

## Research

# The interplay between globalisation and economic growth: a multi-regional analysis

Dinithi Athalage<sup>1</sup>  · Piyara Wijesuriya<sup>1</sup>  · Irushi Sandanayaka<sup>1</sup>  · Danushi Rathnayake<sup>1</sup>  · Ruwan Jayathilaka<sup>2</sup> 

Received: 9 January 2025 / Accepted: 28 May 2025

Published online: 10 June 2025

© The Author(s) 2025 [OPEN](#)

## Abstract

Globalisation is recognised as a prospective dynamic that facilitates the performance and expansion of economies. This study analyses the causal progression between globalisation, its sub dimensions (economic, social and political) and economic growth spanning 97 countries and six regions (Africa, Asia, Europe, North America, Oceania, and South America) covering the period from 1971 to 2021. The Panel Granger causality test is employed as the statistical methodology to comprehend the nexus between globalisation and economic growth. The Granger results reveal bi-directional causal flows between economic growth and globalisation in Asia, North America, and Oceania, along with one-way causal flows in Africa, South America, and Europe. Bidirectional dynamics pertaining to economic globalisation were also revealed in Asia, Africa, Oceania, and Europe. This study recommends the enhancement of regional integration, addressing of structural changes, leveraging the use of technology, and the development of comprehensive globalisation strategies with respect to regions with the intention of reinforcing their globalisation-growth stance, while complementing the Sustainable Development Goals of the United Nations.

**Keywords** Economic growth · Globalisation · Economic globalisation · Social globalisation · Political globalisation

## 1 Introduction

Globalisation, defined as a process giving rise to co-dependence and joint reliance amongst nations through the unification of economies, cultures, systems of governance [1], is discerned as a vital phenomenon in the contemporary era which prevents nations and economies from seclusion and stagnation [2]. This global phenomenon is multidimensional and comprises economic, social, and political dimensions, and are quantified using the 'Konjunkturforschungsstelle' (KOF) Globalisation Index [1].

Economic Growth interpreted as the expansion of a nation's economy over time, is the enhanced capability for production of goods and services derived from the increased attainability to quality resources and the accessibility to state-of-the-art technology [3]. Economic growth is a main macroeconomic goal of nations and is often measured in terms of

---

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s43621-025-01403-6>.

✉ Ruwan Jayathilaka, [ruwan.j@sliit.lk](mailto:ruwan.j@sliit.lk), <https://www.sliit.lk/faculty-of-business/staff/ruwan.j/>; Dinithi Athalage, [dinithiathalage02@gmail.com](mailto:dinithiathalage02@gmail.com); Piyara Wijesuriya, [piyarawijesuriya@gmail.com](mailto:piyarawijesuriya@gmail.com); Irushi Sandanayaka, [irushisandanayaka20@gmail.com](mailto:irushisandanayaka20@gmail.com); Danushi Rathnayake, [danushirathnayake01@gmail.com](mailto:danushirathnayake01@gmail.com) | <sup>1</sup>SLIIT Business School, Sri Lanka Institute of Information Technology, New Kandy Road, Malabe, Sri Lanka. <sup>2</sup>Department of Information Management, SLIIT Business School, Sri Lanka Institute of Information Technology, New Kandy Road, Malabe, Sri Lanka.



the Gross Domestic Product (GDP). At present nations do not tend to make economic decisions solely considering the domestic economic conditions, but by deploying more attention on the global economic stance [4].

Economic globalisation through its trade and financial components allows international trade and the flow of foreign capital thus facilitating capital formation and sectoral development in an economy. Technological exchange and labour migration comprised within social integration allows growth and development through access to international knowledge and resources facilitating economic productivity. The political integration achieved through global organisations and international treaties for peace enforcement and the spread of political practices promotes diplomatic harmony across territories. On the contrary, enhanced economic growth too drives economic globalisation integration through means of increased demand resulting in elevated levels of trade openness and engagement in international trade, while also encouraging foreign investments. Economic prosperity allows cultural integration through increased tourism and allows the mobility of international labour and students through global education and employment networks. Furthermore, the reinforcement of governance and regulatory frameworks enable the further integration of nations into the global system.

The interplay between globalisation and economic growth, which has forged the cornerstone of this proposed study, is recognised as contentious and debatable, by numerous researchers [5–12]. Economic globalisation, inclusive of trade and financial factions have been extensively studied under many studies prominently contributing to literature [7, 13, 14]. However, the nexus between social and political dimensions of globalisation with economic growth have been comparatively understudied in the existing literature.

This study therefore aims to expand the existing knowledge repository pertaining to the globalisation—growth nexus in the following manner. Firstly, the study is conducted across 97 countries categorised under six world regions as Africa, Asia, Europe, North America, Oceania and South America [15]. By basing the study on these regions which are diverse to each other in their economic, social and political capabilities and dynamics, the study intends to comparatively portray how each of these regions interact with the universal phenomenon of globalisation. It was observed how past studies had exerted a lesser focus on North and South America and Oceania, while studies analysing all regions together in a unified framework were largely unavailable. This is why the study is focused on the entirety of the regions to endow novelty to the discussion.

Secondly, this study explores the interaction of economic growth with globalisation and all its sub-dimensions (economic, social and political) corresponding to the world regions, where the social and political integrations have been previously under-explored, to contribute in a comprehensive and convenient perspective to all interested parties through a single document.

Thirdly, this study utilises a panel data set covering a period of 51 years from 1971 to 2021, bound by the limitations confined to the inaccessibility of data. Furthermore, the Granger causality approach; a popular statistical methodology employed in diverse disciplines to analyse the causality of variables and capable of evaluating large panels of data, which is less utilised in similar discussions is utilised in this study to accurately reveal all possible causal flows (both bi-directional and unidirectional) between the considered variables. The Westerlund cointegration; which identifies long-term relationships between variables and is less used in comparison to other cointegration approaches in similar discussions, is also applied in the study in an integrated approach with Granger causality to result in a more solid analysis.

Lastly, the study produces well-informed and specific policy recommendations for the policymakers and related stakeholders based on the study findings. These policy actions conform to the Sustainable Development Goals (SDGs) specified by the United Nations, and specifically covers the SDG 4: Quality Education, SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG 9: Industry, Innovation, and Infrastructure, SDG 10: Reduced Inequalities, SDG 11: Sustainable Cities and Communities, SDG 13: Climate Action, SDG 14: Life Below Water, SDG 15: Life on Land, SDG 16: Peace, Justice and Strong Institutions, and SDG 17: Partnerships for the Goals.

In this regard, the study attempts to uncover answers to the research question of what the direction of causality between globalisation; inclusive of its economic, social, and political subdimensions, and economic growth is for each of the six world regions.

## 2 Literature review

A thorough review of the prevailing literature pertaining to the scope of this study was undertaken, extending emphasis on the interactions amongst economic growth, globalisation, economic globalisation, social globalisation, and political globalisation in each region.

## 2.1 Globalisation and the economic growth nexus

The association between globalisation and economic growth is argumentative; hence, many researchers have studied the impact of globalisation on economic growth at a global level and also pertaining to the world regions [11, 16–21]. These studies have resulted in diverse findings supporting the argument of contributions made by globalisation indices on the economic growth and vice-versa.

In the global context Globalisation tends to offer an optimistic effect on economies that portray impoverished performance, whereas it facilitates a negative impact on well-performing economies [22]. A unilateral significant influence of overall globalisation on economic expansion was also identified in the long term accordingly [16]. Furthermore, the causality between economic growth and global integration bi-directionally have been examined in the same scope [16, 23], in contrast to the unidirectional impact of globalisation indices on economic growth.

In the African region, With the increase in the overall globalisation index, economic growth is promoted to higher rates, depicting a positive impact of globalisation on the economic development [19, 24]. Globalisation positively promotes economic expansion up to a specific benchmark and then gradually decreases its impacts, demonstrating a non-linear effect of globalisation on economic growth aspects [19]. Furthermore, overall globalisation was also identified to exert a negative influence thereby hindering economic growth in the region [25]. Inverse to the impact of globalisation on economic growth, economic growth has proven to have a unidirectional impact on economic globalisation in the long run [25]. Accordingly, globalisation can be deduced as a double-edged sword to the African region owing to its ambivalent influence on the region.

Studies basing the European region elaborate that globalisation acts as a promoter of growth rates during the initial stages of transitional economies [17]. Some studies also reveal a significant relationship between globalisation and economic growth concerning the region when studied with multiple other economic and environmental variables [26, 27]. However, the bi-directional interrelation between globalisation and economic growth in the European region tends to be unexplored.

The effect of overall globalisation on economic growth was found to be significant in the Asian region regarding multiple studies [28, 29]. Overall globalisation tends to act as a catalyst in economic development and supports the growth rates in Asia [21, 30, 31]. This implies that, with an increase in the globalisation indices in the Asian nations, the economic growth rates embrace a positive influence from it. Similarly, an escalation in indices confined to globalisation will enhance the financial development in Asian nations [32], and globalisation tends to have a catalyst impact on private investments, a thriving factor contributing to the economic growth rates [33]. Accordingly, the influence of overall globalisation on the Asian economic progress is determined to be positive. Inverse to this, economic growth exerts an impact on globalisation with a significant influence, as revealed in a study in Bangladesh [34]. Moreover, significant bi-directional relationships between globalisation and economic growth were also revealed with regard to majority of countries tested from the Asian region [35], signifying the symbiotic manner of the dynamic where globalisation not only aids economic prosperity through its economic, social, and political aspects, but also capitalises on the affluence of flourishing economies in the region.

Australia and New Zealand; two major players of Oceania, when studied with the rest of the member nations in the Organisation for Economic Cooperation and Development, reveal the presence of statistically significant associations between globalisation and economic growth. A one-way causal flow is disclosed from globalisation to economic growth [16], while globalisation displays the potential of attracting more investments into an economy [36]. Furthermore, Australia, when studied as one of the countries incurring the highest healthcare costs, also reveals a causal flow from globalisation to economic expansion [20]. Although the unidirectional dynamic between global integration and economic growth in Oceania has been analysed both directly and indirectly, studies providing insights on the bi-directional causality in the region are scarce.

Canada and the United States of America (USA), the most frequently studied nations in literature basing the North American region, unveils a one-way causality from globalisation to economic growth [16, 20], with the former being capable of securing more monetary resources for the economy [36]. The preliminary phases of the globalisation process are reflected by a slower momentum of economic progress of USA and Canada [11]. Mexico, another North American country, demonstrates a bi-directional interconnection between globalisation and financial development, an aspect of economic growth [18]. However, it is observed as to how this interrelation between economic growth and globalisation has been tested in prevailing literature by only emphasising specific nations considered under North America rather than its entirety.

Results about Brazil, which is the only South American nation in the inter-governmental organisation BRICS (Brazil, Russia, India, China, South Africa), where the interplay between global integration and economic development has been studied, reveals the existence of a mono-directional relationship from globalisation to financial development through a Granger causality approach employed [18]. Accordingly, in this regard South America also turns out to be a region in which the globalisation-growth nexus has been understudied owing to the sparseness of literature explaining the nature of the impact exerted by globalisation on growth, along with studies basing more nations in the region.

Going by the concept of integrated sustainability [37, 38], the spillover effects like global partnerships and peacekeeping contribute to the interaction between globalisation and the economic pillar of sustainability stimulating economic development. Hence, integrated sustainability assists global integration in terms of the harmonious spillover effects imposed on the economic domain in the global context [38–43] and in regional blocs like MENA, OECD, North America and Europe [40, 44, 45]. However, weak levels of sustainability were discovered across Asian nations [46] although globalisation and integrated sustainability across Asian nations stimulate sustainable economic development with spillover effects [47, 48].

## 2.2 Economic globalisation and the economic growth nexus

Economic integration was found to have a positive impact on economic expansion, promoting growth rates to higher levels on a global extent [7, 13, 14]. However, findings from a study conducted on Middle East and North African (MENA) countries reveal that the impact of economic integration on economic growth rates tends to take a positive outlook only in the long run, hence depicting a negative effect in the short term [49]. In the case of emerging economies, economic globalisation is found to hurt growth rates [5]. Furthermore, the actual flows owing to economic integration, contribute to the promotion of economic growth while barriers and restrictions of economic globalisation hinder economic development [6]. High-tech trade which is a component of trade globalisation (under economic globalisation) is found to have lasting impacts on growth [50]. Financial globalisation, which is also a constituent of economic integration, tends to contribute to economic expansion with a positive influence [9, 12, 51], whereas debt factors contributing to economic globalisation cause a negative impact on growth rates [8]. Moreover, the developments in the financial sector improve growth rates at a global level [52–54]. On the contrary, in the presence of governmental corruption, financial integration exerts a pessimistic impact on the growth rates [55]. The financial globalisation confined to the banking sector is found to have a significant impact on the economic growth rates [18], whereas the effect it exerts on the growth rates in advanced and emerging economies is found to be detrimental [10]. Overall, financial globalisation can lead to financial development, ultimately ensuring the growth of an economy. However, constraints such as domestic and foreign debt and corruption may hinder this development. Foreign direct investments, a constituent of economic integration, facilitates a reciprocal effect on economic proliferation, where increase in foreign direct investments tends to drag the economy to higher growth rates while higher growth rates promote investments [16, 56]. While many studies basing the economic integration and economic proliferation in the global context had focused on discovering monodirectional casualties, a significant gap in literature analysing the bidirectional dynamic persists.

Financial development; a constituent of economic globalisation was found exerting a significant positive effect on economic growth in the long run specific to the African countries [53]. With an increase in exports; a parameter considered under economic integration, the promotion of economic expansion takes place in the context of South Africa [57]. The South African economy, studied together with other BRICS nations, collectively depicts a positive effect of economic globalisation on economic growth [7]. In contrast, a negative impact of economic globalisation on economic development was also discovered pertaining to 21 low-income countries in the African region [58]. Accordingly, it can be discerned as to how economic globalisation with its trade and financial facets exerts a mixed blessing to the economic prosperity of Africa.

In the European region, with an increase in economic globalisation, the growth rates get stimulated [17]. However, economic integration acts as insignificant factors influencing economic growth in the long run, respectively [2]. Furthermore, financial globalisation which is a faction of economic integration demotes economic growth exerting a negative impact on growth rates during crisis and economic imbalanced situations [59]. Economic integration was found to positively impact employment aspects in industries which led to economic expansion, in a study where a bi-directional causal relationship was tested between economic integration and deindustrialisation [60]. Accordingly, though studies were conducted to ascertain the bidirectionality of the variables in the European context, only unidirectional relationships were majorly discovered.

Trade; an element in the economic integration spectrum, tends to exert a positive effect on Asian emerging economies [61]. Likewise, financial development, which is also a faction of the economic dimension of globalisation, promotes growth rates specifically in the Asian region [30, 62]. However, an increase in economic globalisation was found to hinder economic development [63]. Hence, while the impact of economic globalisation on the Asian economic growth can be discerned as negative, the influence of its trade and financial sub dimensions have taken a positive face.

A steady relationship is identified among economic globalisation and economic growth [64] with financial globalisation positively influencing economic growth [12] in USA and Canada; two of the most influential North American regions. Furthermore, in the South American context economic globalisation tends to positively influence the economic growth in the Latin American countries [65]. However, while the insights pertaining to the economic globalisation-growth nexus in North and South America are limited to its prominent nations, literature studying this nexus in the Oceanian context is scarce.

### 2.3 Social, political globalisation and the economic growth nexus

Research findings reveal that the social and political dimensions of globalisation have had a constructive, positive influence on economic development, encouraging growth rates at a global level, [6, 14] whereas, political integrations exert a negative impact while social globalisation fosters economic growth in emerging economies [5]. The impact extended by the social and political dimensions at a global level are contradictory, being positive and negative, respectively.

Political globalisation tends to have a positive impact on economic expansion while the social dimension of globalisation negatively impacts economic development in 21 low- income nations in the African region [58]. With an increase in the social globalisation, the growth rates get stimulated [17] in the European region. However, social integration acts as an insignificant factor influencing economic growth in the short run. A negative impact of political integration on economic growth was discovered in the short run, whereas, the political dimension exerts a significant favourable influence in the promotion of growth rates in the long run [2]. However, findings reveal that the political dimension of globalisation, tends to have no significant impact at a 5% significance level related to the Central and Eastern European region [17]. A positive impact of the political aspect of globalisation on economic development was discovered in the long run surrounding the Asian region [66]. An increase in social globalisation tends to hinder economic development [63]. Moreover, political integration tends to have a demoting influence on the economic growth of India in both the long and the short terms [63] nonetheless, South Korea, Japan and China tend to have a similar detrimental influence of political globalisation on economic expansion only in the short run [66]. Furthermore, a significant impact of social globalisation on growth rates were discovered surrounding the economic development of Malaysia [67]. While the impact of social globalisation on the Asian economic progress is determined to be negative, the effect of the political dimension seem to vary with the time focused.

Gender parity being a constituent of social integration, it was discovered that female empowerment culminates in economic progress through the yield of human capital, while the transfer of female labour is highly probable to bring forth to be advantageous in growth [68] in the North American region. It is possible to generate positive economic outputs through the addressing of gender and other disparities of opportunities (a component of social globalisation) [69] in the South America.

Table 1 summarises the literature review conducted in the study. It summarises the nature of the relationships (unidirectional and bidirectional) between the variables discussed in the literature review, and the corresponding studies in which they were explained.

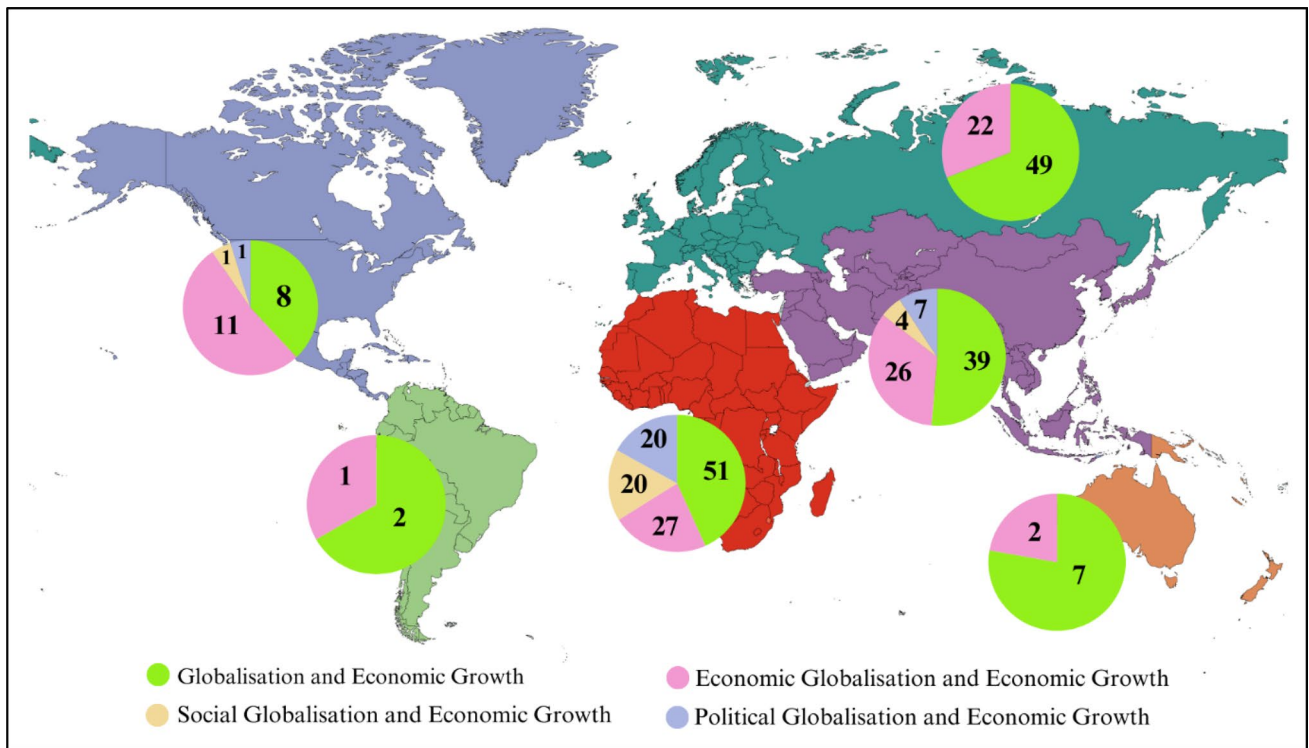
### 2.4 Detected research gap

After evaluating the studies included under the Literature Review section, the following gaps were observed. Firstly, it was identified how most of the scholarly studies examining the globalisation-growth nexus have focused the Asian, African, and European regions, thus highlighting the limited focus on the North American, South American, and the Oceanian regions. Confirming this observation, the Fig. 1 visualises the studies considered in the Literature Review section, analysed by the region and the dimension of globalisation focused. Furthermore, studies investigating the growth-globalisation connection for all world regions in a comprehensive framework were also noticeably lacking, with current literature

**Table 1** Literature summary

Relationship	Related literature
Globalisation ↓ Economic Growth	[7, 16, 17, 19–22, 24, 25, 30–33, 53, 58]
Globalisation ↑ Economic Growth	[25, 34]
Economic Globalisation ↓ Economic Growth	[5–10, 12–14, 16–18, 30, 49, 51–55, 57–63, 65, 67]
Social Globalisation ↓ Economic Growth	[6, 14, 16, 58, 63, 67]
Political Globalisation ↓ Economic Growth	[2, 5, 6, 14, 16, 58, 63, 66]
Globalisation ↕ Economic Growth	[18, 53]
Economic Globalisation ↕ Economic Growth	[16, 56]

Source: Authors' compilation



**Fig. 1** Articles as per regional representation and the type of globalization. Source: Authors' illustration

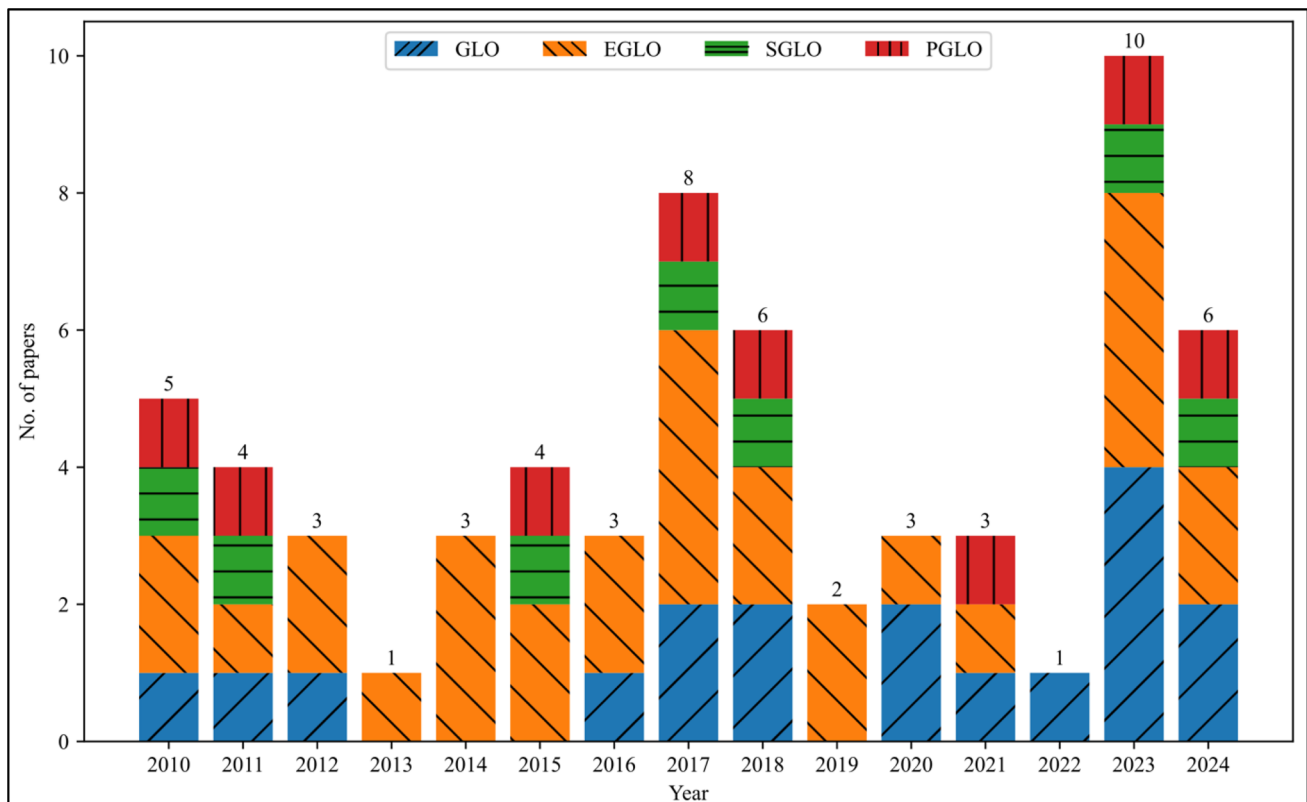
largely being based on individual nations, sub-regional classifications, income classifications, or the global context. These limitations in terms of research tend to inhibit a holistic understanding related to phenomenon.

Secondly, it was observed how the existing scholarly discussions have been centred on the overall and the economic dimensions of globalisation, while the social and political facets of integration have been comparably underexplored. The Fig. 2 visualises the yearly count of articles which had investigated the association between economic growth and globalisation, categorised by their focused dimension of globalisation. With literature published during a period of 14 years (2010–2024) providing the base to the literature review conducted in this study, it can be discerned as to how a significant number of those studies have discussed the nexus between economic globalisation with economic growth. Accordingly, it is evident that the least focus during this publication period has been garnered by the social and the political facets of globalisation. The limited focus on the multidimensional aspect of globalisation tends to obstruct the comprehensive understanding on the globalisation-growth nexus.

Thirdly, a significant void of studies using the Panel Granger Causality technique in related analyses are observed. Granger Causality tests are popularly used in the identification of general directional tendencies and are ideal for long-term analyses extending over multiple regions and variables. The study also uses the Westerlund cointegration test which accounts for long-term relationships between variables; a cointegration test utilised less in comparison to other panel cointegration tests. Through this combined approach, the study aims to result in a more robust analysis of which accounts for the shortcomings of the other econometric techniques used in similar literature.

### 3 Data and methodology

This section details the variables studied in this context and the Panel Granger causality test employed in the analysis.



**Fig. 2** Articles per year classified by the type of globalization. *Source:* Authors' illustration

### 3.1 Data

The study utilised panel datasets from 1971 to 2021, emphasising 97 global nations subjected to the standard (secondary) data availability. These data were gathered by referring to the databases of the World Bank and the KOF Swiss Economic Institute, as depicted in the Table 2. However, the data gathered in this study is confined to a period of 50 years abiding by the limitations of data unavailability and inaccessibility from both the databases utilised.

The identified nations were thereafter allotted to six world regions: Asia (24%), Europe (19%), Africa (34%), North America (13%), South America (7%), and Oceania (3%) as per the classification of the World Bank. The data file utilised for the study is provided in the Supplementary Data S1.

### 3.2 Methodology

This study examines the relationship between globalisation, its subdimensions and economic growth. Panel Granger approach [70] is utilised to evaluate the relationships between the variables which is highly preferred by many under similar discussions [63, 71, 72]. Prior to conducting the causality test, Cross-sectional dependency, stationarity, homogeneity was tested. All variables were converted to the natural logarithmic formats as the variables are in different units and needed to be taken into a common base.

#### 3.2.1 Cross sectional dependency test

The Cross-Sectional Dependency test (CSD) [73] is deployed in this study to determine the existence of cross-sectional dependencies in the panel utilised in this study. The existence of such dependencies among the cross sections could arise due to the inherent variations and un-noticeable associations between the variables which is common in macro-economic variables [74]. Equation 1 was utilised to evaluate the CSD in the study.  $N$  and  $T$  symbolise the observations of the sample and the time variant respectively.  $\hat{\rho}_{ij}$  presents the correlations between residuals of the countries ( $i$  and  $j$ ) delineating the extent of association of the unexplained variabilities of one nation with another.

$$CSD = \sqrt{\frac{2}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^N \sqrt{T_{ij}} \hat{\rho}_{ij} \right) \quad (1)$$

#### 3.2.2 Cross-sectionally augmented im-peseran-shin test

In the presence of cross-sectional dependency, Cross-sectionally Augmented Im-Pesaran-Shin unit root test (CIPS) [75] which is a second-generation unit root test was utilised to determine the stationarity of the variables. The CIPS was computed using the Eq. 2. The value of  $t_j(N, T)$  is equivalent to the t-statistic value of Cross-sectional Augmented Dickey Fuller (CADF). Hence, CIPS is computed by averaging the value of CADF regression [74]. At the existence of unit roots, the difference of the variables is obtained, and the same treatment is carried out until the variables reach stationarity. The differenced variables are denoted with a 'D' prefix to the variable acronym.

$$CIPS = N^{-1} \sum_{i=1}^N t_j(N, T) = \frac{\sum_{i=1}^N CADF_i}{N} \quad (2)$$

The stationarity is tested on the null hypothesis of,

H0: The panel is non-stationary.

**Table 2** Variables' data sources

Variable	Measurement	Source
Economic Growth (GDP)	GDP Per Capita (Current US\$)	World Bank (2022) <a href="https://data.worldbank.org/indicator/NY.GDPPCAPCD">https://data.worldbank.org/indicator/NY.GDPPCAPCD</a>
Globalisation (GLO)	KOF Globalisation Index (scaling from 1 to 100)	KOF Swiss Economic Institute (2022) <a href="https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html">https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html</a>
Economic Globalisation (EGLO)	KOF Economic Globalisation Index (scaling from 1 to 100)	KOF Swiss Economic Institute (2022) <a href="https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html">https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html</a>
Social Globalisation (SGLO)	KOF Social Globalisation Index (scaling from 1 to 100)	KOF Swiss Economic Institute (2022) <a href="https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html">https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html</a>
Political Globalisation (PGLO)	KOF Political Globalisation Index (scaling from 1 to 100)	KOF Swiss Economic Institute (2022) <a href="https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html">https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html</a>

Source: Authors' compilation

### 3.2.3 Slope homogeneity test

Slope Homogeneity test [76] was conducted in this study to examine the heterogenous nature of the dataset owing to the weight deviations of nations in the panel [74]. The Eqs. 3 and 4 present the evaluation of the slope symbolised by  $\Delta$  and adjusted slope symbolised by  $\Delta_{adj}$  respectively.

$$\Delta = \sqrt{N \left( \frac{N^{-1} S\% - K}{\sqrt{2K}} \right)} \quad (3)$$

$$\Delta_{adj} = \sqrt{N \left( \frac{N^{-1} S\% - K}{\sqrt{\frac{2K(t-k-1)}{T+1}}} \right)} \quad (4)$$

The slope homogeneity is tested on the null hypothesis of,

H0: Slope coefficients are homogeneous.

### 3.2.4 Westerlund cointegration test

Westerlund Cointegration test [77] was carried out to test for the existence of any long-term relationships within the variables. This test was used in this context with its capability of being deployed for datasets with a high number of observations. This study consists of two categories of tests performed at the panel level as well as the group level, where the null hypothesis of the absence of cointegration among the variables in the panel is tested against an alternative hypothesis of all panels (panel level) or at least one panel (group level) demonstrating cointegration.

The alternative hypotheses utilised in this context are,

H1 A: All panels are cointegrated

H1B: Some panels are cointegrated

### 3.2.5 Panel vector autoregression

Panel Vector Autoregression (PVAR) was deployed in this study to determine the stability of the variables. This technique incorporates the Vector Autoregression into the panel aspect by considering variables to be endogenous [78]. PVAR was utilised to determine the optimal lag length in this study. The lag selection criteria consist of the Moment selection Akaike Information Criteria (MAIC), the Moment selection Bayesian Information Criterion (MBIC), and the Moment selection Hannan and Quinn Information Criterion (MQIC) parameters, from which the lag length minimising each criterion is to be selected as the optimal lag length [72]. The statistical expression used for the PVAR is stated in the Eq. 5.  $W$  and  $f$  denote the endogenous variable vector and the fixed effects variable respectively.

$$W_{it} = \gamma_0 + \gamma_1 W_{i,t-1} + f_i + \varepsilon_{i,t} \quad (5)$$

### 3.2.6 Panel Granger causality test

Panel Granger Causality test is a highly favoured statistical analysis method by many researchers across diverse disciplines, including Neuroscience [79–81], Finance [82], Global Supply Chain [83], Engineering [84–86], and Decision Sciences [87], to investigate the causality of variables in a time series. This methodology entails numerous advantages. Primarily, it is used in causal analysis in time series data and can be defined as the ability of an independent variable to predict the future values of a dependent variable with enhanced accuracy, resulting in more reliable forecasts [88]. Furthermore,

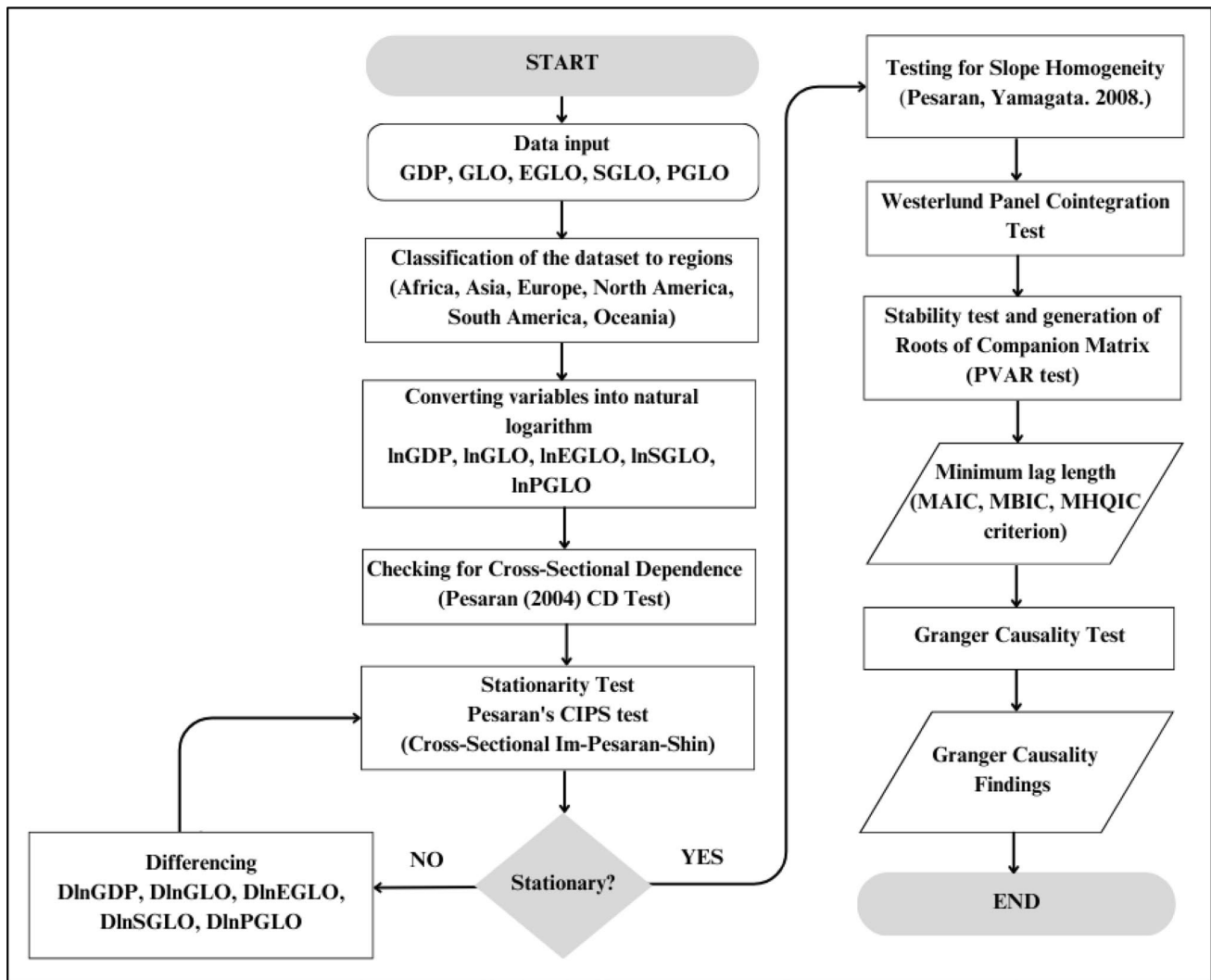


Fig. 3 Data methodology flow diagram. Source: Authors' illustration

it also helps to ascertain the direction and the strength of the causal relation, thereby assisting the credible evaluation and the interpretation of the results obtained [89]. Equation 6 was utilised to formulate the Granger equations to all the variables studied.

$$\ln Y_{i,t} = \sum_{k=1}^{\rho} \beta_i \ln Y_{i,t-k} + \sum_{k=0}^{\rho} \theta_k \ln X_{i,t-k} + u_{i,t} \quad (6)$$

$\ln X$  and  $\ln Y$  in the equation act as the natural log forms of independent and dependent variables respectively, whereas  $i$  and  $t$  represent the region and the period in years.  $k$  depicts the frequency of lags and  $\rho$  symbolises the number of lags.  $\Omega$  is the regression coefficient while  $\delta$  acts as the constant values of regression where  $k$  may vary between the range from 1 to  $N$  (total number of observations in the population).  $u$  delineates the error term in the equation. Figure 3 portrays the steps followed by the study in its data analysis in the sequential order.

## 4 Empirical results

This section begins with a descriptive analysis of the variables and then presents and discusses the Granger causality test, elucidating the interrelationships revealed in the study.

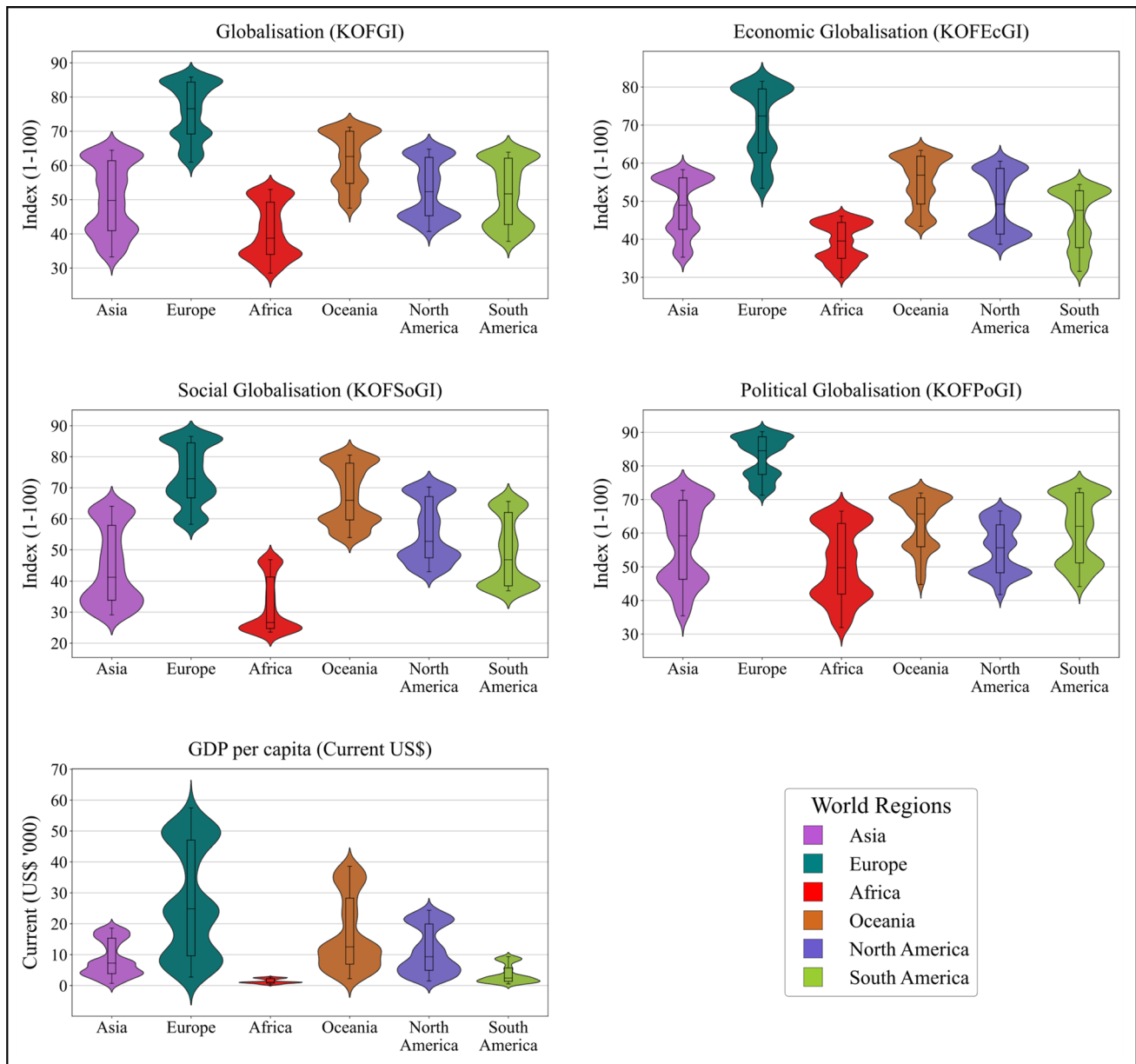


Fig. 4 Violin plots for the variables; classified by region. Source: Authors' illustration

### 4.1 Descriptive analysis

Illustrated in the Fig. 4 is a violin plot which amalgamates a box plot and a density plot, to present the average levels of GDP per capita and degrees of globalisation documented in the regions during the 51-year period from 1971 to 2021. An extended version of the descriptive statistics is depicted in the Supplementary Table S2.

Europe’s economic growth shows a slight positive skewness with globalisation approximately distributed normally. The dimensions of economic and political globalisation show a negative skewness, while the social dimension is positively skewed in Europe. In comparison to all regions, Africa presents considerably low values for globalisation. Overall, social, and political globalisation of Africa outline positive skewness whereas, the economic dimension is distributed approximately normally. The violin plots of globalisation indices of all other regions lie between Europe’s maximum values and Africa’s minimum values.

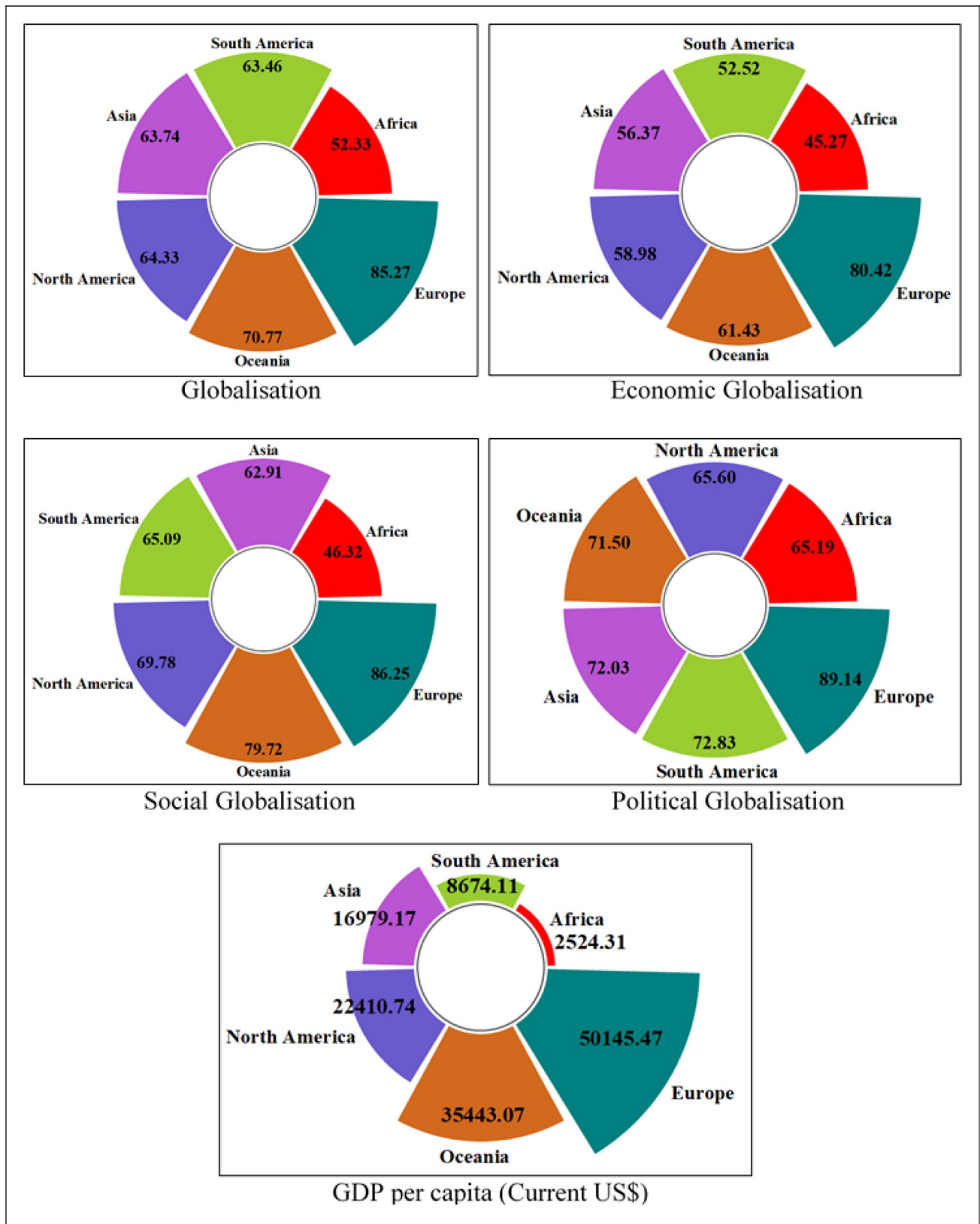


Fig. 5 The average values of GDP and Globalisation indices during 2012–2021. Source: Authors' illustration

The Fig. 5 visualises the average levels of GDP per capita, and the degrees of globalisation recorded in the regions considered during the recent 10 years of the analysis (2012–2021).

It is observable as to how Europe and Africa still hold the highest and the least positions in economic growth and globalisation dimensions. Except for Asia which has surpassed South America in the context of globalisation, and Oceania being surpassed by both South America and Asia in the context of political globalisation, it can be concluded that no significant change had occurred in the regional trend of economic growth and globalisation during the course of time.

## 4.2 Granger causality analysis

Before implementing the Granger causality analysis, the cross-sectional dependency of the variables was determined, and it is presented in Supplementary Table S3. At the existence of cross-sectional dependency, stationarity of the variables  $\ln\text{GDP}$ ,  $\ln\text{GLO}$ ,  $\ln\text{EGLO}$ ,  $\ln\text{SGLO}$  and  $\ln\text{PGLO}$  was verified. In this regard, the second-generation CIPS unit root test was conducted to test the null hypothesis of a variable having a unit root (non-stationarity) against an alternative hypothesis of stationarity.

Accordingly, the variable  $\ln\text{GDP}$  became stationary for all world regions except for Africa and Oceania at first difference ( $D\ln\text{GDP}$ ). While Asia, Oceania and North America achieved stationarity at the first difference ( $D\ln\text{GLO}$ ), all other regions stayed stationary at its base level in the context of overall globalisation. Economic globalisation reached stationarity for Asia, Oceania, North and South American regions at the first difference ( $D\ln\text{EGLO}$ ). Apart from Europe, North and South America, all other areas had to be differenced once ( $D\ln\text{SGLO}$ ) to reach stationarity in social integration. Under the context of political globalisation, all regions except for Europe and Oceania became stationary without differencing ( $\ln\text{PGLO}$ ). None of the variables had to be differenced beyond the first difference within any region to reach stationarity.

The above CIPS unit root test results presented in the Supplementary Table S4 suggests that the null hypothesis (non-stationarity) should be rejected at a 1% significance level to accept the alternative hypothesis of stationarity. Slope homogeneity test was conducted to determine the heterogenous nature of the variables, and it is presented in the Supplementary Table S5. The slopes of the variables were identified to be heterogenous, hence rejecting the null hypothesis at 5% significance level.

Post ascertaining the homogeneity test, the Westerlund panel cointegration test is conducted to ascertain the existence of a long-term relationship among the variables in the panel. The Westerlund cointegration test consists of two categories of tests performed at the panel level as well as the group level, where the null hypothesis of the absence of cointegration among the variables in the panel is tested against an alternative hypothesis of all panels (panel level) or at least one panel (group level) demonstrating cointegration. The Supplementary Table S6 illustrates the Westerlund cointegration test results thus obtained. Accordingly, at the 5% significance level the null hypothesis is rejected and all panels pertaining to all regions except South America are identified as cointegrated thus suggesting the presence of a long-term relationship across all variables. At the same significance level but under the group context, for all regions except Asia, the null hypothesis is rejected to indicate at least one panel is cointegrated implying heterogeneity within the panel.

Thereafter the Panel Vector Autoregression schema was utilised to determine the optimal lag length. The lag selection criteria consist of the Moment selection Akaike Information Criteria (MAIC), the Moment selection Bayesian Information Criterion (MBIC), and the Moment selection Hannan and Quinn Information Criterion (MQIC) parameters, from which the lag length minimising each criterion is to be selected as the optimal lag length. Upon determining the ideal lag length, as demonstrated in the Supplementary Fig. S7 the data series fulfilled the condition of stability for all variables and the corresponding regions.

Ultimately, the Granger causality test was conducted for which the results have been illustrated in the Table 3.

Accordingly, the Asian region depicted bidirectional interrelations between  $D\ln\text{GDP}$  and  $D\ln\text{GLO}$  and  $D\ln\text{GDP}$  and  $D\ln\text{EGLO}$ . Additionally, one-way causal flows were also signified from  $D\ln\text{SGLO}$  towards  $D\ln\text{GDP}$  and  $\ln\text{PGLO}$  towards  $D\ln\text{GDP}$ . In the North American region, a two-way causal flow was revealed between  $D\ln\text{GDP}$  and  $D\ln\text{GLO}$ , along with monodirectional relationships originating from  $D\ln\text{EGLO}$  to  $D\ln\text{GDP}$ , and  $D\ln\text{GDP}$  to  $\ln\text{SGLO}$ . Unidirectional causal relationships flowing from  $\ln\text{GLO}$  and  $\ln\text{PGLO}$  towards  $\ln\text{GDP}$  were identified in the African context in addition to the bidirectional dynamics between  $\ln\text{GDP}$  and both  $\ln\text{EGLO}$  and  $D\ln\text{SGLO}$ . In Oceania, two-way causalities were revealed between  $\ln\text{GDP}$  and both  $D\ln\text{GLO}$  and  $D\ln\text{EGLO}$ , along with the one-way causal links from  $\ln\text{GDP}$  towards  $D\ln\text{SGLO}$ , and  $D\ln\text{PGLO}$  towards  $\ln\text{GDP}$ . The South American region however revealed only unidirectional causal flows from  $\ln\text{GLO}$  towards  $D\ln\text{GDP}$ , and  $D\ln\text{GDP}$  to  $\ln\text{SGLO}$ . Ultimately, in the European region, while the nexus between  $D\ln\text{GDP}$  and  $D\ln\text{PGLO}$

**Table 3** Summary of Granger causality test results

	DlnGDP → DlnGLO	DlnGLO → DlnGDP	Remarks
Asia	5.142**	24.839***	DlnGDP ↔ DlnGLO
North America	8.362***	10.198***	DlnGDP ↔ DlnGLO
	lnGDP → DlnGLO	DlnGLO → lnGDP	
Oceania	18.289***	4.829*	lnGDP ↔ DlnGLO
	lnGDP → lnGLO	lnGLO → lnGDP	
Africa	2.343	32.071***	lnGDP ← lnGLO
	DlnGDP → lnGLO	lnGLO → DlnGDP	
South America	3.111	13.236***	DlnGDP ← lnGLO
Europe	2.857	5.391*	DlnGDP ← lnGLO
	DlnGDP → DlnEGLO	DlnEGLO → DlnGDP	
Asia	3.955**	6.816***	DlnGDP ↔ DlnEGLO
North America	1.876	13.421***	DlnGDP ← DlnEGLO
South America	1.245	1.518	DlnGDP <del>↔</del> DlnEGLO
	lnGDP → lnEGLO	lnEGLO → lnGDP	
Africa	6.614**	42.008***	lnGDP ↔ lnEGLO
	lnGDP → DlnEGLO	DlnEGLO → lnGDP	
Oceania	10.665***	5.419*	lnGDP ↔ DlnEGLO
	DlnGDP → lnEGLO	lnEGLO → DlnGDP	
Europe	4.316**	2.983*	DlnGDP ↔ lnEGLO
	DlnGDP → DlnSGLO	DlnSGLO → DlnGDP	
Asia	1.494	3.19**	DlnGDP ← DlnSGLO
	DlnGDP → lnSGLO	lnSGLO → DlnGDP	
North America	8.403***	2.668	DlnGDP → lnSGLO
South America	11.966**	6.421	DlnGDP → lnSGLO
Europe	1.023	5.855*	DlnGDP ← lnSGLO
	lnGDP → DlnSGLO	DlnSGLO → lnGDP	
Africa	4.9*	9.74***	lnGDP ↔ DlnSGLO
Oceania	5.464**	0.203	lnGDP → DlnSGLO
	DlnGDP → DlnPGLO	DlnPGLO → DlnGDP	
Europe	0.955	0.001	DlnGDP <del>↔</del> DlnPGLO
	DlnGDP → lnPGLO	lnPGLO → DlnGDP	
Asia	1.407	13.532***	DlnGDP ← lnPGLO
North America	0.025	1.931	DlnGDP <del>↔</del> lnPGLO
South America	0.274	0.088	DlnGDP <del>↔</del> lnPGLO
	lnGDP → DlnPGLO	DlnPGLO → lnGDP	
Oceania	4.234	5.463*	lnGDP ← DlnPGLO
	lnGDP → lnPGLO	lnPGLO → lnGDP	
Africa	1.545	5.095*	lnGDP ← lnPGLO

**Table 3** (continued)

Source: Authors' compilation

\*\*\*Significance at 1%, \*\* Significance at 5%, \* Significance at 10%

→, ← Uni directional relationships, ↔ Bidirectional relationships, ~~—~~ No relationships

turned out as statistically insignificant, bidirectional casual flows were identified between DlnGDP and lnEGLO, in addition to the one-way causal links from lnGLO and lnSGLO to DlnGDP.

The findings of this study are grounded in a robust theoretical framework that links multidimensional globalisation to economic growth. The use of the KOF globalisation index and its subdimensions enables a detailed exploration of causal relationships, extending the scope of prior research. While Panel Granger causality analysis has been widely applied, our study offers unique insights by integrating multidimensional indices and a long-term dataset, thus contributing novel perspectives to the existing literature.

### 4.3 Discussion economic growth and globalisation in Asia

In the Asian region a two-way relationship is signified between economic growth and globalisation reaffirming literature which mentions that globalisation is an ample opportunity for the transfer of technology, knowledge, and goods [35]. As a testament to this fact, the digitisation speed in the Asian region is proven to be developing at a faster momentum [21]. On the other hand, economic growth facilitates globalisation when studied with both financial development and ecological factors in Bangladesh, which is an Asian economy [34].

The results of this study imply a bi-directional relationship between economic globalisation and economic growth. However, this contradicts with the existing literature where unidirectional impact of economic globalisation was discovered on economic growth [30, 61, 62]. The effect of economic integration on economic expansion could arise due to the accessibility to diverse global markets and the constant flow of investments and capital [21]. Furthermore, the advancements in the financial (revenue from taxes and levies) and banking factions backed by economic integration results in economic enhancement [67]. The velocity of digitisation in Asia is comparatively high compared to the rest of the regions in the globe owing to the exponential speed of technology adoption of powerful nations like South Korea, Japan, Singapore and Hong Kong SAR, while underperforming nations in the region also having a comparatively high technological adoption rate compared to other regions [21]. This facilitates social integration across the region to influence economic growth at a macroeconomic level. Furthermore, political integration has an impact on the economic growth based on the outcomes of this study which is consistent with the empirical findings of the existing literature [63, 66]. China, being a prominent nation which contributes highly to the production of goods and services in the entire world joined hands with the World Trade Organisation in 2001 [32] with prospects of political and economic integration. This has influenced the financial institutions of the Chinese economy and the entire region as a whole.

With reference to the causal progressions discovered the Asian region, it is highly recommended to focus on futuristic policy making strategies where all the nations in the region would benefit from high tech nations in Asia with favourable technology transfers and prospects in global integration.

### 4.4 Economic growth and globalisation in North America

The North American region which houses some of the world's powerhouses are innately highly integrated into the global system. The economic development in North America is facilitated by the technological and digitalisation trends [12], and financial sector development created by globalisation [18]. These circumstances eventually strengthen their integration to global financial markets and access for more financial openness, ultimately fostering growth, and thus confirming the bidirectional dynamic between economic growth and global integration in North America. Economic globalisation named the 'inevitable trend of international economic development' [36], moulds economic growth in North America through the powerful weapons of trade openness and foreign direct investments [16]. Facets of interpersonal globalisation such as cultural heterogeneity, tourism and education can be identified to be facilitated through economic prosperity induced by high technological and financial capabilities in the region. Further, an educated population in a nation; an indicator of economic development, provides better converge for technology, further ensuring informational globalisation. With USA and Canada being the leading nations of North America, their diplomatic initiatives exert a

powerful effect on the fellow countries in the region. Given that reason, there is a strong alliance of the USA and Canada with intergovernmental organisations, agreements and affiliations for regional and international cooperation influencing the region's economic outlook [11, 12]. Despite such circumstances, the results of the study have not revealed any statistically significant dynamics between political integration and growth in the region.

The findings of the study where economic integration is found to influence growth in North America is confirmed by existing discussions which identifies trade openness as a key stimulant of growth [16, 36]. In contrast to flow of causality from growth to social integration, digitalisation; comprised under informational globalisation of the social facet of globalisation have been identified as vital for growth in past research [11]. Furthermore, converse to the two-way nexus identified between globalisation and economic growth in the study, existing research have identified globalisation as driving growth of an economy in terms of trade, investments, education, and international alliances. Political integration has also been observed impacting growth rates in North American nations [16], though the no statistically significant causal connections between the two variables have been revealed in the study.

The bidirectional nexus identified between globalisation and growth along with the unidirectional causal flow from economic globalisation to growth calls for policy actions to sustain and elevate both global and economic integration in North America, while also facilitating all its nations to harness its benefits in an equal manner.

#### 4.5 Economic growth and globalisation in Oceania

In the Oceanian region a two-way causal relationship was discovered between global integration and economic growth. However, the existing literature contradicts the bidirectional causal flows for the region. In the context of economic globalisation, findings of this study provide bi-directional causalities. Being a powerful nation in the region, the efforts of Australia in transitioning into a circular economy with the aim of reducing waste simultaneously maintaining high levels of urban development [90] contributes to the global economy and the Oceanian region in a favourable manner contributing to economic integration. A one-way relationship was evident from political integration to economic growth. This can be largely owed to the affiliation of the Oceanian nations with prominent international organisations, diplomatic agreements and partnerships initiated with the intention of ensuring international cooperation [16]. However, it is recommended to expand intergovernmental cohesion within the region to protect all communities and to ensure transparency of institutions in Oceania in the policy formulation.

#### 4.6 Economic growth and globalisation in South America

The South American region houses nations such as Brazil, Chile, Colombia, Ecuador, Paraguay, and Venezuela; nations which are largely engaged in the exports of fuel and agricultural products. In this endeavour they largely rely on global markets based in Europe, Asia, and the United States [91], thus facilitated by global integration. This phenomenon validates the observed causal flow from global integration towards the growth in South America. Granger causality results pertaining to the South American region indicates that the social integration in the region is facilitated by growth. Economic expansion results in an increase in the export of technological infrastructure, internet access and press freedom, leading to informational and, eventually, social globalisation. In almost 20 countries in the South American region, thirty percent of the GDP is earned through tourism [92]. Economic development in this case increases an economy's potential of investing in international travel infrastructure (international airports) which results in social globalisation. The political and economic challenges faced by South America both internally and internationally, due to inhibitive consequences of regional politics, weak strategies for regional development, and economic and political uncertainties in the global context [93], can be cited as possible causes for the observed absence of causal relationships between its growth and economic and political integration.

When compared with the existing body of literature, both similarities and contradictions to the study's findings can be identified. A study basing oil producing nations in Latin America, including Brazil, identifies how the growth in these nations have benefitted through globalisation. However, though studies had revealed a causal connection from economic integration towards gross domestic product in Brazil and vice-versa in Columbia [65], the results obtained in this study pertaining to the context of the entire South American region reveals a statistically insignificant dynamic between the variables. With both Brazil and Columbia being key players in the South American economical context, the varying infrastructural capabilities, diverse globalisation dynamics, and the country-specific challenges faced when compared with other nations in the region can be cited as possible reason for this difference. Converse to the observed interrelation from economic growth to social globalisation, existing literature has established the vice versa where increased

social movement is observed enabling human capital development in a country [69], and ultimately their economic development.

The causal relationships identified between social globalisation and growth in South America delineates the necessity for policy actions to augment interpersonal, informational, and cultural integration through economic growth, while also reinforcing its global standing.

#### 4.7 Economic growth and globalisation in Europe

This study consistently affirms the unidirectional impact of globalisation on economic growth proved in literature in the European region [17]. Economic globalisation tends to have a bidirectional impact on economic growth in the European region and this contradicts with the existing literature which delineates unidirectional impacts of economic integration on economic expansion [2, 17, 59, 60]. Findings state that Europe experienced some level of disintegration in trade activities after the course of Brexit where Britain exited from the European Union [94]. Furthermore, the course of industrialisation which leads to heightened economic development through the widening of the production capacity [60] mutually impacts the economic development and economic integration acting as constituents of both. However, industrialisation of such extents impact on the ecological balance resulting in harmful long-term results. It is essential to align the policies of Europe and its high-income nations in an eco-friendly and sustainable manner.

#### 4.8 Economic growth and globalisation in Africa

The African region is getting consolidated to the global system through various economic, social, and political partnerships with global organisations such as the World Bank, International Monetary Fund, and the United Nations. Alliances of Africa in the regional context are observable through regional partnerships such as the West African Economic and Monetary Union (WAEMU), Economic Community of West African States (ECOWAS), and Southern African Development Community (SADC). These partnerships materialise as relationships allowing opportunities for trade, investment, human capital development, and institutional and infrastructural development, and governance guidance thereby sustaining the globalisation-growth nexus in Africa. Such observations can thus be considered as potential grounds for the observed relationships between growth and overall, economic, social and political globalisation in Africa.

Critical comparisons with existing literature both justify and contradicts the findings of the study. The unidirectional flow from globalisation to growth is consistent with the outcomes of a study which had studied the Sub-Saharan Africa where actual global flows were found promoting economic advancement in the region [24]. Economic integration was identified as having a two-way casual dynamic with economic growth with respect to low-income African nations [95], whereas financial globalisation included within the economic dimension of globalisation were also discovered to have a bidirectional dynamic with economic growth with regards to Western Africa thereby aligning with the study's findings. In the context of social globalisation, globalisation brought about by increased investments on human capital were identified enhancing economic advancement in the Sub-Saharan Africa [19]. Furthermore, how the increased income of an economy allows informational globalisation was also found [24] thus justifying the observed bidirectional causal connection. Political globalisation was found to positively influence economic growth in relation to low-income African nations [95], aligning with the findings of the study.

Based on the detected causalities, the African region requires policy actions to uphold and uplift the current globalisation-growth nexus and its benefits.

### 5 Policy recommendations

While potential underlying causes for each region to have achieved their respective levels of globalisation and economic growth have been elaborated in this study, stakeholders and policymakers can gain insights to develop and progress their performance in each dimension. At a global level, this can be accomplished by creating comprehensive and precise globalisation initiatives spanning all the economic, social and political dimensions. The identified policy initiatives are developed in-line with the Sustainability Development Goals (SDG) agenda introduced by the United Nations to ensure their global relevance and sustainable implementation.

Asia consists of a bi-directional causal flow between globalisation and economic growth; hence it is highly recommended to facilitate regional integration through initiatives launched to promote cross-border investments, reinforce

inter-regional trade partnerships to attract capital and funding from foreign regions while gaining access to global capital markets by adequately utilising the benefits of globalisation. Social globalisation was found to have a significant impact on economic growth in Asia. Hence, augmentation of digital infrastructure and literacy, encouragement of technological innovation, amplification of digital and technological transfers from high-tech champions within the Asian region (Japan and South Korea) and the rest of the world to leverage digital technology would create opportunities in economic expansion. Such initiatives are bound to redirect financial capital and facilitate the dissemination of technologies within the Asian region, ensure official development assistance from developed world nations to developing and least developed nations within the Asian region, and enhance global partnerships for sustainable development attached to SDG 17: Partnerships for the Goals. Furthermore, developing Asian countries will be endowed with increased avenues to access to financial services, global value chains and markets and to upgrade their industrial capabilities to eventually build sustainable and resilient infrastructure in line with the SDG 9: Industry, Innovation, and Infrastructure. These efforts will enhance the growth avenues in economic integration which bi-directionally causes economic growth.

The African region which portrays a bi-directional causal flow between economic globalisation and growth can benefit from the expansion of avenues to attract foreign direct investments and the increase capital market interactions. This can be achieved through affiliations in cross-border trade agreements and the eradication of economic embargoes. These actions will also assemble supplementary financial capital for developing African nations, facilitate market access on a lasting basis for least developed African nations, along with the enhancement of collaborative alliances to diffuse capital within Africa in line with SDG 17: Partnerships for the Goals. Moreover, social globalisation which constitutes a two-way causal flow with economic growth, can be encouraged in the region through initiatives to facilitate cultural transfers. Such initiatives are expected to create a society versed in the appreciation of cultural diversity and its role in ensuring sustainable diversity, while reinforcing endeavours to safeguard the global cultural heritage attached to the SDG 4: Quality Education, and SDG 11: Sustainable Cities and Communities, respectively. This will eventually result in the eradication of inequalities while uplifting the living standards of the developing and least developed nations in the African region contributing to the SDG 10: Reduced Inequalities. Africa can also reap benefits of political globalisation which has a significant impact on economic expansion, through the endorsement of democratic values and the empowerment of internal and external cohesion within the African Union. Thereby the accomplishment of macroeconomic stability and sustainable development across Africa is expected through policy synergy as per the SDG 17.

The European region which delineates a two-way causality between economic globalisation and economic growth, can execute strategies to reinforce economic integration by adopting measures to ensure uninterrupted trade activities, encouraging cross-border investments in the region post -Brexit, while boosting industrial capacity. However, it is essential to abide by eco-friendly industrialisation agendas to minimise the emission of harmful substances to the ecosystem. Such efforts will contribute to achieving the targets of SDG 13: Climate Action, SDG 14: Life Below Water and SDG 15: Life on Land. Additionally, technological exchanges can also be motivated to foster regional integration owing to the significant impact exerted by social globalisation on economic growth in the European region. It is expected by these actions to facilitate sustained and inclusive economic growth along with the construction of resilient infrastructure capable of ascertaining inclusive and sustainable industrialisation as per the SDG 8: Decent Work and Economic Growth and SDG 9: Industry, Innovation, and Infrastructure, respectively.

Enhancement of economic cohesion by stimulation of external funding and the promotion of global partnerships can be undertaken by North America to improve economic globalisation which has a unidirectional impact on economic growth within the region while accomplishing economic prosperity and international integration. In addition, the rest of the North American region can benefit through its interactions with USA and Canada, which are two of the most advanced and progressive nations in the world owing to its affiliations with influential inter-governmental and economic associations. These efforts will facilitate opportunities in reaching the SDG 17 where the powerful and developed nations' assistance and efforts in development penetrates to the developing and least developed nations as a part of international corporation. Such actions will improve chances of economic expansion, benefitting from the bi-directional causal flows between global integration and economic growth in North America.

Oceania can reap advantages in terms of political integration which is having a significant impact on economic growth, through the consolidation of its diplomatic international and regional interconnections and partnerships. These advantages can come in the form of enhanced inter-regional security, collective efforts for peacekeeping and ensuring political stability across the countries in the region. Such attempts would sustainably influence the entirety of the Oceanic region with satisfaction of targets and aims of SDG 16: Peace, Justice and Strong Institutions by supporting nations to attain increased participation and transparency in global governance ensuring justice.

South American economy which is exerting an impact on social integrational aspects can benefit in uplifting living standards of the region through amplifying access to the internet, promoting press freedom and civil liberties, and diminishing gender parity to propel social integration. Efforts in diminishing gender parity while eliminating any form of discrimination and provision of equal rights will lead towards achieving SDG 5: Gender Equality. In comparison to other regions South American nations having oceanic resources and diverse cultural heritages, can implement measures to augment its tourism—related infrastructure while expanding its focus in job creation and promotion of local products at the attainment targets of SDG 8: Decent Work and Economic Growth by the year 2030.

## 6 Limitations and avenues for future research

Based on the inconsistency in data availability, only 97 countries have been utilised for this study. The methodology used in this study consists of inherent limitations in its inability to be implemented on non-stationary and interdependent data. Hence, this study possesses opportunities for enhancement and avenues for future studies. The methodology used in this study can be extended further by deploying more advanced and sophisticated methodologies to determine the causality. Potential researchers have the possibility of penetrating more into the building blocks of the sub- dimensions of globalisation; economic (financial and trade indices), and social (interpersonal, informational, and cultural indices), which may lead to deviating results. Furthermore, while the objective of this study is to identify the causal relationships between globalisation, its subdimensions and economic growth over the period of 51 years considered, potential researchers can expand this scope to explicitly analyse how the structural changes which had affected the economic, social, and the political dynamics during the period considered have influenced the identified casual relationships.

## 7 Conclusion

This study examined the causality between globalisation and economic growth utilising a panel dataset over the period from 1971 to 2021, encompassing 97 countries classified into 06 regions. This study contributes to the extant literature, specifically by focusing on the nexus between the variables in the North American, South American, and Oceanian regions on which previous studies are less prominent. Furthermore, this research extends over five decades and deploys the Panel Granger causality approach in analysis while also evaluating the dynamics of social and political integration which are also underexplored in literature, further distinguishing this study. However, the findings of this study provide both consistent and contrasting dynamics from the existing literature.

Two-way causal relationships were identified between economic growth and globalisation in Asia, North America and Oceania. Hence, nations in the such regions should invest in cross-border integration in terms of trade, technology and governance in order to extract the benefits of globalisation. Economic globalisation presenting bidirectional causal progressions with economic growth in regions like Asia, Africa, Oceania and Europe should focus on lifting unfavourable trade barriers and increasing their opportunities in global market access. African region which shows two-way causal flows in terms of social globalisation should focus on developing the nations suffering from poverty, inequality and hunger to enhance the living standards of the African nations to extract the growth prospects in the socio-economic context. Europe, which is home for a multitude of high-income nations receives a unidirectional impact of globalisation on the economic growth. However, such nations should invest more on sustainable and eco-friendly development methodologies, hence extracting the favourable outcomes of global integration to the economies. Political globalisation unidirectionally influences economic growth in Asia, Africa and Oceania. Active participation in intergovernmental pacts and treaties will result in opportunities for economic expansion. All regions showing causal effects from globalisation and its dimensions would favourably benefit by aligning their policies to the UN SDGs agenda towards sustainable development.

**Author contributions** D.A.: writing original draft, conceptualization, formal analysis, investigation, data analysis, Validation, methodology and writing (review/editing). P.W.: writing original draft, conceptualization, formal analysis, investigation, data analysis, Validation, methodology and writing (review/editing). I.S.: writing original draft, conceptualization, formal analysis, data analysis, methodology and writing (review/editing). D.R.: writing original draft, conceptualization, formal analysis, data analysis, methodology and writing (review/editing). R.J.: conceptualization, formal analysis, methodology, supervision, validation, writing (review/editing).

**Funding** This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

**Data availability** All the data utilised in the analysis is attached as a supplementary material Supplementary Data S1.

## Declarations

**Ethics approval and consent to participate** Not applicable. This study used publicly available secondary data, and no direct involvement of human participants, human tissue, or identifiable personal data was required.

**Consent for publication** Not applicable.

**Competing interests** The authors declare no competing interests.

**Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

## References

1. Dreher A. Does globalization affect growth? Evidence from a new index of globalization. *Appl Econ*. 2006;38:1091–110. <https://doi.org/10.1080/00036840500392078>.
2. Radulović M, Kostić M. Globalization and economic growth in Western Balkan countries. *Region Sci Policy Pract*. 2024. <https://doi.org/10.1016/j.rspp.2024.100031>.
3. Ortiz-Ospina MRaPAaJHaHRaE. Economic Growth: Our World in Data; 2023 [Available from: <https://ourworldindata.org/economic-growth>]
4. Akadiri SS, Lasisi TT, Uzuner G, Akadiri AC. Examining the impact of globalization in the environmental Kuznets curve hypothesis: the case of tourist destination states. *Environ Sci Pollut Res*. 2019;26:12605–15. <https://doi.org/10.1007/s11356-019-04722-0>.
5. Acheampong AO, Boateng E, Amponsah M, Dzator J. Revisiting the economic growth–energy consumption nexus: Does globalization matter? *Energy Economics*. 2021;102:1–18. <https://doi.org/10.1016/j.eneco.2021.105472>.
6. Burhan NAS, Sidek AH, Kurniawan Y, Mohamad MR. Has globalization triggered collective impact of national intelligence on economic growth? *Intelligence*. 2015;48:152–61. <https://doi.org/10.1016/j.intell.2014.11.003>.
7. Coulibaly SK, Erbao C, Metuge MT. Economic globalization, entrepreneurship, and development. *Technol Forecast Soc Chang*. 2018;127:271–80. <https://doi.org/10.1016/j.techfore.2017.09.028>.
8. Gaies B, Goutte S, Guesmi K. What interactions between financial globalization and instability? Growth in developing countries. *J Int Dev*. 2019;31:39–79. <https://doi.org/10.1002/jid.3391>.
9. Gaies B, Goutte S, Guesmi K. Does financial globalization still spur growth in emerging and developing countries? Considering exchange rates. *Res Int Bus Financ*. 2020;52:1–19. <https://doi.org/10.1016/j.ribaf.2019.101113>.
10. Ghosh A. How does banking sector globalization affect economic growth? *Int Rev Econ Financ*. 2017;48:83–97. <https://doi.org/10.1016/j.iref.2016.11.011>.
11. Meng B, Xue K, Han M. Digitalization, natural resources rents, and financial market risk: evidence from G7 countries. *Resour Policy*. 2022;79:1–8. <https://doi.org/10.1016/j.resourpol.2022.103074>.
12. Ze F, Yu W, Ali A, Hishan SS, Muda I, Khudoykulov K. Influence of natural resources, ICT, and financial globalization on economic growth: evidence from G10 countries. *Resour Policy*. 2023;81:1–9. <https://doi.org/10.1016/j.resourpol.2022.103254>.
13. Khan MTI, Anwar S, Sarkodie SA, Yaseen MR, Nadeem AM. Do natural disasters affect economic growth? The role of human capital, foreign direct investment, and infrastructure dynamics. *Heliyon*. 2023;9:1–19. <https://doi.org/10.1016/j.heliyon.2023.e12911>.
14. Marques LM, Fuinhas JA, Marques AC. Augmented energy-growth nexus: economic, political and social globalization impacts. *Energy Proc*. 2017;136:97–101. <https://doi.org/10.1016/j.egypro.2017.10.293>.
15. Our World in Data. World regions according to Our World in Data 2024 [Available from: <https://ourworldindata.org/grapher/continents-according-to-our-world-in-data>].
16. Chang C-P, Lee C-C. Globalization and economic growth: a political economy analysis for OECD countries. *Glob Econ Rev*. 2010;39(2):151–73. <https://doi.org/10.1080/1226508X.2010.483835>.
17. Gurgul H, Lach Ł. Globalization and economic growth: evidence from two decades of transition in CEE. *Econ Model*. 2014;36:99–107. <https://doi.org/10.1016/j.econmod.2013.09.022>.
18. Muye IM, Muye IY. Testing for causality among globalization, institution and financial development: Further evidence from three economic blocs. *Borsa Istanbul Rev*. 2017;17:117–32. <https://doi.org/10.1016/j.bir.2016.10.001>.
19. Zahanogo P. Globalization and economic growth in developing countries: Evidence from Sub-Saharan Africa. *Int Trade J*. 2018;32:189–208. <https://doi.org/10.1080/08853908.2017.1333933>.
20. Yang B, Usman M, Jahanger A. Do industrialization, economic growth and globalization processes influence the ecological footprint and healthcare expenditures? Fresh insights based on the STIRPAT model for countries with the highest healthcare expenditures. *Sustain Prod Consum*. 2021;28:893–910. <https://doi.org/10.1016/j.spc.2021.07.020>.

21. Elfaki KE, Ahmed EM. Digital technology adoption and globalization innovation implications on Asian Pacific green sustainable economic growth. *J Open Innov Technol Mark Complex*. 2024;10:1–10. <https://doi.org/10.1016/j.joitmc.2024.100221>.
22. Lee C-C, Lee C-C, Chiou Y-Y. Insurance activities, globalization, and economic growth: new methods, new evidence. *J Int Finan Mark Inst Money*. 2017;51:155–70. <https://doi.org/10.1016/j.intfin.2017.05.006>.
23. Latif Z, Mengke Y, Danish, Latif S, Ximei L, Pathan ZH, et al. The dynamics of ICT foreign direct investment, globalization and economic growth: panel estimation robust to heterogeneity and cross-sectional dependence. *Telemat Inform*. 2018;35:318–28. <https://doi.org/10.1016/j.tele.2017.12.006>.
24. Glennice Fosah M-S, Mama N, Dohba Dinga G, Nchofoung TN. The effect of globalisation on Sub-Saharan Africa's development thrives. *Res Global*. 2023;7:1–8. <https://doi.org/10.1016/j.resglo.2023.100149>.
25. Baidoo ST, Tetteh B, Boateng E, Ayibor RE. Estimating the impact of economic globalization on economic growth of Ghana: Wavelet coherence and ARDL analysis. *Res Global*. 2023;7:1–14. <https://doi.org/10.1016/j.resglo.2023.100183>.
26. Nasreen S, Mahalik MK, Shahbaz M, Abbas Q. How do financial globalization, institutions and economic growth impact financial sector development in European countries? *Res Int Bus Financ*. 2020;54:1–58. <https://doi.org/10.1016/j.ribaf.2020.101247>.
27. Balsalobre-Lorente D, Sinha A, Driha OM, Mubarak MS. Assessing the impacts of ageing and natural resource extraction on carbon emissions: a proposed policy framework for European economies. *J Clean Prod*. 2021;296:1–14. <https://doi.org/10.1016/j.jclepro.2021.126470>.
28. Law SH, Tan HB, Azman-Saini WNW. Globalisation, institutional reforms and financial development in East Asian economies. *World Econ*. 2015;38:379–98. <https://doi.org/10.1111/twec.12168>.
29. Tariq G, Sun H, Fernandez-Gamiz U, Mansoor S, Pasha AA, Ali S, et al. Effects of globalization, foreign direct investment and economic growth on renewable electricity consumption. *Heliyon*. 2023;9:1–14. <https://doi.org/10.1016/j.heliyon.2023.e14635>.
30. Shahbaz M, Mallick H, Mahalik MK, Sadorsky P. The role of globalization on the recent evolution of energy demand in India: implications for sustainable development. *Energy Economics*. 2016;55:52–68. <https://doi.org/10.1016/j.eneco.2016.01.013>.
31. Ozcan B, Danish, Temiz M. Re-visiting resource curse hypothesis in China through the lens of human capital and globalization. *J Environ Manag*. 2023;338:1–12. <https://doi.org/10.1016/j.jenvman.2023.117685>.
32. Guan J, Kirikkaleli D, Bibi A, Zhang W. Natural resources rents nexus with financial development in the presence of globalization: Is the “resource curse” exist or myth? *Resour Policy*. 2020;66:1–9. <https://doi.org/10.1016/j.resourpol.2020.101641>.
33. Abid M, Alotaibi MN. Crude oil price and private sector of Saudi Arabia: Do globalization and financial development matter? New evidence from combined cointegration test. *Resour Policy*. 2020;69:1–15. <https://doi.org/10.1016/j.resourpol.2020.101774>.
34. Nathaniel SP, Ahmed Z, Shamansurova Z, Fakher HA. Linking clean energy consumption, globalization, and financial development to the ecological footprint in a developing country: insights from the novel dynamic ARDL simulation techniques. *Heliyon*. 2024;10:1–17. <https://doi.org/10.1016/j.heliyon.2024.e27095>.
35. Fachrurrozi K, Masbar R, Aliasuddin, Sefarita C. Energy-growth-globalization (EGG) nexus in N-11 countries. *Heliyon*. 2022;8:1–9. <https://doi.org/10.1016/j.heliyon.2022.e10522>.
36. Yang X, Li N, Mu H, Zhang M, Pang J, Ahmad M. Study on the long-term and short-term effects of globalization and population aging on ecological footprint in OECD countries. *Ecol Complex*. 2021;47:1–12. <https://doi.org/10.1016/j.ecocom.2021.100946>.
37. Nodehi M, Arani AA, Taghvaei VM. Sustainability spillover effects and partnership between East Asia & Pacific versus North America: interactions of social, environment and economy. *Lett Spat Resour Sci*. 2022;15(3):311–39. <https://doi.org/10.1007/s12076-021-00282-5>.
38. Taghvaei VM, Nodehi M, Arani AA, Jafari Y, Shirazi JK. Sustainability spillover effects of social, environment and economy: mapping global sustainable development in a systematic analysis. *Asia Pac J Region Sci*. 2023;7(2):329–53. <https://doi.org/10.1007/s41685-022-00231-0>.
39. Afshari E, Ebrahimi M, Zare H. Sustainable development spillover effects of China and the US on Iran: analysis of integrated sustainability perspective. *Environ Dev Sustain*. 2024;26(6):15163–75. <https://doi.org/10.1007/s10668-023-03243-8>.
40. Mohamad-Taghvaei V, Assari-Arani A, Soretz S, Agheli L. Sustainable development spillover in MENA and Europe: regional interactions of social, environment and economy. *Iran Econ Rev*. 2023;27(2):471–503. <https://doi.org/10.22059/ier.2023.312834.1007127>.
41. Soretz S, Nodehi M, Taghvaei VM. Sustainability and sustainable development concepts: Defining the perspectives and pillars. *Reference Module in Social Sciences: Elsevier*; 2023. p. 1–15. Available at: <https://www.sciencedirect.com/science/article/pii/B9780443137761000301>
42. Taghvaei V, Sharifpour Y, Akbari F, Arani AA, Tatar M. Integrated sustainability of social, environment and economy: Defining the hypotheses and theories interconnecting the pillars of sustainable development. *Reference Module in Social Sciences: Elsevier*; 2023. p. 1–20. Available at: <https://www.sciencedirect.com/science/article/pii/B9780443137761001562>
43. Xiao H, Bao S, Ren J, Xu Z, Xue S, Liu J. Global transboundary synergies and trade-offs among sustainable development goals from an integrated sustainability perspective. *Nat Commun*. 2024;15(1):1–12. <https://doi.org/10.1038/s41467-023-44679-w>.
44. Mohamad Taghvaei V, Assari Arani A, Agheli L. Sustainable development spillover effects between North America and MENA: analyzing the integrated sustainability perspective. *Environ Sustain Indic*. 2022;14:1–8. <https://doi.org/10.1016/j.indic.2022.100182>.
45. Nasrollahi Z, Hashemi M-S, Bameri S, Mohamad Taghvaei V. Environmental pollution, economic growth, population, industrialization, and technology in weak and strong sustainability: using STIRPAT model. *Environ Dev Sustain*. 2020;22(2):1105–22. <https://doi.org/10.1007/s10668-018-0237-5>.
46. Agheli L, Taghvaei VM. Political stability effect on environment and weak sustainability in Asian countries. *Sustain Anal Model*. 2022;2:1–6. <https://doi.org/10.1016/j.samod.2022.100007>.
47. Huang H, Akbari F. Integrated sustainability perspective and spillover effects of social, environment and economic pillars: a case study using SEY model. *Socioecon Plann Sci*. 2024;96:1–20. <https://doi.org/10.1016/j.seps.2024.102077>.
48. Liang Y, Jin X, Taghvaei V. Sustainable development spillover effects among selected Asian countries: analysis of integrated sustainability perspective. *Socioecon Plann Sci*. 2024;91:1–20. <https://doi.org/10.1016/j.seps.2023.101781>.
49. Alariqi M, Long W, Singh PR, Al-Barakani A, Muazu A. Modelling dynamic links among energy transition, technological level and economic development from the perspective of economic globalisation: evidence from MENA economies. *Energy Rep*. 2023;9:3920–31. <https://doi.org/10.1016/j.egyr.2023.02.089>.
50. Ekanayake PNSP, Madsen JB, Bharati T. Trade and economic growth: Does the sophistication of traded goods matter? *J Econ Growth*. 2023;28:481–524. <https://doi.org/10.1007/s10887-023-09224-w>.

51. Gomes Neto D, Veiga FJ. Financial globalization, convergence and growth: the role of foreign direct investment. *J Int Money Financ.* 2013;37:161–86. <https://doi.org/10.1016/j.jimonfin.2013.04.005>.
52. Bekaert G, Harvey CR, Lundblad C. Financial openness and productivity. *World Dev.* 2011;39(1):1–19. <https://doi.org/10.1016/j.worlddev.2010.06.016>.
53. Falahaty M, Law SH. The effect of globalization on financial development in the MENA region. *Trans Stud Rev.* 2012;19:205–23. <https://doi.org/10.1007/s11300-012-0242-6>.
54. Kandil M, Shahbaz M, Nasreen S. The interaction between globalization and financial development: new evidence from panel cointegration and causality analysis. *Empir Econ.* 2015;49:1317–39. <https://doi.org/10.1007/s00181-015-0922-2>.
55. Kunieda T, Okada K, Shibata A. Corruption, capital account liberalization, and economic growth: theory and evidence. *Int Econ.* 2014;139:80–108. <https://doi.org/10.1016/j.inteco.2014.03.001>.
56. Iamsiraroj S. The foreign direct investment–economic growth nexus. *Int Rev Econ Financ.* 2016;42:116–33. <https://doi.org/10.1016/j.iref.2015.10.044>.
57. Sunde T. Foreign direct investment, exports and economic growth: ADRL and causality analysis for South Africa. *Res Int Bus Financ.* 2017;41:434–44. <https://doi.org/10.1016/j.ribaf.2017.04.035>.
58. Rao BB, Vadlamannati KC. Globalization and growth in the low income African countries with the extreme bounds analysis. *Econ Model.* 2011;28:795–805. <https://doi.org/10.1016/j.econmod.2010.10.009>.
59. Carp L. Financial globalization and capital flows volatility effects on economic growth. *Proc Econ Finance.* 2014;15:350–6. [https://doi.org/10.1016/S2212-5671\(14\)00521-8](https://doi.org/10.1016/S2212-5671(14)00521-8).
60. Cengiz O, Manga M. Does economic globalization trigger de-industrialization in Western Balkan countries? Empirical evidence based on augmented mean group estimator. *Reg Sci Policy Pract.* 2023;16:1–21. <https://doi.org/10.1111/rsp3.12709>.
61. Dumrongritikul T, Anderson H, Vahid F. The global effects of productivity gains in Asian emerging economies. *Econ Model.* 2019;83:127–40. <https://doi.org/10.1016/j.econmod.2019.02.004>.
62. Anwar S, Cooray A. Financial development, political rights, civil liberties and economic growth: evidence from South Asia. *Econ Model.* 2012;29:974–81. <https://doi.org/10.1016/j.econmod.2012.02.009>.
63. Shahbaz M, Mallick H, Mahalik MK, Hammoudeh S. Is globalization detrimental to financial development? Further evidence from a very large emerging economy with significant orientation towards policies. *Appl Econ.* 2018;50:574–95. <https://doi.org/10.1080/00036846.2017.1324615>.
64. Ahmad M, Jiang P, Murshed M, Shehzad K, Akram R, Cui L, et al. Modelling the dynamic linkages between eco-innovation, urbanization, economic growth and ecological footprints for G7 countries: Does financial globalization matter? *Sustain Cities Soc.* 2021;70:1–13. <https://doi.org/10.1016/j.scs.2021.102881>.
65. Tillaguano B, Hossain MR, Cuesta L, Ahmad M, Alvarado R, Murshed M, et al. Impact of oil price, economic globalization, and inflation on economic output: evidence from Latin American oil-producing countries using the quantile-on-quantile approach. *Energy.* 2024;302:1–16. <https://doi.org/10.1016/j.energy.2024.131786>.
66. Xie C, Jin X. The role of digitalization, sustainable environment, natural resources and political globalization towards economic well-being in China, Japan and South Korea. *Resour Policy.* 2023;83:1–11. <https://doi.org/10.1016/j.resourpol.2023.103682>.
67. Raihan A, Voumik LC, Akter S, Ridzuan AR, Fahlevi M, Aljuaid M, et al. Taking flight: exploring the relationship between air transport and Malaysian economic growth. *J Air Transp Manag.* 2024;115:1–12. <https://doi.org/10.1016/j.jairtraman.2024.102540>.
68. Doepke M, Tertilt M. Does female empowerment promote economic development? *J Econ Growth.* 2019;24:309–43. <https://doi.org/10.1007/s10887-019-09172-4>.
69. Neidhöfer G, Ciaschi M, Gasparini L, Serrano J. Social mobility and economic development. *J Econ Growth.* 2024;29:327–59. <https://doi.org/10.1007/s10887-023-09234-8>.
70. Granger CWJ. Investigating causal relations by econometric models and cross-spectral methods. *Econometrica.* 1969;37:424–38. <https://doi.org/10.2307/1912791>.
71. Akadiri SS, Alola AA, Akadiri AC. The role of globalization, real income, tourism in environmental sustainability target. Evidence from Turkey. *Sci Total Environ.* 2019;687:423–32. <https://doi.org/10.1016/j.scitotenv.2019.06.139>.
72. Sandanayaka I, Rathnayake D, Athalage D, Wijesuriya P, Jayathilaka R. Interweaving globalisation and growth: a causal exploration across income levels. *Soc Sci Humanit Open.* 2025;11:1–18. <https://doi.org/10.1016/j.ssaho.2025.101399>.
73. Pesaran H. General diagnostic tests for cross section dependence in panels. *CESifo Working Papers.* 2004;69:1–42. <https://doi.org/10.2139/ssrn.572504>.
74. Raihan A, Bala S, Akther A, Ridwan M, Eleais M, Chakma P. Advancing environmental sustainability in the G-7: the impact of the digital economy, technological innovation, and financial accessibility using panel ARDL approach. *J Econ Technol.* 2024;1:26. <https://doi.org/10.1016/j.ject.2024.06.001>.
75. Pesaran MH. A simple panel unit root test in the presence of cross-section dependence. *J Appl Econ.* 2007;22:265–312. <https://doi.org/10.1002/jae.951>.
76. Hashem Pesaran M, Yamagata T. Testing slope homogeneity in large panels. *J Econ.* 2008;142(1):50–93. <https://doi.org/10.1016/j.jeconom.2007.05.010>.
77. Westerlund J. Testing for error correction in panel data. *Oxford Bull Econ Stat.* 2007;69:709–48. <https://doi.org/10.1111/j.1468-0084.2007.00477.x>.
78. Love I, Zicchino L. Financial development and dynamic investment behavior: evidence from panel VAR. *Q Rev Econ Finance.* 2006;46(2):190–210. <https://doi.org/10.1016/j.qref.2005.11.007>.
79. Gupta S, Gandhi TK. ERP and functional connectivity reveal hemispheric asymmetry in perceptual grouping. *Neurosci Inf.* 2024;4:1–12. <https://doi.org/10.1016/j.neuri.2024.100167>.
80. Liang Y, Zhao Q, Neubert JK, Ding M. Causal interactions in brain networks predict pain levels in trigeminal neuralgia. *Brain Res Bull.* 2024;211:1–11. <https://doi.org/10.1016/j.brainresbull.2024.110947>.
81. Rowe EG, Garrido MI, Tsuchiya N. Feedforward connectivity patterns from visual areas to the front of the brain contain information about sensory stimuli regardless of awareness or report. *Cortex.* 2024;172:284–300. <https://doi.org/10.1016/j.cortex.2023.11.016>.

82. Feng Y, Xiao Z, Zhou J, Ni G. Asymmetrically examining the impact of green finance and renewable energy consumption on environmental degradation and renewable energy investment: the impact of the COVID-19 outbreak on the Chinese economy. *Energy Rep.* 2023;9:5458–72. <https://doi.org/10.1016/j.egy.2023.04.361>.
83. Ren X, Fu C, Jin C, Li Y. Dynamic causality between global supply chain pressures and China's resource industries: a time-varying Granger analysis. *Int Rev Financ Anal.* 2024;95:1–17. <https://doi.org/10.1016/j.irfa.2024.103377>.
84. Ahmadi S, Nair GN. Granger causality of gaussian signals from binary or non-uniformly quantized measurements. *IFAC Pap OnLine.* 2021;54:677–83. <https://doi.org/10.1016/j.ifacol.2021.06.129>.
85. Lin R, Dong C, Zhou P, Ma P, Ma S, Chen X, et al. Motor imagery EEG task recognition using a nonlinear Granger causality feature extraction and an improved Salp swarm feature selection. *Biomed Signal Process Control.* 2024;88:1–10. <https://doi.org/10.1016/j.bspc.2023.105626>.
86. Yuan T, Qin SJ. Root cause diagnosis of plant-wide oscillations using Granger causality. *IFAC Proc Vol.* 2012;45:160–5. <https://doi.org/10.3182/20120710-4-SG-2026.00172>.
87. Du W-B, Zhang M-Y, Zhang Y, Cao X-B, Zhang J. Delay causality network in air transport systems. *Transp Res Part E Logist Transp Rev.* 2018;118:466–76. <https://doi.org/10.1016/j.tre.2018.08.014>.
88. Jayawardhana T, Jayathilaka R, Anuththara S, Nimnadi T, Karadanaarachchi R, Galappaththi K. Exploring the dynamics of the elderly population and economic growth: a comparative analysis across continents. *Soc Indic Res.* 2024;173(3):543–68. <https://doi.org/10.1007/s11205-024-03353-4>.
89. Dissanayake H, Perera N, Abeykoon S, Samson D, Jayathilaka R, Jayasinghe M, et al. Nexus between carbon emissions, energy consumption, and economic growth: Evidence from global economies. *PLoS ONE.* 2023;18:1–27. <https://doi.org/10.1371/journal.pone.0287579>.
90. Feldman J, Seligmann H, King S, Flynn M, Shelley T, Helwig A, et al. Circular economy barriers in Australia: How to translate theory into practice? *Sustain Prod Consump.* 2024;45:582–97. <https://doi.org/10.1016/j.spc.2024.02.001>.
91. World Trade Organization. Trade trends estimates Latin America and the Caribbean. 2019; 04th February 2025. Available at: [https://www.wto.org/english/tratop\\_e/devel\\_e/a4t\\_e/gr19\\_e/trade\\_trends\\_estimates\\_latin\\_america\\_and\\_the\\_caribbean\\_2019\\_edition\\_1q\\_update\\_en\\_e.pdf](https://www.wto.org/english/tratop_e/devel_e/a4t_e/gr19_e/trade_trends_estimates_latin_america_and_the_caribbean_2019_edition_1q_update_en_e.pdf)
92. Navarro-Drazich D, Lorenzo C. Sensitivity and vulnerability of international tourism by covid crisis: South America in context. *Res Global.* 2021;3:1–8. <https://doi.org/10.1016/j.resglo.2021.100042>.
93. Vaz AC. South America's economic and political landscape: recent developments and trends. The Norwegian Peacebuilding Resource Centre; 2014; 04th February 2025. Available at: <https://www.files.ethz.ch/isn/183889/541931998cab5a031d3fa893e1066938.pdf>
94. de Lucio J, Mínguez R, Minondo A, Requena F. The negative impact of disintegration on trade: the case of Brexit. *Eur Econ Rev.* 2024;163:1–19. <https://doi.org/10.1016/j.euroecorev.2024.104698>.
95. Ehigiamusoe KU. A disaggregated approach to analysing the effects of globalization and energy consumption on economic growth: new insights from low-income countries. *Int J Finance Econ.* 2023;28(4):3976–96. <https://doi.org/10.1002/ijfe.2631>.

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.