures deviations of unit i from the common trend μ_t. This component is referred to as the individual transition factor, as it measures relative performance compared to the common trend.

To analyze convergence, relative transition factors $h_{i,t}$ are derived by scaling individual performance to the sample average:

$$h_{i,t} = \frac{\delta_{i,t}}{\frac{1}{N}\sum_{i=1}^{N}\delta_{i,t}} = \frac{log\, y_{i,t}}{\frac{1}{N}\sum_{i=1}^{N} log\, y_{i,t}} \tag{5}$$

[3] See Barro (2015), among others, for a discussion of the pros and cons of the two approaches.

Table 3
β-convergence results.

Decile	Full period		1980–2000		2000–2019	
	β coeff.	s.e.	β coeff.	s.e.	β coeff.	s.e.
Av. income	0.0228***	0.0041	0.0145***	0.0045	0.0293***	0.0051
Bottom 20	0.0126***	0.0038	0.0102*	0.0054	0.0126***	0.0032
3th	0.0144***	0.0031	0.0114**	0.0045	0.0168***	0.0032
4th	0.0167***	0.0031	0.0126**	0.0045	0.0207***	0.0036
5th	0.0186***	0.0032	0.0136***	0.0046	0.0236***	0.0038
6th	0.0202***	0.0034	0.0142***	0.0046	0.0259***	0.0042
7th	0.0214***	0.0036	0.0151***	0.0046	0.0271***	0.0045
8th	0.0225***	0.0038	0.0162***	0.0048	0.0277***	0.0047
9th	0.0238***	0.0042	0.0175***	0.0051	0.0289***	0.0053
Top 10	0.0295***	0.0056	0.0141***	0.0038	0.0395***	0.0075

* Indicate significance at the 90 percent confidence level.
** Indicate significance at the 95 percent confidence level.
*** Indicate significance at the 99 percent confidence level.

Under convergence, $\delta_{i,t} \to \delta$ and $h_{i,t} \to 1$ as $t \to \infty$ for all i. Consequently, the variance of the relative transition factors, H, converges to zero:

$$H_t = \frac{1}{N}\sum_{i=1}^{i=N}(h_{i,t}-1)^2 \to 0 \text{ as } t \to \infty \tag{6}$$

Conversely, if convergence does not occur, the variance does not approach zero, and H_t does not shrink to zero over time.
To rigorously test convergence, a structure is imposed on $\delta_{i,t}$. Specifically, Phillips and Sul (2007) assume:

$$\delta_{i,t} = \delta_i + \frac{\rho_i \epsilon_{i,t}}{log(t)t^{\alpha}} \tag{7}$$

This allows the null hypothesis of convergence to be tested using the following regression (see Phillips & Sul, 2007, for more details):

$$log\left(\frac{H_1}{H_t}\right) - 2log(log\, t) = \alpha + \gamma log\, t + u_t; \quad t = rT, rT+1, \ldots..T; \quad 0 < r < 1 \tag{8}$$

where γ is the parameter of interest, which can be shown to be twice the speed of convergence α in Eq. (7). If positive, the higher the value of γ, the faster the speed of convergence. In particular, when μ_t follows a random walk with drift or trend stationary process, convergence in growth rates (conditional convergence) emerges if $0 < \gamma < 2$, while level convergence emerges if $\gamma \geq 2$.

The null hypothesis of convergence can be tested using a one-sided t-test on γ, with HAC standard errors. The null is rejected at the 5% significance if $t_{\gamma} < -1.65$. Rejection suggests either no convergence or the presence of club convergence. In the case of club convergence, an algorithm has been proposed by Phillips and Sul (2007) to automatically identify these subgroups, making their approach particularly appealing in such circumstances.[4]

While this test has typically been applied to average income or GDP (Tomal, 2024), the analysis extends its application to the income decile level. This simply requires redefining the variable of interest in Eq. (4) as $y^d_{i,t}$ for different income deciles d.

5. Results

Let us now focus on the results of the analysis.

Table 3 reports results for β-convergence tests at each decile. Several observations can be made. Firstly, when examining β-convergence based on average income levels – essentially ignoring the novel aspects of this paper – an absolute convergence rate of around 2% is found, aligning with the so-called "iron law of convergence" (Barro, 2015; Sala-i Martin, 1996). This finding is nonetheless intriguing, as this evidence is here re-emerging at the country level, and in an absolute, rather than conditional, sense. However, sub-period analyses reveal that this convergence process has not been uniform over time. Notably, the convergence rate was nearly twice as high in the first two decades of the 21st century compared to the period from 1980 to 2000. Given that convergence is a long-term phenomenon, analyzing it over a relatively short interval may not provide a definitive evaluation. Therefore, the observed variability in the convergence rate over time should be interpreted with caution. Nonetheless, the likely recent acceleration in the pace of convergence is an interesting result, aligning with recent evidence presented by Patel et al. (2021) and Kremer et al. (2022), which suggest a resurgence of global convergence in the new millennium.

Let us now turn to the main contribution of the analysis: are average convergence rates a reliable proxy for convergence rates across different segments of the income distribution, or do significant differences emerge? The results suggest that the β-convergence process has been notably uneven across various income deciles. For instance, the convergence rate for the top income

[4] For further details on the test and the club detection algorithm, see Phillips and Sul (2007, 2009).

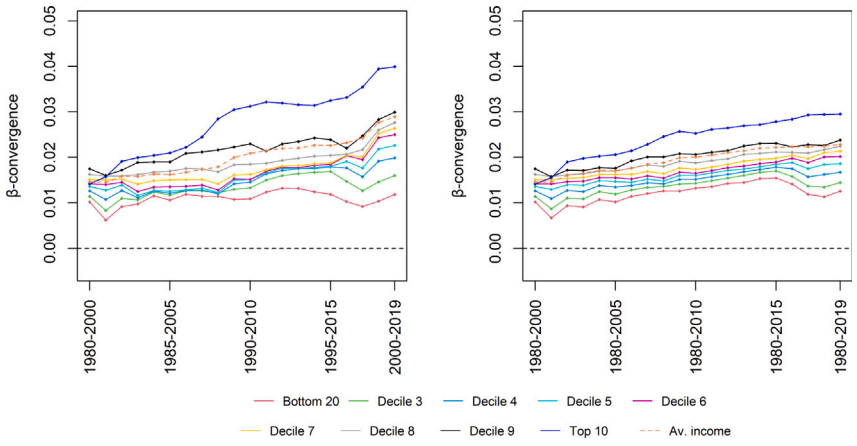

Fig. 4. β-convergence across subsample periods.

decile is more than double that of the bottom 20%. Quite surprisingly, a clear pattern emerges, revealing a declining speed of convergence as we transition from higher to lower income deciles. Convergence results derived from average income data thus tend to significantly overestimate the extent of convergence experienced by low-income groups while simultaneously underestimating convergence processes among top-income groups. According to the results, while it takes approximately 30 years to halve average income disparities, the bottom 20% requires around 55 years to achieve the same outcome, while the top decile accomplishes it in just 23 years.

Sub-sample analysis uncovers notable trends. While income convergence was more homogeneous across groups during the late 20th century, this pattern has shifted markedly in recent decades. The process has become more heterogeneous, with significantly stronger convergence observed among the top income deciles compared to the lower ones. The convergence speed in the top decile is about tree times higher that of the bottom 20%, when the analysis is restricted to the last two decades. Fig. 4 further illustrates this shift by displaying the decile-specific β coefficients estimated using rolling windows of 20 years (left panel) and forward-expanding windows (right panel). Several key insights emerge. First, disparities across deciles have widened over time, particularly between the top 10% and bottom 20% deciles. This divergence stems from stagnating convergence rates in the lower deciles, contrasted by accelerated convergence at the top of the income distribution, which reached value close to 4% in recent years. At this speed of convergence, 17 years are required to halve cross-country income disparities for the top decile. Second, a relatively stable ranking of convergence strength across deciles persists throughout the analyzed period, underscoring the structural consistency of these dynamics.

Fig. 5 explores whether the observed β-convergence dynamics translate into a measurable reduction in income dispersion over time, indicating the presence of σ-convergence processes. The figure presents percentage changes in the two metrics used to assess σ-convergence across income deciles, expressed relative to their baseline levels in 1980. Several key trends emerge. (1) The data indicate a general reduction in income dispersion across the sample. Between 1980 and 2019, income dispersion decreased by approximately 45% when measured by the standard deviation and by 23% when assessed using the coefficient of variation. An overall process of σ-convergence is thus emerging in the sample. (2) Consistent with previous findings, the σ-convergence process is significantly stronger for the top and middle income deciles compared to the bottom ones. Notably, there is no evidence of σ-convergence for the bottom 20% of the income distribution when measured by the coefficient of variation. In contrast, the most substantial reductions in income dispersion are observed among the top decile, according to both metrics. (3) Aligning with the documented intensification of β-convergence in recent decades, the σ-convergence process, as measured by the standard deviation, has accelerated over the past 20 years. However, this trend is less evident when using the coefficient of variation as the metric for cross-country income dispersion.

Results of the log-t test are reported in the Table 4. Consistent with prior findings, evidence of convergence in average income is emerging. However, the effect remains relatively modest, suggesting a slow convergence dynamics. A clear ranking across deciles is again observed, with convergence patterns being more rapid and pronounced among high-income groups than low-income groups. In fact, no evidence of convergence is found for the bottom 20%, consistent with the σ-convergence evidence based on the coefficient of variation. Stronger convergence is observed in the top decile, aligning with the previously presented σ-convergence results.

However, some evidence of club convergence emerges for the bottom 20%, with two distinct clubs identified, although convergence within these subgroups remains relatively weak. The relative performance of these two groups is illustrated in Fig. 6, which shows the club-average relative transition patterns. As shown, while some convergence between the two clubs occurred until the mid-1990s, they began to diverge thereafter. This divergence is primarily driven by the weak relative performance of the bottom 20% in the second group, which includes France, Germany, Spain, the United States, Portugal, and Thailand. Similarly, very poor performance is observed in three of the four divergent countries: Hungary, Greece, and Italy. Although outside the scope of this study, it is noteworthy that poor performance is registered in nearly all of the so-called PIIGS countries, as well as in core nations like Germany, France, and the United States. Exploring the factors underlying this emerging polarized scenario and the clustering of the data offers a promising avenue for future research.

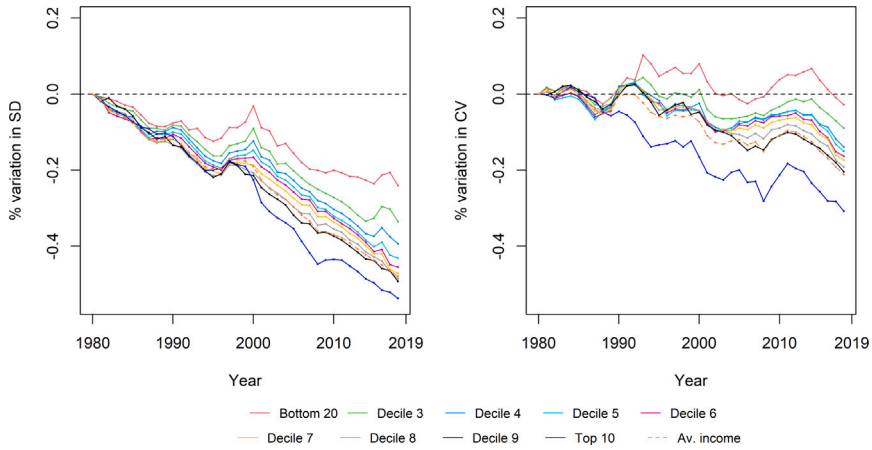

Fig. 5. σ-convergence: % change in standard deviation (left - panel) and coefficient of variation (right - panel) relative to the 1980 baseline.

Table 4
t-log-convergence results. The number in brackets stands for the number of countries in the club.

Decile	γ coeff.	s.e.	t stat.
Av. income	0.394	0.059	6.697
Bottom 20	−0.159	0.042	−3.805
Club 1	0.208	0.056	3.699
Club 2	0.233	0.049	4.724
3th	0.046	0.045	1.032
4th	0.169	0.045	3.719
5th	0.243	0.046	5.324
6th	0.279	0.045	6.159
7th	0.287	0.044	6.604
8th	0.317	0.044	7.152
9th	0.371	0.080	4.636
Top 10	0.668	0.077	8.656

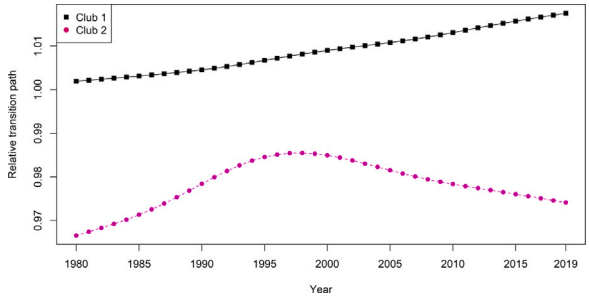

Fig. 6. Club convergence: average transition paths in each club. Bottom 20 decile. Club 1: Switzerland, Sweden, Denmark, Austria, Netherlands, Belgium, Finland, Czech Republic, New Zealand, Ireland, United Kingdom, Korea, Poland, Croatia, China; Club 2: France, Germany, Spain, USA, Portugal, Thailand; Divergent units: Norway, Hungary, Greece, Italy.

5.1. Linking heterogeneous convergence and within-country inequality

Contextualizing these findings within the observed within-country inequality trends provides valuable insights into the uneven patterns of economic convergence and their broader welfare implications. Specifically, the weaker convergence observed among the bottom deciles, coupled with a concurrent shrinkage in the income share of these groups, suggests that the benefits of convergence in terms of improving living standards and reducing poverty may have been particularly limited for low-income groups in poorer, yet converging economies. In contrast, the strong convergence observed in the top deciles, alongside a concentration of income within these groups, suggests that the benefits of convergence and growth have been disproportionally concentrated among wealthier segments of the population.

Table 5
Convergence outcomes for the bottom 20% and top deciles under three scenarios: baseline and two simulated cases. Frozen inequality: income shares fixed at 1980 levels. Converging inequality: income shares remain fixed at 1980 levels for most countries, but a gradual convergence in the top decile share is assumed for low-income, high-inequality countries.

	Baseline	Frozen inequality	Converging inequality
	β-convergence		
β-coeff.:			
Bottom 20	0.0126	0.0152	0.0182
Top 10	0.0295	0.0212	0.0200
	σ-convergence		
% var. in σSD			
Bottom 20	−0.240	−0.322	−0.388
Top 10	−0.537	−0.441	−0.408
% var. in σCV			
Bottom 20	−0.028	−0.134	−0.154
Top 10	−0.308	−0.236	−0.188
	Log-t-convergence		
γ-coeff.			
Bottom 20	−0.159	−0.070	0.081
Top 10	0.668	0.357	0.265

The data are illuminating in this sense. To illustrate, while per capita incomes for the top decile in China, Poland, and Korea increased by approximately $68,000, $95,000, and $148,000, respectively, between 1980 and 2019, income gains for the bottom 20% were in the range of: $900 in China, $1900 in Poland, and $4300 in Korea. These stark disparities highlight the unequal distribution of growth benefits and serve as concrete evidence of the unevenness of economic convergence across the income distribution, as found in the study.

To further investigate the relationship between within-country inequality and cross-country convergence across different income groups, simulations were conducted under two hypothetical scenarios. In the first, the *frozen inequality* scenario, income shares were fixed at their 1980 levels, effectively removing any observed changes in within-country inequality. The second, the *converging inequality* scenario, builds upon the first by introducing a gradual redistribution of income from the top decile to lower-income groups in low-income, high-inequality countries. This scenario is calibrated so that, by the end of the analyzed period, the top income share in these countries nearly converges to the sample mean.

The results, summarized in Table 5, reveal that the inequality trends of recent decades have amplified divergence in convergence rates between the top and bottom 20% deciles. When within-country inequality is frozen, a somewhat more balanced convergence process emerges, consistent with evidence pointing to slightly more uneven and unbalanced growth trajectories across lower-income economies, as discussed in Section 3. However, even under this artificially neutralized dynamic, substantial disparities in convergence rates persist between the bottom and the top decile. True convergence across the income distribution is achieved only when above-average growth in low-income countries disproportionately benefits the less well-off, in relative terms, as illustrated in the *converging inequality* scenario.[5]

The takeaway is clear: pairing convergence with reductions in within-country income inequality in low-income, high-growth converging countries can lead to a far more balanced cross-country convergence process. This highlights the crucial need to promote inclusive growth in converging economies, ensuring that the benefits of growth are more equitably distributed across all income groups. While growth and development can, eventually, lead to more equal societies over time (Kuznets, 1955), well-designed policies play a crucial role in shaping this process.[6] Targeted measures can address pre-tax inequalities – through structural reforms such as expanding access to education and healthcare, implementing labor market reforms, and closing gender gaps – while redistributive fiscal policies can reduce post-tax disparities. By fostering a more inclusive and sustainable convergence process, these policies play a crucial role in making convergence more equitable and accelerating the catch-up of low-income groups in converging economies — those most in need of improved well-being.

6. Conclusions

This paper offers a novel perspective on cross-country economic convergence by moving beyond the traditional focus on average income and examining the process at the decile level.

By extending traditional convergence methods to the this level of detail, this approach reveals an overlooked dimension of the convergence process: its asymmetric and uneven nature across the income distribution. Higher-income deciles demonstrate markedly stronger convergence compared to their lower-income counterparts, with this disparity widening over recent decades. This

[5] The connection between this analysis and the broader literature on convergence in income inequality is evident.
[6] See Milanovic (2016), among others, for a critical discussion of the Kuznets curve hypothesis.

asymmetry points to the emergence of what can be described as *income-class convergence clubs*, where convergence and reductions in cross-country income disparities predominantly benefit upper- and middle-income groups, leaving lower-income groups lagging or progressing at a much slower pace. Relying solely on economic convergence and trickle-down mechanisms to close income gaps for the poorest groups risks, therefore, being largely unsatisfactory and excessively slow.

A direct link between within-country inequality trends and cross-country convergence across the income distribution has also been established. Rising inequality in recent decades has exacerbated divergence in the convergence process, particularly by disproportionately channeling the benefits of high growth in converging countries to top earners, while leaving lower-income groups increasingly marginalized. In the absence of clear redistributive policies targeting both pre-tax and/or post-tax income inequality, convergence is likely to remain slow, uneven, and insufficient to meaningfully improve living standards, enhance well-being, and reduce poverty rates among low-income groups in these economies.

This study represents an initial step in analyzing economic convergence for different segments of the income distribution. As such, several avenues for future research remain. First, it is important to note that the sample analyzed here is relatively small, both in terms of the number of countries and the time span covered. Expanding the analysis to include longer time periods and a more diverse set of economies, particularly those with lower income levels, would be a valuable extension. Second, testing the results with post-tax data remains a crucial and necessary direction for future research, allowing for a direct assessment of how public policies have influenced and eventually reduced the unevenness of convergence identified in this study. An in-depth investigation into club convergence dynamics across different segments of the income distribution, utilizing novel techniques such as the one recently proposed by Panagiotidis et al. (2023) for long-memory stationary frameworks, and exploring the drivers behind the formation of clusters, would offer another important avenue for future research.

Declaration of competing interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Aldy, J. E. (2006). Per capita carbon dioxide emissions: convergence or divergence? *Environmental and Resource Economics*, *33*(4), 533–555.

Arvanitopoulos, T., Monastiriotis, V., & Panagiotidis, T. (2021). Drivers of convergence: The role of first-and second-nature geography. *Urban Studies*, *58*(14), 2880–2900.

Barro, R. J. (1991). Economic growth in a cross section of countries. *The Quarterly Journal of Economics*, *106*(2), 407–443.

Barro, R. J. (2015). Convergence and modernisation. *The Economic Journal*, *125*(585), 911–942.

Barro, R. J., & Sala-i Martin, X. (1990). *economic growth and convergence across the United states: NBER Working Paper (w3419)*.

Barro, R. J., & Sala-i Martin, X. (1992). Convergence. *Journal of Political Economy*, *100*(2), 223–251.

Barro, R. J., Sala-i Martin, X., & Blanchard, O. J. (1991). Convergence across states and regions. *Brookings Papers on Economic Activity*, 107–182.

Bartkowska, M., & Riedl, A. (2012). Regional convergence clubs in Europe: Identification and conditioning factors. *Economic Modelling*, *29*(1), 22–31.

Baumol, W. J. (1986). Productivity growth, convergence, and welfare: what the long-run data show. *The American Economic Review*, 1072–1085.

Benabou, R. (1996). Inequality and growth. *NBER Macroeconomics Annual*, *11*, 11–74.

Bhattarai, K., & Qin, W. (2022). Convergence in labor productivity across provinces and production sectors in China. *The Journal of Economic Asymmetries*, *25*, Article e00247.

Bishop, J. A., Formby, J. P., & Thistle, P. D. (1992). Convergence of the South and non-South income distributions, 1969–1979. *The American Economic Review*, *82*(1), 262–272.

Borsi, M. T., & Metiu, N. (2015). The evolution of economic convergence in the European Union. *Empirical Economics*, *48*, 657–681.

Boyle, G. E., & McCarthy, T. G. (1999). Simple measures of convergence in per capita GDP: a note on some further international evidence. *Applied Economics Letters*, *6*(6), 343–347.

Caselli, F., Esquivel, G., & Lefort, F. (1996). Reopening the convergence debate: a new look at cross-country growth empirics. *Journal of Economic Growth*, *1*, 363–389.

Chambers, D., & Dhongde, S. (2017). Are countries becoming equally unequal? *Empirical Economics*, *53*, 1323–1348.

Chancel, L., & Piketty, T. (2021). Global income inequality, 1820–2020: the persistence and mutation of extreme inequality. *Journal of the European Economic Association*, *19*(6), 3025–3062.

Chancel, L., Piketty, T., & Saez, E. (2022). *world inequality report 2022*. Harvard University Press.

Dalgaard, C. J., & Vastrup, J. (2001). On the measurement of σ-convergence. *Economics Letters*, *70*(2), 283–287.

Deckers, T., & Hanck, C. (2014). Multiple testing for output convergence. *Macroeconomic Dynamics*, *18*(1), 199–214.

DeJuan, J., Persson, J., & Tomljanovich, M. (2012). Regional Income Convergence in Sweden, 1911–2003: A Time Series Analysis. *The Journal of Economic Asymmetries*, *9*(1), 67–87.

Durlauf, S. N., Johnson, P. A., & Temple, J. R. (2005). Growth econometrics. *Handbook of Economic Growth*, *1*, 555–677.

Friedman, M. (1992). Do old fallacies ever die? *Journal of Economic Literature*, *30*(4), 2129–2132.

Furceri, D. (2005). β and σ-convergence: A mathematical relation of causality. *Economics Letters*, *89*(2), 212–215.

Holmes, M. J., Otero, J., & Panagiotidis, T. (2011). Investigating regional house price convergence in the united states: Evidence from a pair-wise approach. *Economic Modelling*, *28*(6), 2369–2376.

Holmes, M. J., Otero, J., & Panagiotidis, T. (2014). A note on the extent of us regional income convergence. *Macroeconomic Dynamics*, *18*(7), 1635–1655.

Islam, N. (1995). Growth empirics: a panel data approach. *The Quarterly Journal of Economics*, *110*(4), 1127–1170.

Johnson, P., & Papageorgiou, C. (2020). What remains of cross-country convergence? *Journal of Economic Literature*, *58*(1), 129–175.

Kremer, M., Willis, J., & You, Y. (2022). Converging to convergence. *NBER Macroeconomics Annual*, *36*(1), 337–412.

Kuznets, S. (1955). Economic Growth and Income Inequality. *The American Economic Review*, *45*(1), 1–28.

Le Pen, Y. (2011). A pair-wise approach to output convergence between european regions. *Economic Modelling*, *28*(3), 955–964.

Liddle, B. (2010). Revisiting world energy intensity convergence for regional differences. *Applied Energy*, *87*(10), 3218–3225.

Lin, P. C., & Huang, H. C. (2012). Convergence in income inequality? Evidence from panel unit root tests with structural breaks. *Empirical Economics*, *43*, 153–174.

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics*, *107*(2), 407–437.
Markandya, A., Pedroso-Galinato, S., & Streimikiene, D. (2006). Energy intensity in transition economies: is there convergence towards the eu average? *Energy Economics*, *28*(1), 121–145.
Sala-i Martin, X. X. (1996). Regional cohesion: evidence and theories of regional growth and convergence. *European Economic Review*, *40*(6), 1325–1352.
Mello, M. (2011). Stochastic convergence across us states. *Macroeconomic Dynamics*, *15*(2), 160–183.
Milanovic, B. (2016). *Global inequality: a new approach for the age of globalization*. Harvard University Press.
Monfort, P. (2008). *convergence of EU regions: measures and evolution*. European Commission, Regional Policy Brussels.
Panagiotidis, T., Papapanagiotou, G., & Stengos, T. (2023). Dying together: A convergence analysis of fatalities during covid-19. *The Journal of Economic Asymmetries*, *28*, Article e00315.
Patel, D., Sandefur, J., & Subramanian, A. (2021). The new era of unconditional convergence. *Journal of Development Economics*, *152*, Article 102687.
Pesaran, M. H. (2007). A pair-wise approach to testing for output and growth convergence. *Journal of Econometrics*, *138*(1), 312–355.
Phillips, P. C., & Sul, D. (2007). Transition modeling and econometric convergence tests. *Econometrica*, *75*(6), 1771–1855.
Phillips, P. C., & Sul, D. (2009). Economic transition and growth. *Journal of Applied Econometrics*, *24*(7), 1153–1185.
Piketty, T., & Saez, E. (2003). Income inequality in the United States, 1913–1998. *The Quarterly Journal of Economics*, *118*(1), 1–41.
Quah, D. (1993). Empirical cross-section dynamics in economic growth. *European Economic Review*, *37*(2–3), 426–434.
Ram, R. (2018). Comparison of cross-country measures of sigma-convergence in per-capita income, 1960–2010. *Applied Economics Letters*, *25*(14), 1010–1014.
Ravallion, M. (2003). Inequality convergence. *Economics Letters*, *80*(3), 351–356.
Rodrik, D. (2013). Unconditional convergence in manufacturing. *The Quarterly Journal of Economics*, *128*(1), 165–204.
Saba, C. S., & David, O. O. (2020). Convergence patterns in global ICT: Fresh insights from a club clustering algorithm. *Telecommunications Policy*, *44*(10), Article 102010.
Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, *70*(1), 65–94.
Tomal, M. (2024). A review of Phillips-Sul approach-based club convergence tests. *Journal of Economic Surveys*, *38*(3), 899–930.
Tsai, I. C. (2018). House price convergence in euro zone and non-euro zone countries. *Economic Systems*, *42*(2), 269–281.
Tselios, V. (2009). Growth and convergence in income per capita and income inequality in the regions of the EU. *Spatial Economic Analysis*, *4*(3), 343–370.
Von Lyncker, K., & Thoennessen, R. (2017). Regional club convergence in the EU: evidence from a panel data analysis. *Empirical Economics*, *52*, 525–553.
Young, A. T., Higgins, M. J., & Levy, D. (2008). Sigma convergence versus beta convergence: Evidence from US county-level data. *Journal of Money, Credit and Banking*, *40*(5), 1083–1093.