

Exploring Global Economy Evolution: Clusters and Patterns

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Abstract: Economic integration and globalization are expected to promote economic growth and convergence. This article offers a comparative analysis of the pace of development in terms of GDP per capita in 79 economies from 1970 to 2019. Usually, economic convergence literature aims to establish whether catching-up processes have been successful. This article verifies the existence of growth path similarities to identify clusters of countries that grow at a similar pace and react in a similar way to crises, and compares their dynamics in time. According to the results, coherently with globalization pressures, clusters have become fewer and larger. However, growth path divergences persist and suggest a cluster-based convergence. Integration processes, such as the European Union, have not influenced this trend. The extent to which these clusters are composed of structurally similar economies has been investigated and some consistencies have emerged between the composition of clusters and the classifications provided by the varieties of capitalism theory.

Keywords: cluster analysis; comparative economics; convergence; economic integration; economic system; globalization; structural change; varieties of capitalism; world economy

JEL Classification: O11; P1; P2; P5; P51



Citation: Casagrande, Sara, and Bruno Dallago. 2024. Exploring Global Economy Evolution: Clusters and Patterns. *Economies* 12: 32. <https://doi.org/10.3390/economies12020032>

Academic Editor: Sajid Anwar

Received: 10 January 2024

Revised: 21 January 2024

Accepted: 24 January 2024

Published: 29 January 2024



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1. Introduction

Globalization is a “multifaceted concept” (Gygli et al. 2019, p. 544). It can be interpreted as a worldwide process of socio-economic interaction and interdependence based on the removal of barriers to trade, flows of capital, movements of people, ideas and technology.

Despite different definitions, globalization is assimilated to a process of integration and convergence. The willingness of countries to apply common policies and stipulate agreements to promote economic harmonization is considered a precondition for economic integration and, thus, convergence. The latter should be understood as an economic mechanism able to reduce the differences in the “levels of some measures of economic welfare” (Ghirmay 2014, p. 63), or differences in interest rates and prices (Streeten 2001). In the economic literature, the issue of convergence is mainly addressed by verifying the actual catch-up in terms of GDP per capita and, to a lesser extent, in terms of business cycle synchronization (Lopez et al. 2021).

The connection between globalization, integration and convergence is, however, controversial. Indeed, the empirical evidence does not unequivocally allow scholars to establish an effective worldwide convergence or a causal relationship between globalization, integration and convergence. Economic literature usually aims to establish whether economic convergence has been achieved or not. However, interesting information can be obtained from the analysis of the similarity of growth patterns. Verifying the existence of similarities in the growth paths of GDP per capita at a global level can be a useful exercise to identify clusters of countries that grow at a similar pace and react in a similar way to crises and stimuli. Given that the dynamics of GDP are linked to the dynamics of the economic structure, and it is expected that globalization and integration processes can also impact institutional

frameworks, it cannot be ruled out that these clusters of countries share structural affinities and, thus, a particular variety of capitalism.

The goal of this article is to verify the existence of similarities in the GDP per capita growth patterns of 79 major world economies from 1970 to 2019. This empirical comparative analysis allows identification of clusters of countries that grow at a similar pace and react in a similar way to crises and comparison of their dynamics in time. The methodology is based on the computation of root mean square errors (RMSE), which can be interpreted as measures of the degree of similarity between growth paths. The advantage of this basic approach consists in the transparency of results and its ability to reveal the degree of similarity between the growth path of a given country compared to those of all other countries in the world. The calculation of these different degrees of similarity allows identification of groups of countries (clusters) with similar growth paths.

We expect that globalization has fostered the formation of increasingly fewer but larger clusters over time; however, convergence clubs can also emerge. The extent to which these clusters are composed of structurally similar economies has been investigated through a comparison between the composition of clusters and the classifications provided by the varieties of capitalism theory. Results indicate that a worldwide heterogeneity persists in growth paths, despite the fact that clusters have become fewer and larger, coherently with globalization pressures. In recent decades, there seems to have been a “polarized convergence”, in the sense that the more developed countries tend to become similar and the same happens to the less developed countries which, however, do not seem to achieve a successful catch-up process. Another interesting aspect is the heterogeneity that persists within Europe, with a clear polarization between southeastern and northwestern European countries, despite the European integration process.

The article is organized as follows: Section 2 offers a brief literature review of the controversial connection between globalization, integration and structural convergence. In Section 3, the methodology is explained in detail, with a discussion of the importance of comparing growth patterns. In Section 4, the results are presented and commented on. Section 5 concludes with some reflections about the future evolution of the global economy and the issues and aspects that could be explored further by future research.

2. Globalization, Integration and Convergence

2.1. Globalization as a Process of Integration and Convergence: Issues and Debates

Although ideas related to globalism and the concept of statelessness are quite old and trace back to the analysis of famous thinkers such as Immanuel Kant and Karl Marx, the term “globalization” first appeared in the 1920s to describe the ways in which capitalism and modernity were spreading (Axford 2013). The term became popular in the last decades of the 20th century, when globalization seemed to be a concrete and irreversible phenomenon, thanks also to global communications and the end of the Cold War (Martell 2010). Broadly speaking, globalization implies continuous cross-border exchanges of resources, capital flows, and knowledge thanks to a process of liberalization of trade and free movements of commodities, ideas and people. According to Cernat (2006, p. 23),

the most commonly agreed definition of globalization refers to the growth, or more precisely the accelerated growth, of economic activity across national and regional political boundaries. It finds expression in the increased movement of tangible and intangible goods and services, including ownership rights, via trade and investment, and often of people, via migration. It can be (and often is) facilitated by a lowering of government impediments to that movement, and by technological progress, notably in transportation and communications. The actions of individual economic actors, firms, banks and people drive it, usually in the pursuit of profit, often spurred by the pressures of competition.

Other definitions of globalization underline its multi-dimensional nature. As described by Gygli et al. (2019, p. 546), globalization “describes the process of creating networks of connections among actors at intra- or multi-continental distances, mediated through a

variety of flows including people, information and ideas, capital, and goods.” [Dreher \(2006\)](#) and [Nye and Keohane \(2000\)](#) identify, beyond economic globalization, political and social globalization, which express respectively the spread of policies and people along with their ideas and information.

There are various views on globalization. Some scholars see globalization as an expression of linear and irreversible global capitalist development, with a turning point at the end of the 20th century, in which an acceleration in liberalization and worldwide interconnections occurred. This acceleration has led to the introduction of the term hyper-globalization ([Rodrik 2011](#)), which identifies the period of the 1990s and 2000s ([Anderson and Obeng 2021](#)). Some scholars see hyper-globalization as the result of the adoption of neoliberal economic policies within democratic political frameworks, such as deregulation and privatization, and are convinced that these can also guarantee success in the global economy to developing countries through a restriction of the role of national states ([Friedman 2000](#)). Their predictions about the future of globalization seem in line with the expectations of [Fukuyama \(1989, p. 4\)](#), who introduced the term “end of history” to indicate the type of society that globalization was producing: “the end point of mankind’s ideological evolution and the universalization of Western liberal democracy as the final form of human government”.

Others, however, see globalization as a wave-like phenomenon, with its peculiar geographical centers, driving forces, technological innovations and declining phases ([Szul 2010](#); [Ng and Pitakdumrongkit 2023](#)). Some scholars trace the first wave back to the first Industrial Revolution, others, even, to the great discoveries of the 15th and 16th centuries. The second wave resumed in the first half of the 19th century and lasted until World War One. The third started after the end of World War Two and has lasted until today, despite some scholars affirming that a phase of “deglobalization” opened with the international financial crisis in 2008 (e.g., [James 2018](#); [Baldwin et al. 2023](#); [Thakur-Weigold and Miroudot 2023](#); [Arimura and Sugino 2024](#)). This vision, which sees globalization as a non-recent phenomenon capable of experiencing phases of decline, lends itself better to understanding the events of recent decades and to welcoming the most skeptical views on globalization. Indeed, the optimism of the proponents of hyper-globalization has been put to the test by the “skeptics”, who understand globalization as an “ideological project of the West” giving rise to the so-called ‘great globalization debate’ ([Tadić 2006, p. 186](#)). Skeptics sustain that globalization is not a new phenomenon and recent history is marked by a segmented international economy dominated by national governments ([Held et al. 1999](#)). Between these two extreme poles, there are various scholars who, while recognizing the importance of globalization, do not fail to underline its contradictions, its negative aspects ([Tadić 2006](#)), threats to democracy ([Rodrik 2011](#)), its inability to eradicate poverty ([Dreher 2006](#); [Milanovic 2003](#)), the tendency of globalization and inequality to grow together ([Gozgor and Ranjan 2017](#)), and the presence of cluster-based economic growth.

There have also been attempts to “measure” globalization through composite indexes. For example, [Dreher \(2006\)](#) and [Dreher et al. \(2008\)](#) introduced and developed the KOF Globalization, a worldwide composite index able to measure the economic, social and political dimensions of globalization since 1970, and to offer a ranking of world countries according to their level of globalization. A revised version has been provided by [Gygli et al. \(2019\)](#) and results indicate that globalization is positively correlated with economic growth (and social globalization is particularly relevant) especially in developing countries. In particular, “economic growth increases when de jure economic and political globalization and de facto social globalization are more pronounced” ([Gygli et al. 2019, p. 571](#)).

The relationship between globalization and the processes of integration and convergence is, however, controversial. Many scholars believe that the growing interdependence between economies and cultures has been facilitated by the various agreements and partnerships between states, aimed at promoting growing economic integration (e.g., harmonization of policies, breaking down of barriers). However, interdependence and integration are not synonymous. According to [Waltz \(1999\)](#), greater interdependence, in terms of

greater volumes of trade, does not mean greater integration. Integration requires not only globalized markets but also a unitary world government which therefore affects the powers of individual states. The transition from interdependence to integration is therefore not a given and certainly has not occurred, except partially among Western countries, in particular within transnational projects such as the European Union.

Despite that empirical evidence does not unequivocally allow scholars to establish a causal relationship between globalization, integration and convergence, globalists, especially radicals, are convinced that globalization will lead to integration and, consequently, convergence. Convergence is a mechanism that eliminates heterogeneity and differences and can be measured more easily, especially if we focus on the convergence of economic indicators, such as income, prices or interest rates. Starting from these theoretical premises, [Barro and Sala-i-Martin \(1992\)](#) sustained that countries starting from lower levels of GDP per capita grow faster than others and are able to catch up with richer countries, realizing convergence. This type of convergence, in which poor economies are expected to grow faster than rich ones, is usually called beta-convergence, to be distinguished from sigma-convergence, which refers to the reduction in income differences across economies. Despite the fact that these results have been questioned by various scholars (e.g., [Rey and Montouri 1999](#); [Caggiano and Leonida 2009](#)), other scholars have found evidence of the presence of economic globalization convergence both in developed and developing regions ([Lau et al. 2022](#)).

However, empirical evidence does not support unequivocally the idea that globalization produces convergence, both due to the dubious convergence-generating effects of globalization and the various factors that limit convergence ([Kenworthy 1997](#)). Literature on conditional convergence (e.g., [Howitt and Mayer-Foulkes 2002](#)) investigates the factors that hinder catch-up processes and suggests that countries converge in economic terms only if they fulfill certain conditions.

The economic convergence literature has experienced a revival along with the integration process of the European Union ([Lopez et al. 2021](#)). The similarities with the mechanics of globalization and its neoliberal influence induced the introduction of the term 'Europeanization' ([Cernat 2006](#)), despite that the EU project has been interpreted both as the unfolding of globalization in Europe and as a defensive reaction to globalization ([Wincott 2000](#)). Many scholars agree that the European integration process allowed a certain degree of beta- and/or sigma-convergence, especially among those Central and Eastern countries that accessed membership in 2004 ([Micallef 2020](#); [Nagy and Šiljak 2022](#)). This has been possible thanks to an integration process based on agreements that promoted, by the other things, convergence in nominal variables (e.g., inflation, interest rates, debts and deficits). With the establishment of the Eurozone and the introduction of the single currency, a debate commenced on the need for real (structural) convergence, in order to fulfil the requirements of an optimal currency area ([Mundell 1961](#)), and to reduce the impact of asymmetric shocks. However, empirical evidence seems to support the idea of a cluster-based regional convergence within the European Union ([Monfort et al. 2013](#); [Cutrini 2019](#); [Iammarino et al. 2019](#)). This phenomenon could be influenced by the heterogeneity of the institutional frameworks. Indeed, contrary to the expectation of an institutional convergence favored by the EU's effort to promote harmonization and the diffusion of best practices ([Alesina et al. 2017](#)), institutional convergence cannot be taken for granted ([Schönfelder and Wagner 2019](#)). Empirical studies confirm that institutional divergence, both in terms of formal and informal institutions, persists between core and peripheral European countries ([García-Solanes et al. 2022](#)). Contrary to expectations, the introduction of the euro has not favored institutional improvements at the European periphery ([Fernández-Villaverde et al. 2013](#)). The issue has been studied both in terms of catching-up processes (in beta- and sigma-convergence) and stochastic convergence. The latter occurs when countries share the same long-run development path and is investigated using unit-root tests ([Evans and Karras 1996](#)). [Beyaert et al. \(2019\)](#) found no evidence of institutional stochastic convergence among European countries, even when considering sub-groups.

2.2. Structural Convergence and Varieties of Systems

The complex relationship between economic and institutional convergence calls into question the heterogeneity of socio-economic structures and institutional frameworks. Indeed, a thesis supported by radical globalists is that globalization induces economic structures to converge towards the supposedly most efficient model, the liberal one. Structural and institutional convergence seems to be, therefore, the prerequisite for economic convergence. This occurs through a kind of competitive process according to which only the most suitable variety of capitalism survives, i.e., the one that meets the requirements of the neoliberal agenda (Cerny 1997). However, many scholars have put into question these views in different ways. For example, Albert (1993) feared that globalization, with its deregulatory drive capable of creating market-driven and depoliticized economic orders, would lead to convergence towards the lower performing model, i.e., the liberal Anglo-Saxon model, to the detriment of the better performing continental Rhine model¹ (Streeck 1997).

Many supporters of the Varieties of Capitalism (VoC) theory believe, however, not only that this structural convergence is undesirable, but also that it is unfeasible. Indeed, they believe that the Anglo-Saxon model and the Continental model can coexist, because of the comparative institutional advantage of different socio-economic models (Hall and Soskice 2001). This seems confirmed empirically both globally and within the EU, in which, despite the neoliberal influence, a struggle persists between competing capitalist models (Hooghe 1998; Beyaert et al. 2019; García-Solanes et al. 2022). Consequently, the idea that structural convergence is a prerequisite of economic convergence is controversial since “there is increasing recognition in the economics literature that high-quality institutions can take a multitude of forms and that economic convergence need not necessarily entail convergence in institutional forms” (Rodrik 2007, p. 52).

Recent literature seems to testify that there are varieties of capitalism beyond the classical dualistic classification (i.e., Anglo-Saxon liberal model versus continental model). Some scholars have considered, as distinct varieties of capitalism, the Mediterranean Market Economies (MMEs)², Eastern European Market Economies (EMEs) (Dilli et al. 2018), and Scandinavian social democratic market economies (Vallejo-Peña and Giachi 2018). Outside Europe, Amable (2016) identifies also an Asian model of capitalism for Japan and Korea. Latin America, with its high levels of inequality, can be considered as composed of Hierarchical Market Economies (HMEs) (Schneider 2009). HMEs are characterized by negative institutional complementarities among organizations. In these regions, business groups matter more than formal institutions and there are also low levels of competitiveness, skills, and union density.

Many countries are still struggling to find a clear place within these classifications. For example, the Balkan countries have sometimes been classified as Liberal Market Economies (LMEs), Coordinated Market Economies (CMEs), or MMEs, while others are convinced that these countries form a particular variety called “Balkan capitalism”. According to Saucedo-Acosta et al. (2019), Balkan countries may be classified as Hierarchical Market Economies (HMEs). The VoC approach has also been applied to the analysis of African countries, with a distinction between South African and Sub-Saharan countries (e.g., Natrass 2014; Gaiya 2018). Some have also started to glimpse an Arab variety of capitalism (e.g., Hertog 2019). However, these latest analyses struggle to identify real alternatives and non-residual models with respect to those already identified in the literature.

Geographical, cultural, economic and political aspects seem to show that a vast variety of interconnected and evolving capitalisms exists, as sustained by the approach to a variegated capitalist world system, a more worldwide and systemic interpretation of the world economy (Jessop 2011; Peck and Theodore 2007). This approach relies on concepts such as commonalities, socio-economic interdependencies and internationalization, and underlines how different capitalist models have to be analysed as co-dependent within the global economy. These trends seem to recall Immanuel Wallerstein’s interpretation of capitalism as a world-system (Hopkins and Wallerstein 1982). According to this approach, the world is characterized by a unique capitalist system in which strong interdependencies

exist between countries. All countries are embedded in this system, but they play different roles in time by following different growth paths. Indeed, the system is divided between the most powerful countries (the core), and the other countries, whose development is subordinated to the core (the periphery and semi-periphery). Streeck (2010) puts forward a worldwide perspective and underlines how it is important to “abandon entirely the idea of *national varieties* of capitalism and advance towards a concept of an *internationally variegated* capitalist world system” (p. 38). He argues more precisely, however, that “capitalism as a more or less integrated global system must not, of course, be taken to imply an equally integrated global regime of economic governance, let alone of political government” (p. 39).

In the literature, there is a tendency to use increasingly sophisticated data-based methodologies to construct the theorization of the variety of capitalisms, starting from the study of existing economic systems (e.g., Witt et al. 2018; Fainshmidt et al. 2018), with the aim of possibly taking into consideration all world economies. Recently, Witt et al. (2018, p. 6) have discussed the importance of building a “general theory of varieties of business systems in the world” as a prerequisite for “theorizing about the implications of these varieties for economic and political outcomes such as wealth generation and distribution or comparative advantages.” With reference to the existing literature, they claim that “a consolidated overview of the overall landscape of the business systems in the world economy, and thus a firmer foundation for theorizing about them, is still absent from the literature.” All this may open the door to a different methodological approach that, starting from a systemic analysis of the world economy, identifies those criteria that may allow distinction between varieties of capitalism. These recent developments seem to support a global approach to the study of economic systems, able to investigate the true nature of the globalization, integration and convergence processes.

3. Methodology and Data

3.1. The Analysis of GDP Growth Patterns

The economic literature seems to confirm the importance of a worldwide study of economic systems, based also on data-driven methodologies. The analysis of the dynamics of globalization, integration and convergence are important for understanding the evolution and transformation of economic systems and the nature of their interrelations. GDP remains one of the most commonly used indicators in this type of investigation, and it is used also for assessing the degree of real convergence (Williamson 1996; Coutinho and Turrini 2019; Lopez et al. 2021).

Despite the fact that the study of economic convergence aims to verify whether convergence has occurred and under what conditions, GDP time series contain other interesting information that can say something about the evolution of an economic system. Indeed, “a look at the evolution of output and expenditure components of GDP provides valuable information about its determinants” (Prados De la Escosura 2017, p. 3). Despite the limitation of GDP as an indicator of economic well-being and human development (Dědeček and Dudzich 2022), the dynamic of the sectoral composition of GDP reveals the structural changes that occur within an economy (Davcev and Hourvoulides 2014; Islam and Iversen 2018). This implies that “economic structure and evolution could be produced by rough approximations of real gross domestic product” (Altman 1988, p. 684) and “GDP not only is the core indicator of national economic accounting but also can be used to measure the economic status and development level of a country or region”, keeping in mind that “the impact of industrial structure on GDP is huge” (Jiang 2022, p. 1).

The connection that exists between GDP, economic structure and structural change suggests that, if two countries show similarities in their GDP growth path (i.e., they react in a similar way to shocks and stimuli), they may share structural affinities. This hypothesis is not new. For example, Crowley and Schultz (2010) compare countries’ GDP growth patterns in order to verify the presence of synchronicity in the GDP and business cycle movements. Webber et al. (2018) group countries according to the similarity of their growth paths in order to investigate whether, and how, long-run evolutionary growth trajectories influence

regional economic resilience, and they found that “regions have empirically identifiable long-run and path-dependent development trajectories that are significantly associated with industrial employment shares and observed resilience outcomes” (p. 355). [Trajkova-Najdovska and Radukić \(2017\)](#) underline the importance of analyzing the behavior of GDP patterns and focalize on shifts in growth regimes in Balkan transition countries, while [Rechnitzer and Toth \(2014\)](#) analyze economic growth path similarities within the European Union through cluster analysis.

The analysis of GDP growth path similarities can reveal the presence of structural affinities within a group of countries, but also the presence of regional heterogeneity. With reference to Europe, [Masuch et al. \(2016, p. 1\)](#) present empirical evidence showing how “initial cross-country institutional differences can explain to a substantial extent the relative GDP performance of European countries.” According to [Cartone et al. \(2021\)](#), European regions are characterized by different convergence rates, as well as heterogeneity; consequently, within Europe “economic growth still is a heterogeneous process” (p. 416). In this regard, the methodological contribution of the concept of stochastic convergence applied to the analysis of GDP growth paths is also precious ([Evans and Karras 1996](#)). Following this approach, [Bernard and Durlauf \(1995\)](#) reject convergence but also find evidence of common trends within Europe. With reference to the EU, [Chapsa and Katrakilidis \(2014\)](#) find limited evidence of stochastic convergence and observe a non-uniform convergence within clubs. These results seem to confirm the intuition that structural heterogeneities can be explained by the presence of convergence clubs or clusters of countries that share a similar growth path ([Durlauf and Johnson 1995](#); [Postiglione et al. 2013](#)).

3.2. Worldwide System: Identifying Clusters

Usually, the comparison of growth paths and the identification of clusters of countries is carried out through sophisticated statistical and econometric methods. However, a more basic and transparent analysis of the raw data, capable of revealing the degree of affinity between the growth path of GDP per capita in a given country compared to that of any other country in the world, may also be interesting.

Suppose we have GDP per capita data (variable Y) for N countries ($i = 1, \dots, j, \dots, N$) for the period $t = 1, \dots, T$, so that Y_i corresponds to the GDP per capita data of country i while Y_j corresponds to the GDP per capita data of country j . The degree of affinity between country i and country j can be interpreted as the ability of Y_i to resemble Y_j in each period of time, thus considering the whole trajectory. The simplest way to measure this ability is the computation of the root mean square error (RMSE):

$$r_{ij} = \sqrt{\sum_{t=1}^T \frac{(Y_{it} - Y_{jt})^2}{T}} \quad (1)$$

Since we do not make initial hypotheses about which pairs of countries show greater affinities, we calculate all possible pairs of countries, so as to obtain a $N \times N$ matrix R of RMSE values (with elements r_{ij}). Since we are interested in identifying pairs of countries that minimize RMSE, we select the minimum value of RMSE within each row r_i . In other words, for each country i , we identify the country j whose GDP per capita path is the most similar. It could be possible that the growth path of a country j is the most similar to more than just one other country’s growth path. In any case, the matrix R potentially contains “chains of connections” if countries are present in more pairs. Indeed, if the growth path of a country A is the most similar with respect to that of country B and the growth path of country B is the most similar with respect to that of country C , there is also an indirect connection between country A and C . These connections allow identification of clusters of countries that share similar growth paths of GDP per capita with different intensities. These clusters may correspond to well-known varieties of capitalism and this is a hypothesis tested in this article.

3.3. Dynamics, Transformations and Composite Countries

As discussed in Section 2.1, globalization can also be interpreted as a wave-like process. According to this conception, we are currently in the descending phase of the third wave. Our database allows us to analyze the dynamics of the third wave of globalization and to verify whether the symptoms of a global slowdown really worsened with the international crisis in 2008 and up to the last decade, in which many scholars started to talk about disintegration, deglobalization and slowbalization (e.g., James 2018; Komolov 2020; Linsi 2021). Consequently, we divided the period into two sub-periods (1970–2000; 2000–2019) and computed for each sub-period the RMSEs and the minimum values for each country.

Beyond this analysis, it is possible to compare the economic performance of each country with that of its composite economy. By composite economy, we mean an economy made up of those countries that have a significant degree of affinity with the one under consideration. The calculation of the GDP per capita of the composite economy of the country i (CE_i) is based on a normalization of the R matrix (such that the sum of each row r_i equals 100 and the values substantially become weights w_i). Since within each row r_i there can be very high RMSE values as a consequence of a complete absence of affinity of country j with country i , we consider only those values inside r_i which are not higher than double the minimum RMSE identified for that country i . This skimming may appear arbitrary, but it is necessary to prevent countries that are not similar to the one tested from being considered in the composite economy, as would happen if we consider values greater than double the minimum value. The GDP values of the composite economy can be computed as a multiplication between the two vectors reported in Equation (2): the row vector of the weights of country i and the column vector containing the average GDP per capita of all countries.

$$CE_i = w_i Y_m \quad (2)$$

3.4. Data

The aim of the article was to consider all the major economies in the world. Unfortunately, it was not possible to collect enough data for all countries, so in the end the following 79 countries have been considered (with country codes in Table 1):

Table 1. World countries with countries' codes from the Penn World Table database.

1	Albania	ALB	21	Estonia	EST	41	Lithuania	LTU	61	Serbia	SRB
2	Algeria	DZA	22	Finland	FIN	42	Luxembourg	LUX	62	Singapore	SGP
3	Argentina	ARG	23	France	FRA	43	Malaysia	MYS	63	Slovak Republic	SVK
4	Australia	AUS	24	Germany	DEU	44	Malta	MLT	64	Slovenia	SVN
5	Austria	AUT	25	Greece	GRC	45	Mexico	MEX	65	South Africa	ZAF
6	Bangladesh	BGD	26	Hong Kong	HKG	46	Morocco	MAR	66	Spain	ESP
7	Belarus	BLR	27	Hungary	HUN	47	Netherlands	NLD	67	Sweden	SWE
8	Belgium	BEL	28	Iceland	ISL	48	New Zealand	NZL	68	Switzerland	CHE
9	Bosnia and Herzeg.	BIH	29	India	IND	49	Nigeria	NGA	69	Taiwan	TWN
10	Brazil	BRA	30	Indonesia	IDN	50	Norway	NOR	70	Thailand	THA
11	Bulgaria	BGR	31	Iran	IRN	51	Pakistan	PAK	71	Tunisia	TUN
12	Canada	CAN	32	Iraq	IRQ	52	Paraguay	PRY	72	Turkey	TUR
13	Chile	CHL	33	Ireland	IRL	53	Peru	PER	73	Ukraine	UKR
14	China	CHN	34	Israel	ISR	54	Philippines	PHL	74	United Arab Emir.	ARE
15	Colombia	COL	35	Italy	ITA	55	Poland	POL	75	United Kingdom	GBR
16	Croatia	HRV	36	Japan	JPN	56	Portugal	PRT	76	United States	USA
17	Cyprus	CYP	37	Kazakhstan	KAZ	57	Qatar	QAT	77	Uruguay	URY
18	Czech Republic	CZE	38	Korea	KOR	58	Romania	ROU	78	Venezuela	VEN
19	Denmark	DNK	39	Kuwait	KWT	59	Russian Feder.	RUS	79	Vietnam	VNM
20	Egypt, Arab Rep.	EGY	40	Latvia	LVA	60	Saudi Arabia	SAU			

The variable Y is the real GDP per capita (PPP). It has been computed using the expenditure-side real GDP at chained PPPs (in millions of USD, 2017) divided by the total population (in millions). Data come from the Penn World Table PWT 10.0 database (series names *rgdpe* and *pop*). These data are considered the most suitable for comparing living standards across countries and years (Feenstra et al. 2015). Most computations and all figures have been calculated using MATLAB and the whole analysis is based on the elaboration of GDP per capita data.

The dataset covers 50 years from 1970 to 2019. The choice of this period has been influenced by the actual availability of data (it is difficult for many countries to have data before 1970). However, 50 years is still a sufficient period for this type of analysis. The period considered stops at 2019 as it is still difficult to assess the impact on growth and globalization of the socio-economic crisis induced by the COVID-19 pandemic and the subsequent geopolitical tensions commencing with the invasion of Ukraine in February 2022. Indeed, these events could represent turning points for the globalization process, so significant as to require a structural break and a dedicated analysis of this sub-period.

4. Preliminary Results and Discussion

4.1. Countries and Clusters

RMSEs have been computed for each possible pair of countries (see Supplementary Materials Table S1). In Table 2, for each country, the best corresponding country has been selected, i.e., the country able to minimize the RMSE. RMSE values are obviously very different, because nothing guarantees that there is another country in the world that experienced a similar growth path in terms of GDP per capita and, in these cases, the RMSE is very high. RMSEs tend to be higher even in those cases in which the countries involved have experienced a strong growth in GDP per capita and/or GDP per capita levels are very high (e.g., Qatar, United Arab Emirates). However, this does not prevent us from identifying for each country the one with the most similar growth trajectory.

Although the interpretation of the RMSE values is not trivial, the literature provides useful insights in this regard. Indeed, generally, in the comparative analysis of world countries' growth paths, values lower than 2000 indicate the presence of comparable paths and similar trajectories, which become particularly noteworthy with values lower than 1000 (e.g., Versteegen et al. 2017; Puzzello and Gomis-Porqueras 2018). Figures 1 and 2 seem to confirm these intuitions. In Figure 1, the GDP per capita growth path of some pairs of countries with RMSE values lower than 1000 are compared, while in Figure 2 some cases with higher RMSE values are considered. RMSE values well below 1000 are associated with pairs of countries with similar paths and low GDP per capita values. Values between 1000 and 2000 still demonstrate similar growth paths, among more developed countries also. Clearly, with values much higher than 2000, the growth paths are totally different or have started to diverge significantly in time.

These comparisons between pairs do not allow us to glimpse the connections between groups of countries. Indeed, it may be that a given country is able to minimize the value of the RMSE for two or more countries. This is the case, for example, of Peru, which minimizes the RMSE of Albania and Paraguay. This also suggests a possible good RMSE between Albania and Paraguay: if we check the value of the RMSE (see Supplementary Materials Table S1), we can verify that it is equal to 916. In addition to this, it is also important to analyze the "chains of connections": if country A minimizes the RMSE compared to country B and country B minimizes the RMSE compared to a country C, an indirect connection is also present between countries A and C.

This way of reasoning induces us to interpret the RMSE values in Table 2 as measures of the strength of the growth paths' similarity, and to see countries as nodes which can be connected to other countries so as to form a great network in which clusters can emerge, i.e., groups of countries with similar GDP per capita growth paths. Figure 3 gives a graphical representation of this intuition. The thickness of the lines increases as the RMSE values reported in Table 2 decrease, while the colors of the nodes correspond to the geographical

location of each country. Countries have been classified according to the *United Nations Geoscheme* (in the United Nations publication *Standard Country or Area Codes for Statistical Use*, commonly referred to as the M49 standard³), which has been reduced to a few main areas: Africa, Asia (East, Central and Southeastern, South, and West), Europe (East, South, North and West), Latin America, North America and Oceania.

Table 2. Pairs of countries and minimum RMSE values.

Country 1	Country 2	Min RMSE	Country 1	Country 2	Min RMSE	Country 1	Country 2	Min RMSE	Country 1	Country 2	Min RMSE
ALB	PER	760	EST	LTU	2.406	LTU	EST	2.406	SRB	ZAF	2.451
DZA	ZAF	1.670	FIN	GBR	1.734	LUX	CHE	22.515	SGP	IRL	11.544
ARG	CHL	2.152	FRA	GBR	2.371	MYS	POL	1.803	SVK	RUS	3.758
AUS	SWE	1.776	DEU	BEL	1.377	MLT	KOR	3.656	SVN	CZE	2.321
AUT	DEU	2.185	GRC	PRT	3.287	MEX	URY	2.687	ZAF	DZA	1.670
BGD	IND	1.002	HKG	AUT	4.524	MAR	PHL	542	ESP	CYP	3.058
BLR	KAZ	3.211	HUN	POL	2.977	NLD	SWE	2.281	SWE	DNK	1.335
BEL	DEU	1.377	ISL	CAN	3.804	NZL	ISR	2.435	CHE	USA	5.156
BIH	CHN	856	IND	VNM	416	NGA	IND	1.581	TWN	GBR	5.721
BRA	COL	1.632	IDN	EGY	966	NOR	NLD	7.029	THA	BRA	1.758
BGR	URY	2.388	IRN	BRA	2.996	PAK	IND	940	TUN	PRY	1.826
CAN	AUS	2.780	IRQ	COL	2.310	PRY	PER	680	TUR	CHL	1.863
CHL	TUR	1.863	IRL	HKG	10.457	PER	PRY	680	UKR	SRB	2.526
CHN	BIH	856	ISR	NZL	2.435	PHL	MAR	542	ARE	QAT	99.874
COL	BRA	1.632	ITA	JPN	1.741	POL	MYS	1.803	GBR	FIN	1.734
HRV	LVA	2.846	JPN	ITA	1.741	PRT	GRC	3.287	USA	CHE	5.156
CYP	ESP	3.058	KAZ	BLR	3.211	QAT	KWT	37.846	URY	TUR	2.156
CZE	SVN	2.321	KOR	MLT	3.656	ROU	BGR	2.621	VEN	DZA	3.803
DNK	SWE	1.335	KWT	CHE	18.321	RUS	LVA	1.913	VNM	IND	416
EGY	IDN	966	LVA	RUS	1.913	SAU	DNK	11.705			

Source of data: own calculations based on PWT data for GDP per capita. Country 2 is the country able to minimize RMSE with respect to country 1.

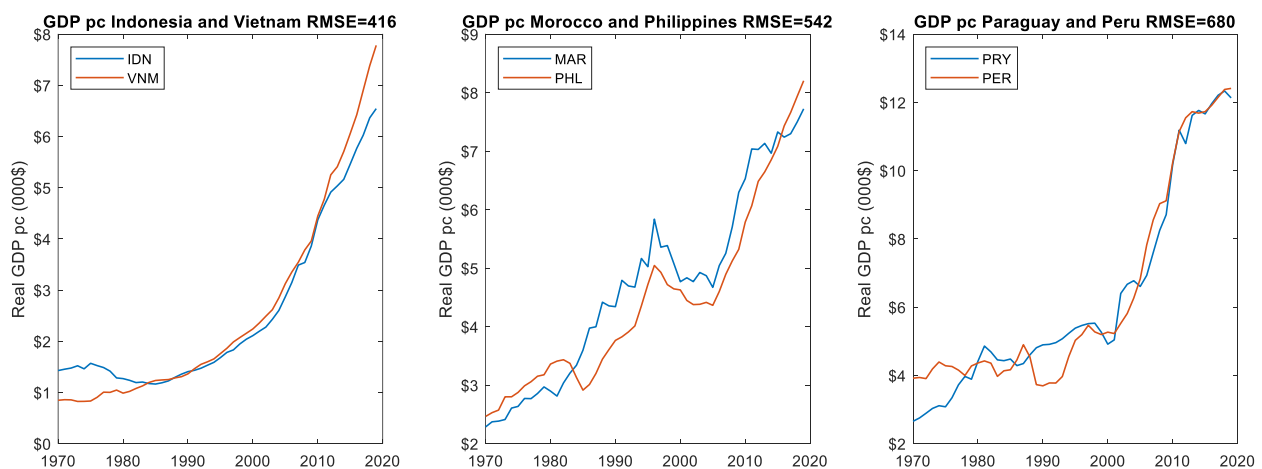


Figure 1. GDP per capita for pairs of countries with RMSE < 1000.

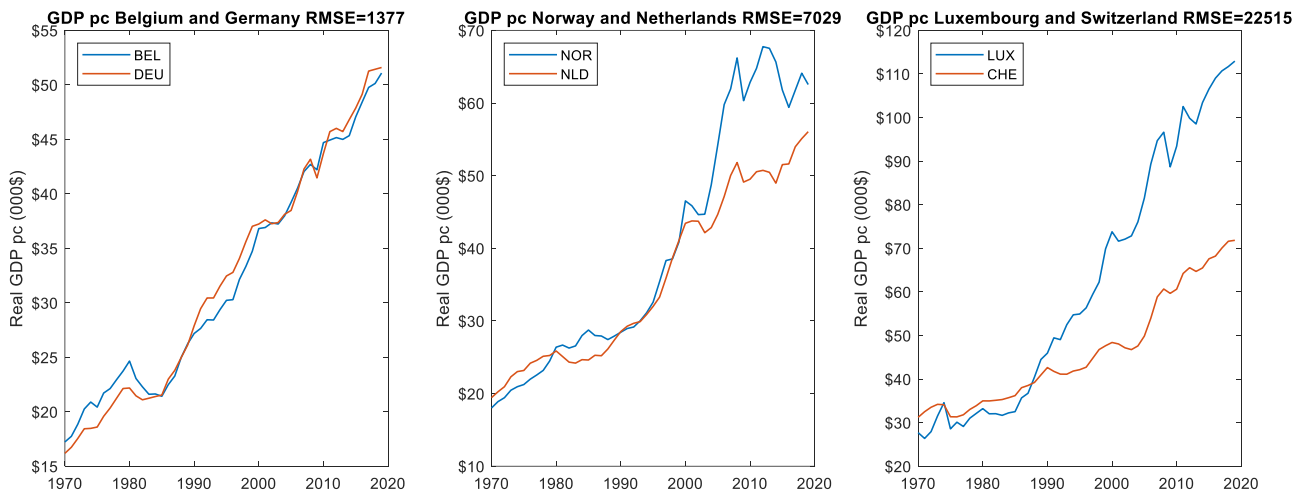


Figure 2. GDP per capita for pairs of countries with RMSE > 1000.

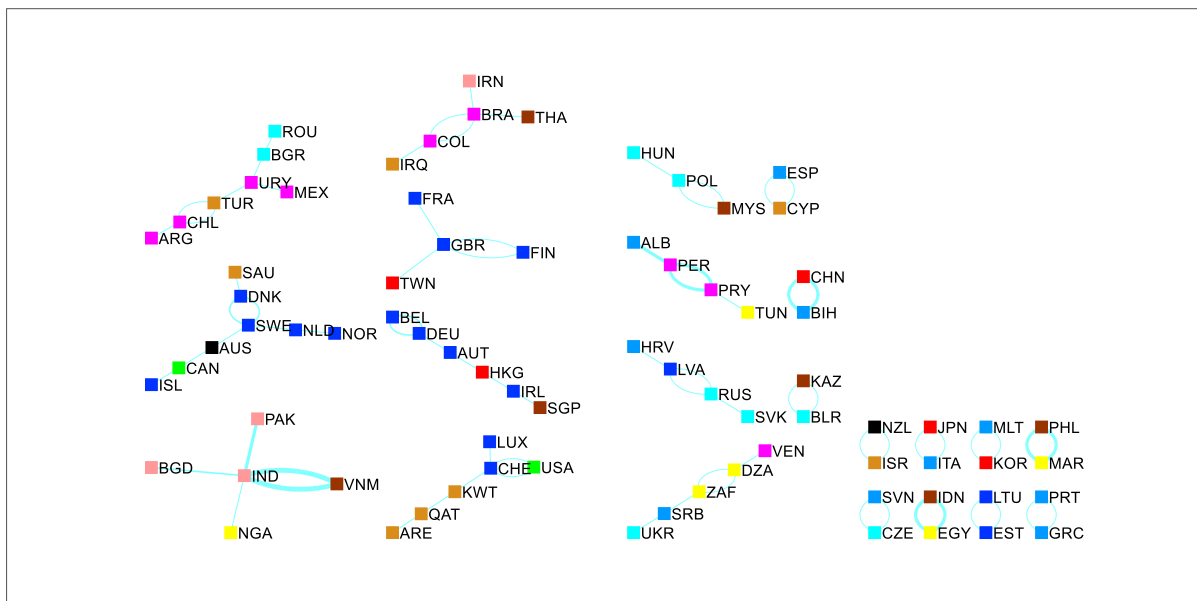


Figure 3. Countries and clusters in the world economy. The color of the squares corresponds to the geographical location of each country (Africa—yellow; Latin America—magenta; North America—green; Eastern Asia—red; Central and Southeastern Asia—brown; Southern Asia—pink; Western Asia—orange; Eastern Europe—cyan; Southern Europe—blue; Northwestern Europe—dark blue; Oceania—black). Each country is connected to the country that minimizes the RMSE. The thickness of the lines increases as the RMSE values decrease, as reported in Table 2.

According to Figure 3, there are 11 clusters with more than three nodes (hereafter, we will use the term cluster for those with three or more nodes). It stands out how three of these clusters are dominated by the presence of northwestern European countries connected to Asian countries that are notoriously well developed (plus Canada and Australia). A fourth cluster is dominated by three countries belonging to OPEC (including Qatar, which was part of OPEC until 2019), to which Luxembourg, Switzerland and the US are added. The substantial lack of connections between northwestern and southeastern European countries is surprising, even though many are part of the EU and, in various cases, of the Eurozone. Various southeastern European countries are connected to Latin or African countries. Countries less developed in terms of GDP per capita tend to form autonomous clusters with strong links in terms of RMSE.

4.2. Cluster Dynamics

In order to verify how these patterns were influenced by the recent phase of hyper-globalization, we divided the period into two parts (period 1: 1970–2000; period 2: 2000–2019), as described in Section 3.1. Among other factors, this would allow us to understand whether the apparent divergence between northwestern and southeastern Europe is less evident if we consider the period in which the Eurozone was established. Results are reported in Figures 4 and 5.

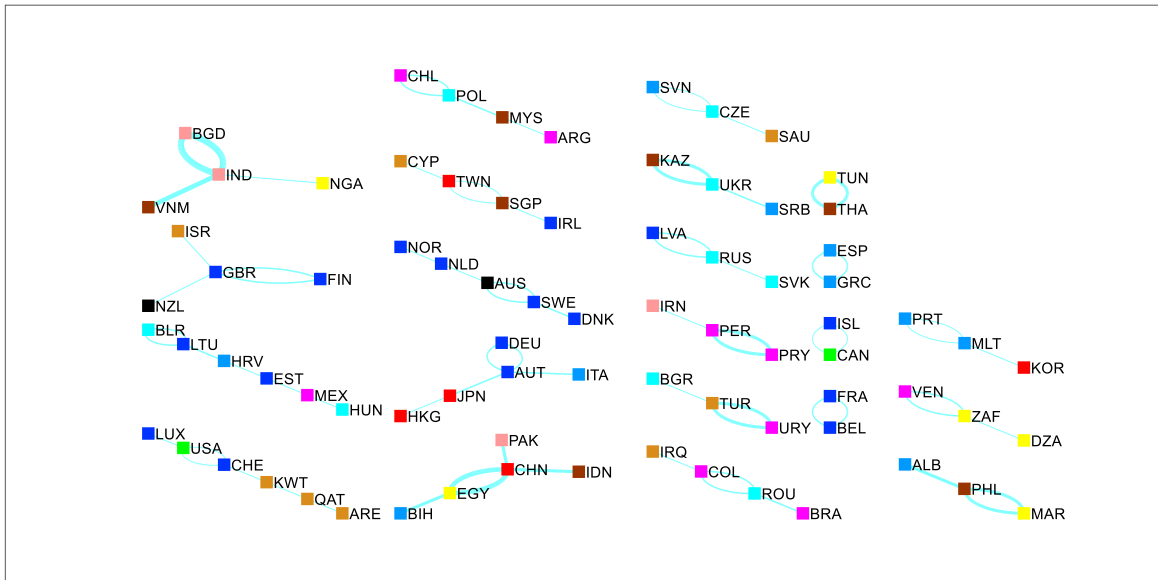


Figure 4. Countries and clusters (1970–2000). The color of the squares corresponds to the geographical location of each country (Africa—yellow; Latin America—magenta; North America—green; Eastern Asia—red; Central and Southeastern Asia—brown; Southern Asia—pink; Western Asia—orange; Eastern Europe—cyan; Southern Europe—blue; Northwestern Europe—dark blue; Oceania—black). Each country is connected to the country that minimizes the RMSE. The thickness of the lines increases as the RMSE values decrease according to the computations for the period 1970–2000.

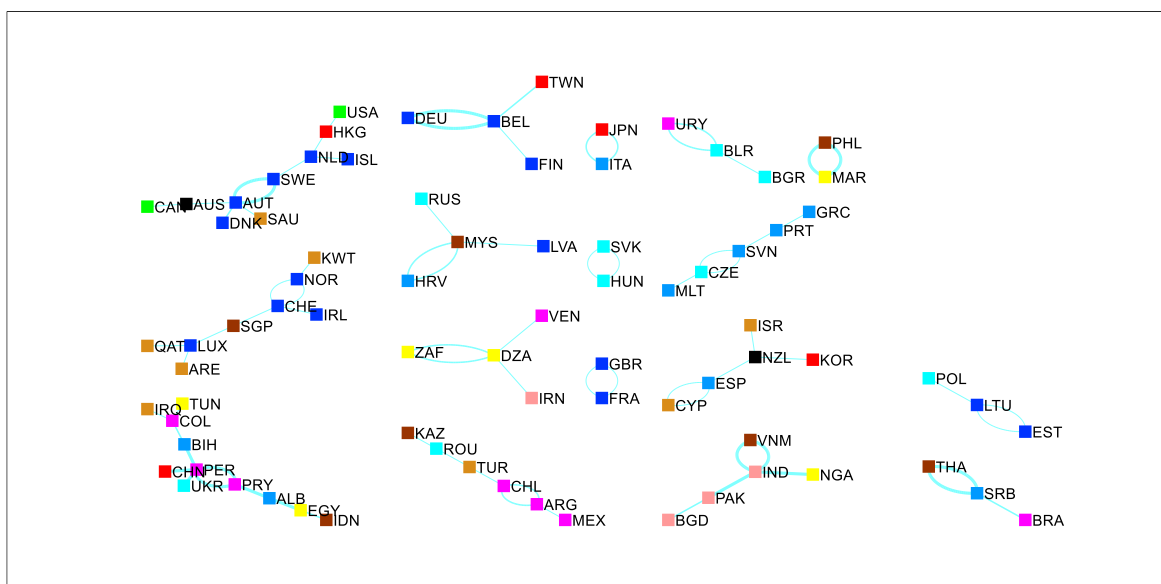


Figure 5. Countries and clusters (2000–2019). See Figure 4 for the interpretation of colors. The thickness of the lines increases as the RMSE values decrease according to the computations for the period 2000–2019.

By considering shorter periods of time, it becomes more likely that similar growth patterns are identified. Consequently, it is not surprising that the number of clusters is higher in both the first period (18) and the second (13). However, it is interesting to note how the number of clusters decreases over time: the small clusters disappear to form larger ones (the average number of nodes in clusters is 4 in the first period and 5.5 in the second).

The clusters represented in Figures 4 and 5 give an idea of their number, dimension and geographical composition. However, it is difficult to perceive their dynamics, i.e., how clusters have changed in time and the connections that exist among them. Table 3 clarifies this aspect, because it shows the movements of the countries within 10 main “cluster groups”, i.e., groups in which countries are present, that in the first or in the second period have been part of the same cluster. In Table 3, for each row, countries with the same color are part of the same cluster, therefore showing how the clusters themselves have changed over time (e.g., some have disappeared, and others have merged or have incorporated other countries).

Table 3. Cluster dynamics and connections.

Period 1					
group of clusters	mean value GDP per capita	variation with respect to C1	variation with respect to previous group	std	
C1	63.5			51.5	LUX CHE USA KWT QAT ARE
C2	28.3	35.3	35.3	1.5	DNK SWE NLD NOR AUS CAN ISL
C3	21.3	42.3	7.0	3.3	DEU AUT HKG IRL SGP ITA JPN TWN CYP
C4	23.5	40.0	−2.3	1.3	FRA GBR FIN ISR NZL BEL
C5	17.8	45.7	5.7	5.3	MLT CZE SVN PRT GRC KOR ESP SAU
C6	13.5	50.0	4.3	2.0	BLR LTU HRV EST MEX HUN LVA RUS SVK
C7	8.8	54.7	4.7	1.0	BGR URY TUR CHL ARG POL MYS
C8	10.0	53.6	−1.1	0.6	UKR SRB ZAF DZA VEN KAZ
C9	4.4	59.1	5.5	1.7	TUN IRQ COL BIH CHN PER PRY ALB EGY IDN ROU BRA PAK THA PHL IRN MAR
C10	1.6	61.9	2.8	0.4	BGD IND VNM NGA
mean	19.3	49.2	6.9	6.9	
Period 2					
group of clusters	mean value GDP per capita	variation with respect to C1	variation with respect to previous group	std	
C1	74.8			19.6	LUX CHE KWT QAT ARE NOR IRL SGP
C2	47.8	27.1	27.1	3.5	SAU DNK SWE NLD AUS CAN ISL AUT HKG USA
C3	41.3	33.5	6.5	2.3	BEL DEU ITA JPN TWN FIN
C4	36.3	38.5	5.0	2.8	FRA GBR ISR NZL KOR ESP CYP
C5	30.8	44.1	5.6	1.6	MLT CZE SVN PRT GRC
C6	22.9	52.0	7.9	1.9	LTU HRV EST HUN LVA RUS SVK MYS POL
C7	17.4	57.5	5.5	1.3	ROU BGR URY MEX TUR CHL ARG KAZ BLR
C8	12.4	62.5	5.0	1.9	ZAF DZA VEN IRN
C9	9.7	65.2	2.7	2.2	TUN IRQ COL BIH CHN PER UKR PRY ALB EGY IDN BRA THA PHL MAR SRB
C10	3.8	71.0	5.8	0.7	BGD PAK IND VNM NGA
mean	29.7	50.1	7.9	3.8	

Table 3 identifies 10 main cluster groups and also shows their evolution in terms of average values of GDP per capita, standard deviation and performance difference between groups in terms of GDP per capita differences. Colors identify the clusters: for each row, countries with the same color are part of the same cluster (or pair). Cluster groups are in decreasing order according to the average GDP per capita of the second period.

According to the globalist thesis, we should expect to find from the first to second period a growing number of countries moving towards the first group, or at least a decrease in the distance between the first and the last group, with the emergence of bigger clusters as a consequence of convergence. Table 3 shows instead a quite different dynamic. Indeed, Table 3 allows observation of how, in the second period, some countries have moved and/or merged to form bigger clusters with, on average, a lower internal dispersion in terms of GDP per capita. However, economic performance disparities among groups remained substantially the same, despite the generalized increase in terms of GDP per capita and the high percentage improvements, especially among the countries within the least performing

Table 5. Cont.

Period 2																
C1	LUX	CHE	KWT	QAT	ARE	NOR	IRL	SGP								
C2	SAU	DNK	SWE	NLD	AUS	CAN	ISL	AUT	HKG	USA						
C3	BEL	DEU	ITA	JPN	TWN	FIN										
C4	FRA	GBR	ISR	NZL	KOR	ESP	CYP									
C5	MLT	CZE	SVN	PRT	GRC											
C6	LTU	HRV	EST	HUN	LVA	RUS	SVK	MYS	POL							
C7	ROU	BGR	URY	MEX	TUR	CHL	ARG	KAZ	BLR							
C8	ZAF	DZA	VEN	IRN												
C9	TUN	IRQ	COL	BIH	CHN	PER	UKR	PRY	ALB	EGY	IDN	BRA	THA	PHL	MAR	SRB
C10	BGD	PAK	IND	VNM	NGA											

The color corresponds to the geographical location of each country (Africa—yellow; Latin America—magenta; North America—green; Eastern Asia—red; Central and Southeastern Asia—brown; Southern Asia—pink; Western Asia—orange; Eastern Europe—cyan; Southern Europe—blue; Northwestern Europe—dark blue; Oceania—grey).

4.3. Composite Countries, Performance and Economic Structures

In Figure 6, there is a comparison between the average GDP per capita of each country (star in Figure 6) and its composite country or economy (CE—square in Figure 6). As described in Section 3.1, by composite economy, we mean an economy made up of those countries that have a significant degree of affinity with that under consideration. We observe how the situation has changed in time by comparing the first and the second period (red and blue respectively). Lines represent the average GDP per capita of all countries in the two periods.

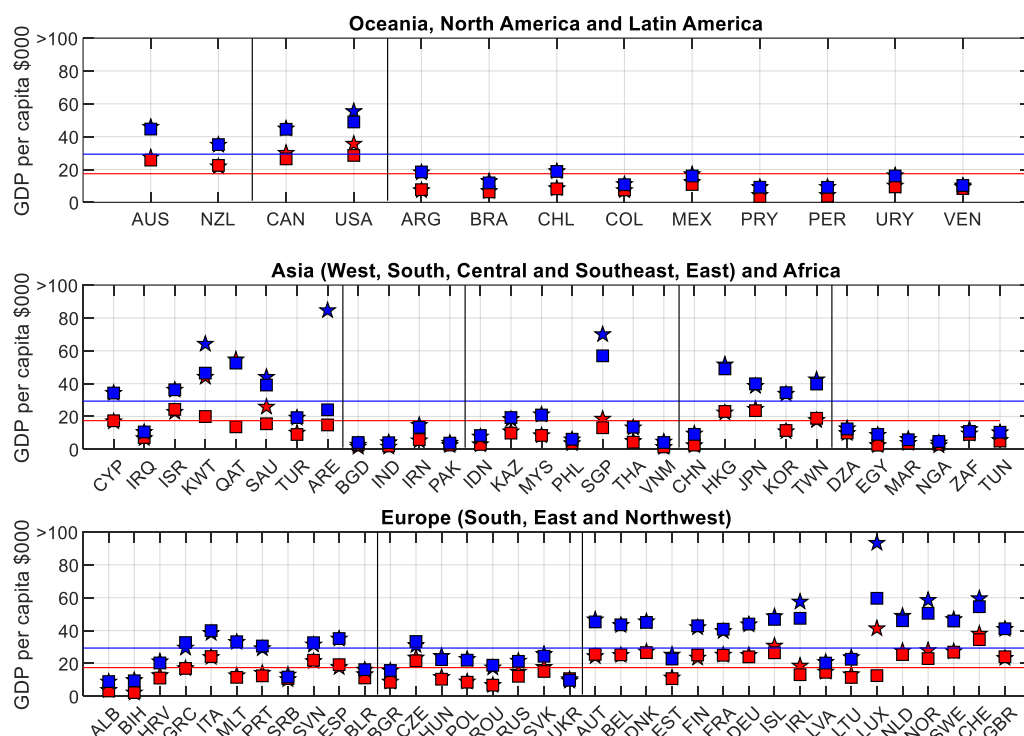


Figure 6. GDP per capita: countries and synthetic economies in periods 1 and 2. In the Figure, there is a comparison between the average GDP per capita of each country (star in the graph) and its composite economy (square in the graph). We observe how the situation has changed in time by comparing the first and the second period (red and blue, respectively). Horizontal lines represent the average GDP per capita of all countries in the two periods, while vertical black lines divide countries according to the geographical regions, as reported in the subtitles.

Results can be interpreted in the following way. If, for a certain economy, we observe a worsening of its performance against an unchanged or improved performance of its CE, we can conclude that the country is experiencing a deterioration due to inefficiencies and country-specific issues. If we observe the opposite (i.e., improvement in the performance of the country compared to its CE), we can hypothesize that the country is experiencing a significant phase of development determined mainly by internal or peculiar factors. If we observe a similar performance dynamic between the country and its CE, we can conjecture that those changes capable of impacting the performance positively or negatively are not only imputable to the country, but must be interpreted as part of an international or regional process. According to Figure 6, in most cases, there is coherence between the growth path of a country and the path of its CE. However, there are countries in which the growth dynamics are decidedly better than their CEs. These countries have experienced unique development paths due to their particular features (e.g., Luxembourg, Kuwait and United Arab Emirates and, to a lesser extent, Singapore and Ireland). The average values of the GDP per capita (represented by the lines) clearly show the relevant improvements occurring from the first to the second period. However, many African, Asian, Latin American and some European countries still show GDP levels below the averages of the first period. This seems to clarify how some clusters are composed by countries that seem trapped into similar low growth paths.

Figure 7 clarifies the effective GDP per capita growth of each country by computing the difference between period 1 and 2. In Figure 7, the disparity between the GDP per capita growth improvements and the geographical coherence of these results is evident.

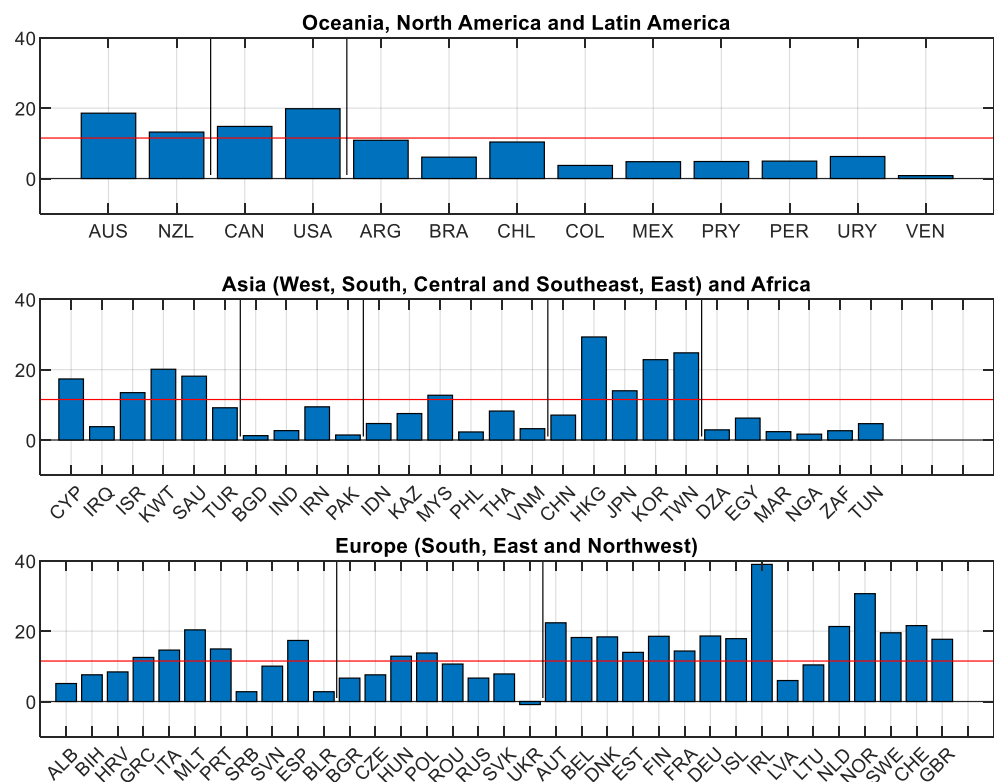


Figure 7. Changes in GDP per capita from period 1 to period 2. The red line corresponds to the average GDP per capita improvement. Outlier countries have been excluded (Qatar, United Arab Emirates, Singapore and Luxembourg). Vertical black lines divide countries according to geographical regions, as reported in the subtitles.

The red lines correspond to the average GDP per capita value improvement considering all countries. Results indicate that many countries show rather low growth performance (e.g., Latin and African countries and some countries in Asia and in Southeastern Europe).

Figure 7 does not reveal global economic convergence but rather a sort of polarization, in which some countries have grown at a rapid pace and others seem trapped in paths of modest or low growth. Groups of countries seem to share similar patterns coherently with the clusters identified. An interesting aspect is that the European integration project not only has not led to any improvement in terms of convergence, but many EU countries experienced low growth performance.

It remains to be clarified to what extent the GDP per capita growth patterns of these countries can reveal something about their economic structures. Since it is certainly necessary to compare many other economic, social and institutional indicators to analyze and compare structural differences and affinities, we will limit ourselves to observing the possible coherence of our results with the classifications of economic systems already present in the literature and discussed in Section 2.2, leaving more in-depth analyzes for future research. An interesting aspect is the affinity between the group of clusters identified and some of the classifications of economic systems proposed within the VoC literature. Indeed, the divergence that seems to emerge between northwestern and southeastern European countries seems to be coherent with the structural difference between LME and CME on the one hand and the EME and MME countries on the other. Some affinities identified between Latin American countries and some southeastern European countries seem to confirm the relevance of a deeper investigation of the HME model and its affinities with the MME and EME models.

5. Conclusions

This article proposed an empirical comparative analysis of the dynamics of the GDP per capita of 79 major world economies from 1970 to 2019. The goal was to verify the existence of similarities in the growth patterns through the identification of clusters of countries that grow at a similar pace and react in a similar way to crises. The literature review in Section 2 confirmed the importance of this type of analysis for a proper assessment of the interrelations between globalization, integration and convergence and their consequences for countries' economic development. We used, as a proxy of growth paths, GDP per capita. However, other alternative development indicators can be analyzed in further research. The period considered stops at 2019 as it is still difficult to assess the impact of the COVID-19 pandemic and the subsequent geopolitical tensions on the globalization process. Indeed, these events could represent structural break that requires a dedicated analysis, which can be object of future research. In Section 3, we discussed the choice of using a basic but transparent analysis approach on the raw data, capable of revealing the degree of affinity in the growth paths of each country compared to every other country in the world. We used RMSE, but other indicators should be tested. We leave discussion on the possible developments of this methodology to future research.

According to the results presented and commented on in Section 4, globalization has brought, as expected, fewer and larger clusters, with improvement in terms of GDP per capita for most countries, despite different measures. The analysis of the clusters reveals that globalization has not led to a global convergence but rather to a regional convergence formed by polarized clusters, which can be summarized in this way: on the one hand, the northwestern countries (European and American), to which we can add many OPEC countries and highly developed Asian countries (such as city-states); on the other hand, the countries of Southeastern Europe, Latin America and many developing African and Asian countries. Some countries in Africa and South Asia seem to be stuck on low growth paths. It is interesting to note how, despite the European integration process, the divergence between northwestern and southeastern European countries has become more pronounced. The coherence of our results with the classifications of the varieties of capitalism theory is an aspect that deserve more in-depth analysis in future research.

These results corroborate the hypothesis, supported by many scholars, that the relationship between globalization, integration and convergence cannot be taken for granted. The heterogeneity of growth paths and institutional frameworks is persistent among coun-

tries despite the pressures of globalization. Globalization has not led to that “end of history” predicted by Fukuyama (1989) but to forms of polarized convergence. This phenomenon can deepen the divergence between developed and developing countries, jeopardizing further developments in the globalization process, with complex geopolitical consequences.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/economics12020032/s1>, Tables S1: The value of the RMSE.

Author Contributions: Conceptualization, S.C. and B.D.; methodology, S.C.; software, S.C.; resources, S.C.; data curation, S.C.; writing—original draft preparation, S.C. and B.D.; writing—review and editing, S.C. and B.D. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Not applicable.

Data Availability Statement: Raw data came from PWT database <https://www.rug.nl/ggdc/productivity/pwt/?lang=en>.

Conflicts of Interest: The authors declare no conflict of interest.

Notes

- ¹ The Rhine model (also called the continental model or coordinated market economy (CME)) is suited to Germany, France, Holland and Switzerland and identifies network-oriented economies characterized by a close coordination between the state, trade unions and industry associations. It is characterized by the presence of a regulatory state, extensive cooperation between social groups, strong centralized trade unions, low flexibility in labour markets, the strong role of banks and a minimal role for markets. The Anglo-Saxon model (also called the liberal market economy (LME)) is suited to the UK and US and identifies market-oriented economies with minimalist state intervention, low cooperation between social groups, flexible labour conditions, weak trade unions and a short-term profit-oriented business with a minimal role for banks.
- ² MMEs are based on a demand-led growth model and are characterized by small and medium-sized businesses, a strong legacy of high levels of state intervention in the economy, associated with weak capacities for strategic co-ordination in labour relations (Hall 2018). EMEs are represented mainly by the post-communist countries, also called developmental or cocktail capitalism economies. Scandinavian economies are characterized instead by an efficient welfare state and efficient markets, with labor protection and high-quality health care and education.
- ³ See <https://unstats.un.org/unsd/methodology/m49/> (accessed on 9 January 2024).

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