Environment, Development and Sustainability (2024) 26:11089–11100
https://doi.org/10.1007/s10668-023-03217-w

The nexus between CO_2 intensity of GDP and environmental degradation in South European countries

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Received: 1 April 2022 / Accepted: 28 March 2023 / Published online: 10 April 2023

Abstract

This paper investigates whether carbon dioxide (CO_2) intensity of gross domestic product (GDP) matters for environmental deregulations in Southern European countries over the period of 1990–2018 while controlling economic growth, globalization, and energy consumption. The present study uses the second generation panel based techniques, namely cross-sectional dependency test, cross-sectional unit-root test, Westerlund cointegration test, augmented mean group and common correlated effects mean group estimators, and Dumitrescu–Hurlin causality test to measure the effect of CO_2 intensity of GDP, economic growth, globalization, and energy consumption on environmental degradation. The empirical finding of the present study reveals that the CO_2 intensity of GDP is an important factor in determining environmental degradation in South European countries, as the outcomes show that a 1% boost in CO_2 intensity of GDP is causing a 1.7728% increase in CO_2 emissions. Moreover, a 1% increase in economic growth caused a 0.2568% boost in CO_2 emissions. The result is crucial for policy decision-making and can perhaps be applied to take decisive policy actions to mitigate environmental issues.

Keywords CO_2 intensity of GDP · Environmental degradation · South European countries · Second generation panel models

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1 Introduction

The United Nations (UN) adopted the 2030 Sustainable Development Goals (SDGs) in 2015 with the purpose of holistically integrating economic advancement, social improvement, and environmental conservation (UN, 2015). The SDGs encourage worldwide sustained economic development, poverty eradication, social advancement, combating injustice and inequality, environmental protection, and confronting global climate change. Besides, the Paris Agreement reinforces greenhouse gas (GHG) emission mitigation objectives focused on bottom–up national determined contributions (NDCs) of countries, with the goal of limiting global temperature rise to less than 2 °C or even with around 1.5 °C, while also protecting global ecological sustainability. The Paris Agreement also underlines the inherent connection between climate change's impact and reaction, fair access to sustainable progress, and other objectives. As a result, countries should be given comprehensive, balanced, and integrated non-market measures in a planned and effective manner to support them in attaining their NDCs targets while supporting sustainable growth and pollution eradication (Haines et al., 2017; Kawakubo et al., 2018). As a result, the SDGs and NDCs are interconnected and reflect pressing needs for sustainable development, and their policy approaches are very consistent and synergistic. Hence, the entire globe must incorporate economic progress and carbon dioxide (CO_2) emission reductions in tackling climate change and adopt coordinated efforts to achieve a win scenario for sustainable development for all economies.

The major cause of GHG emissions is CO_2 emissions from energy usage. The primary idea of reducing CO_2 emissions while guaranteeing long-term economic growth is to lower the CO_2 intensity of economic growth (GDP) or to increase economic production per unit CO_2 emissions. As a result, the confined carbon emission volume is both a limited resource and a critical production element. Thus, increasing production performance per unit CO_2 emission is critical. The reciprocal of GDP's CO_2 intensity is also known as carbon output, and it is expressed by GDP production per unit CO_2 emission (Blair, 2008). Global GDP would nearly tripled by 2050 compared to 2010 levels, while CO_2 emissions would drop by approximately 60%. As a result, carbon production will grow by roughly eight times, and the CO_2 intensity of GDP would reduce by more than 85%, with an estimated yearly declining rate of about 5% (Blair, 2008). In addition, the worldwide average yearly fall rate of CO_2 intensity of GDP was lower than 1% from 2005 to 2014 (IEA, 2016). To keep global warming at 2 °C, the world average yearly lowering rate of CO_2 intensity of GDP has to be greater than 3%. As a result, as worldwide GDP rises at roughly 3% per year, worldwide CO_2 emissions should reach their pinnacle as soon as possible and then begin to decline. To allow overall CO_2 emissions to remain to decline, the average yearly decline in world CO_2 intensity of GDP must exceed 4% by roughly 2030. After 2030, the worldwide CO_2 intensity of GDP should keep falling at a faster rate, achieving 6–7% or more, to guarantee global economic growth while keeping temperatures below 2 °C (He et al., 2019).

The decrease in GDP's CO_2 intensity is a corresponding indication of reduced carbon emissions. Only if the CO_2 intensity of GDP falls quicker than GDP growth can improved carbon efficiency offset the rise in CO_2 emissions caused by GDP growth, resulting in a reduction in overall CO_2 emissions. Against this backdrop, the present study greatly adds to the preexisting environmental literature. First, this study aims to fill the literature gap regarding the impact of CO_2 intensity of GDP on CO_2 emissions in the panel of South European countries. To the extent of the researchers' understanding, this is potentially the first research of its nature in the setting of the South European countries, which is an excellent target for such analysis considering the region's growing CO_2 intensity of GDP and CO_2 emissions level over the last two decades. Second, unlike previous research, we utilized Pesaran's unit root test to account for heterogeneity and cross-sectional dependence in panel data. Besides, we apply the Westerlund panel co-integration test to verify co-integration among parameters. Thirdly, we employ the augmented mean group (AMG) panel estimator and the common correlated effects mean group (CCEMG) estimator for long-run estimates. These approaches help address the issue of panel heterogeneity and cross-section dependence in the panel data. In addition, the Dumitrescu–Hurlin (D–H) panel causality approach is employed to check the causal association among variables. Lastly, significant policy implications for the administration and policymakers are suggested as a result of the findings.

The remaining parts of our research are organized as follows. Section 2 discusses data, model specification and research techniques. The results and their discussion are presented in Sect. 3. Section 4 concludes with a conclusion.

2 Data and methodology

2.1 Theoretical background and data descriptions

This part describes how independent variables influence CO_2 emissions. Given the importance of tackling climate change, the developmental paths of the countries will be substantially hampered by a lack of carbon emission space. In such a case, economies must enhance their energy and economic systems in order to support a low-carbon transformation and accomplish economic and social growth. Therefore, the key approach for developing nations to achieve the dual goals of economic expansion and CO_2 emissions mitigation is to constantly reduce the CO_2 intensity of GDP (He et al., 2019). Energy usage has a detrimental and considerable impact on environmental sustainability since economic progress in any nation is mainly reliant on fossil fuels, which create environmental degradation (Ali et al., 2022; Yang et al., 2020a). According to Huwart and Verdier (2013), CO_2 emissions are increasing in a variety of ways as a result of globalization. Firstly, globalization raises CO_2 emissions from the transportation sector. Secondly, globalization encourages increased consumption and industrial activity, which worsens carbon emissions. Expanding cross-border economic activity stimulates industrial operations, which requires the utilization of power and energy, causing CO_2 emissions to grow. Yang et al. (2020b) and Kirikkaleli et al. (2022) asserted that GDP is the primary source of high CO_2 emissions since economic advancement is dependent on excessive energy usage, which inevitably degrades environmental sustainability. Based on these assumptions, we anticipate the following CO_2 emission model:

$$CO_{2it} = f\left(CINT_{it},\ ENE_{it},\ GLO_{it},\ GDP_{it}\right) \tag{1}$$

In Eq. (1), CO_2 shows carbon dioxide emissions, CINT indicates the CO_2 intensity of GDP, ENE signifies energy consumption, GLO is denotes globalization, and GDP is economic growth. We modified all variables except CINT to natural log for empirical analysis in order to utilize a log-linear configuration instead of a linear pattern. The Eq. 1 is constructed based on the estimamted model of Abbasi et al. (2022). A log-linear modification, according to Shahbaz et al. (2012), produces much more stable and reliable outcomes. The following is the log-linear function of CO_2 emissions:

$$\ln CO_{2t} = \alpha_0 + \alpha_1 CINT_{it} + \alpha_2 \ln ENE_{it} + \alpha_3 \ln GLO_{it} + \alpha_4 \ln GDP_{it} + \varepsilon_{it} \quad (2)$$

In Eq. (2), i is for cross-sections, t is the time period (1990–2018). α are the coefficients, ε shows the error term, and ln is the natural logarithm. CINT increases environmental performance if $\alpha_1 < 0$, otherwise ,the environment is damaged by an increase in CINT. We expect $\alpha_2 > 0$ if ENE is harmful for the environment, if not $\alpha_2 < 0$. We assume $\alpha_3 > 0$ if the link between GLO and CO_2 emissions is positive, if not, $\alpha_3 < 0$. GDP increases CO_2 emissions and impedes the quality of the environment if $\alpha_4 > 0$, if not $\alpha_4 < 0$.

This analysis makes use of secondary data sets gathered from multiple sources and spans the period 1990–2018 for the South European countries. The data on carbon emissions (metric tonnes), comprising emissions from cement production and pollutants from fossil fuels, including coal, natural gas, and oil, is gathered from the World Development Indicators (WDI). The data on CO_2 intensity of GDP measured as CO_2 emissions per unit of GDP, energy consumption measured as total energy consumption, and economic growth measured as constant 2010 USD are downloaded from the WDI of the World Bank. Besides, the data on globalization are measured as an index of globalization, which is a combination of social, political, and economic globalization downloaded from the website of KOF (https://kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html) (Gygli et al., 2019).

2.2 Methodology

The panel's cross-sectional dependence (CSD) cannot be detected with the first-generation root approaches (e.g., Phillip Perron, Levin, Lin, and Chu). Therefore, the cross-sectional Im, Pesaran, and Shin (CIPS) unit root test created by Pesaran (2007) addresses this limitation. The CIPS test is resistant to CSD.

Unlike prior research, this paper uses a more relevant technique, we employed Westerlund's (2007) error component centered test of co-integration to determine the connection of co-integration amongst the variables. This approach efficiently deals with the issue of CSD in the panel data, and it yields long-run co-integration findings for the Equation. This method employs four kinds of statistics, two for group statistics and two for panel statistics. The group panel statistics offer a null hypothesis for the entire group, whereas the panel statistics confirm the null of at least one co-integrated cross-section. The group statistics are represented by Gt and Ga, whereas Pt and Pa designate the panel statistics. In other words, "The Gt and Ga statistics test for the null hypothesis of no cointegration of at least one of the cross-sectional units. Pt and Pa statistics test for cointegration for the panel as a whole" (Boussiga & Ghdamsi, 2016).

The occurrence of co-integration amongst parameters requires the examination of the parameters' long-run connection. We used two distinct estimators to find the long-run connection in order to determine the values of explanatory factors. Teal and Eberhardt (2010) updated the augmented mean group (AMG) panel estimator by including the production function. Pesaran (2006) created this estimation model as a replacement for the common correlated effects mean group (CCEMG) estimator. The AMG technique has the main edge of assisting in the correction of outcomes in the existence of panel heterogeneity and multifactor error terms and being a long-run co-integration estimator compiled for a pragmatic number of cross-sections and times that gives reliable estimates (Nathaniel & Iheonu, 2019). AMG also has the benefit of including time-invariant fixed effects in the simulation. It also includes a setting for a common dynamic effect. This technique works in two steps:

$$\text{AMG step} - 1 \quad \Delta y_{it} = \alpha_{\mathrm{i}} + \beta_i \Delta x_{it} + \gamma_i f_t + \sum_{t=2}^{T} d_i \Delta D_t + \mu_{it} \tag{3}$$

$$\text{AMG step} - 2 \quad \hat{\beta}_{\mathrm{AMG}} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_i \tag{4}$$

In Eq. (3), Δ represents the differenced operator, and y_{it} and x_{it} are variables of the study. β_i displays the coefficients of country-specific estimates. f_t denotes an undetected common factor with a heterogeneous component. d_i is the coefficient of the conventional dynamic process and time dummies; in Eq. (4), $\hat{\beta}_{\mathrm{AMG}}$ signifies "the mean group estimator" for AMG, and μ_{it} and α_{i} signify the error term and intercept.

Eberhardt and Bond (2009) further demonstrated that in Monte Carlo simulations, both CCEMG and AMG worked adequately in combination with root mean square errors and CSD observed in panel data with non-stationary variables (combined or not). As a result, no factor pretesting for stationarity or co-integration is required when using the AMG estimation (Destek & Sarkodie, 2019). Likewise to the explanation in the first phase of estimation, the findings from AMG estimators are next tested for robustness using the CCEMG approach.

The CCEMG approach, first proposed by Pesaran (2006) and later modified by Kapetanios et al. (2011), is beneficial for the CSD scenario. If the data contains panel heterogeneity and multivariable error factors, this technique produces outstanding results. As a result, the linear conjunction of group averages of common effects and factors is utilized (Dong et al., 2018; Atasoy, 2017). The following regression can be used to compute the CCEMG estimation:

$$y_{it} = \alpha_{\mathrm{i}} + \beta_i x_{it} + c_i f_t + \alpha_1 \overline{y}_{it} + \theta_i \overline{x}_{it} + \mu_{it} \tag{5}$$

In Eq. (5), y_{it} and x_{it} are vectors of measurable dependent and independent parameters, correspondingly; β_i denotes the coefficient estimates for each country; The unexamined common factor with the heterogeneous factor is denoted by f_t, while the intercept and error terms are denoted by α_i and μ_{it}, correspondingly. As a result, the CCEMG estimator statistics can be obtained by taking the mean of every coefficient for every individual regression, as shown below:

$$\hat{\beta}_{\mathrm{CCEMG}} = N^{-1} \sum_{i=1}^{N} \hat{\beta}_i \tag{6}$$

In Eq. (6),$\hat{\beta}_i$ can be calculated using the estimation of coefficients in Eq. (5).

Along with understanding the long-run connection between the explanatory variables, it is critical to understand the causal relationships between them. Given the possibility of CSD and heterogeneity in the data, Dumitrescu and Hurlin (2012) created the Dumitrescu–Hurlin (D–H) panel causality test, which is modeled on the Granger (1969) non-causality approach. This method also includes two statistics, namely Wbar statistics and Zbar statistics. The test average statistics are produced by the Wbar statistics, whereas the conventional standard distribution is expressed by the Zbar statistics (Dumitrescu & Hurlin, 2012). Subsequently, the path of causality will help policymakers in the studied countries enforce suitable environmental policies.

Table 1 Unit root test

CO_2	ENE	GLO	GDP	CINT
	At level			
– 2.305	– 0.477	– 1.542	– 1.372	– 2.116
	At first difference			
– 4.944**	– 4.974**	– 4.838**	– 4.240**	– 5.846**
Critical values at	10%	5%	1%	
	– 2.21	– 2.33	– 2.57	

The present study used Pesaran's test of cross-sectional independence, the outcome of Pesaran's test of cross-sectional independence is 2.244 (with probability = 0.024)

**and signify 0.01 level of significance

Table 2 Westerlund cointegration tests

Statistic	Value	*Z*-value	Robust *P*-value
Gt	– 3.589**	– 3.834	0.000
Ga	– 5.498**	1.509	0.000
Pt	– 6.391*	– 1.919	0.028
Pa	– 4.240**	0.628	0.000

**and *signify 0.01 and 0.05 levels of significance, subsequently

3 Results and discussions

The first step in the study is to check the level of stationarity among variables. CSD is the subject of today's environmental economics work in the study of panel data approximations (Ahmad & Zhao, 2018). The conclusions will be misleading if we overlook CSD. Therefore, due to the issue of CSD, we use the CIPS panel unit root test to investigate the integrated level of parameters evaluated for comparability. Table 1 displays the results of the panel unit root test, which show that none of the variables are stationary at level. At the first difference, however, all of the parameters in the series become stationary.

The results of the unit root test help in the execution of Westerlund's recommended second-generation co-integration test. In the situation of cross-independence difficulties, the second-generation test can reveal the co-integration of panel time-series data and finds that the null hypothesis is not co-integrated. The null hypothesis of no co-integration in the model could be rejected, as shown in Table 2. This indicates that the selected variables have a long-run relationship at a 1% and 5% level, respectively, and have a long-run influence on CO_2 emissions.

Table 3 shows the results of AMG and CCEMG estimators, respectively. The energy utilization coefficient is positive but statistically insignificant. The positive impact of energy is derived from fossil resources, and it is frequently known that fossil fuels produce pollution and generate CO_2, all of which increase the pollution level. There is widespread agreement that energy usage has a negative impact on environmental sustainability (Inglesi-Lotz & Dogan, 2018). In this case, one feasible option for combating environmental degradation is to offer financial assistance to organizations that focus

Table 3 Augmented mean group and common correlated effects mean group estimators

	Coef	Std. Err	*z*	*P*>|*z*|	[95% Conf. interval]	
Augmented mean group estimator						
ENE	0.1295284	0.1478715	0.88	0.381	−0.1602945	0.4193512
GLO	0.1866406	0.1752157	1.07	0.287	−0.1567759	0.5300571
GDP	0.2568239**	0.0898861	2.86	0.004	0.0806504	0.4329974
CINT	1.772823**	0.341818	5.19	0.000	1.102872	2.442774
C	−6.020577**	1.715154	−3.51	0.000	−9.382217	−2.658938
Common correlated effects mean group estimator						
ENE	0.2076701	0.1499787	1.38	0.166	−0.0862829	0.501623
GLO	0.3184703	0.1966896	1.62	0.105	−0.0670342	0.7039748
GDP	0.1816902*	0.1021779	1.78	0.025	−0.0185748	0.3819552
CINT	1.769047**	0.3411913	5.18	0.000	1.100324	2.43777
C	2.918375	8.435682	0.35	0.729	−13.61526	19.45201

** and * signify 0.01 and 0.05 levels of significance, subsequently

on inexpensive production through the use of renewable energy. The second alternative option is to adopt policies that raise household understanding of various types of energy consumption and their consequences on environmental sustainability. Therefore, ecological expansion requires enhancing energy efficiency, which can be accomplished through technological advancement. These nations boost their environmental efficiency by employing carbon-free sources of energy, including wind, solar, and nuclear. Governing agencies must acquire renewable technologies; if they cannot manage to do so, extremely energy-intensive industries must be outsourced (Shabir et al., 2021).

Globalization outcomes reveal that it has a positive but statistically insignificant long-term influence on CO_2 emissions, implying that other streams of globalization, such as political, economic, and social globalization, do not help decrease pollution in the studied countries. The rationale for this association is that these countries' social and environmental conservation situations are not durable, as Shahbaz et al. (2017) suggested that social and environmental conservation are requirements for the globalization phase. Another factor could be that industrialization has a greater impact on energy use than globalization, resulting in higher carbon emissions. It is possible that macro policies, such as foreign investment, capital control, and trade, are being implemented due to social and political globalization, which has no consciousness. Furthermore, the benefits of globalization would be limited if operational costs were high. As a result, administrations should take a role in strengthening the economic environment in order to reap the advantages of globalization. These countries must focus on environmental and technological evolution and establish rigorous rules and regulations for highly contaminated sectors that lead to further environmental deterioration. However, these economies must engage in market consolidation with trading counterparts by lowering trade hurdles.

Regarding GDP, the elasticity of GDP displays a significant positive link with CO_2 emissions. It indicates that a 1% increase in GDP is a cause of a 0.2568% augment in CO_2 emissions. This finding is expected considering that countries' economic output develops in synchronism with their energy usage. It is one of the major causes of CO_2 emissions in studied countries. Another possible explanation could be an upsurge in environmental contamination as a result of South European countries' industrial growth, which is connected to the development of infrastructure and economic capitalization, which all have a positive effect on investment and economic operation and therefore boost energy consumption. This revelation should act as a wake-up signal to South European countries' environmental regulators and lawmakers to lessen their emissions levels. Taking GDP into account and its considerable and strong influence on CO_2 emissions validates the findings of Kalmaz and Kirikkaleli (2019) for Turkey, Adebayo and Kirikkaleli (2021) for Japan, Qayyum et al. (2021) for India, and Chunling et al. (2021) for Pakistan, who found a positive association between GDP and environmental degradation.

Regarding CINT, the coefficient of CINT shows a significant positive link with CO_2 emissions. It shows that a 1% boost in CINT is causing a 1.7728% increase in CO_2 emissions. This outcome is consistent with the conclusion of He (2018), who stated that in order to achieve a win–win scenario of economic progress and CO_2 emission mitigation, countries' should make attempts to increase the productivity gain of per unit energy usage and CO_2 emission, which implies dramatically lowering the energy density and CO_2 intensity of GDP. One strategy to lower the CO_2 intensity of GDP is to strive hard to generate clean and renewable energy, increase energy structural transition to a low carbon, and decrease the CO_2 intensity of energy use. The second step is to enhance the technical performance of energy generation, transformation, and usage to fulfill the economic and social progress requirements while consuming the least amount of energy available, like technological energy conservation. Modern energy technology innovations are critical to accomplishing a low-carbon energy system transformation.

Similarly, Table 3 also documents the outcomes of the variables by the CCEMG. As seen in Table 3, the long-term results of the AMG technique are consistent with the results of CCEMG, as the signs for all parameters are alike. Hence, the outcomes from this alternate approach confirm the earlier results achieved utilizing the AMG strategy and enable us to analyze the robustness of long-run outcomes employing diverse measuring techniques.

Moreover, we employed the D-H panel causality test after detecting the long-run effect to determine the causal influences of ENE, GLO, GDP, and CINT on CO_2 emissions. The pattern of causality could assist policymakers in the selected nations in creating appropriate economic approaches in addition to environmental initiatives. The results of the D–H panel causality approach are documented in Table 4. The outcomes disclose that there is bidirectional causality was observed between energy consumption and CO_2 emissions. In contrast, one-way causality runs from globalization to CO_2 emissions and the CO_2 intensity of GDP to CO_2 emissions. However, no causality is detected between economic growth

Table 4 D–H panel causality test

Null hypothesis	*W*-Stat	Zbar-Stat	Prob
ENE does not homogeneously cause CO_2	3.36131**	3.37996	0.0007
CO_2 does not homogeneously cause ENE	2.40603	1.95944	0.5101
GLO does not homogeneously cause CO_2	3.68368**	3.87060	0.0001
CO_2 does not homogeneously cause GLO	0.70388	-0.57100	0.5680
GDP does not homogeneously cause CO_2	4.42240**	4.97171	0.0000
CO_2 does not homogeneously cause GDP	1.56508	0.71267	0.4760
CINT does not homogeneously cause CO_2	3.49083**	3.58315	0.0003
CO_2 does not homogeneously cause CINT	1.23076	0.21435	0.8303

**Signify 0.01 level of significance

and CO_2 emissions. These causal connections between parameters are consistent with the conclusions of recent researchers, i.e. (Salahuddin et al., 2019; Saud et al., 2019; Shujah-ur-Rahman et al., 2019). Figure 1 reports the summary of the main empirical findings.

4 Conclusion

It is critical to encourage energy transformation and a low-carbon economic revolution in order to tackle global climate change and foster sustainable development. Despite previous revolutions that saw firewood substituted by coal and coal replaced by oil and gas, the current energy revolution cannot depend exclusively on market resource deployment. There is an urgent need to replace fossil fuels with innovative and renewable energy sources in order to minimize CO_2 emissions, which will be an international effort to safeguard ecological sustainability. Hence, the government's direction, robust policy actions, and institutional assistance are required. As a result, the present study aims to fill this research vacuum by examining the effect of CO_2 intensity of GDP on CO_2 emissions in South European countries.

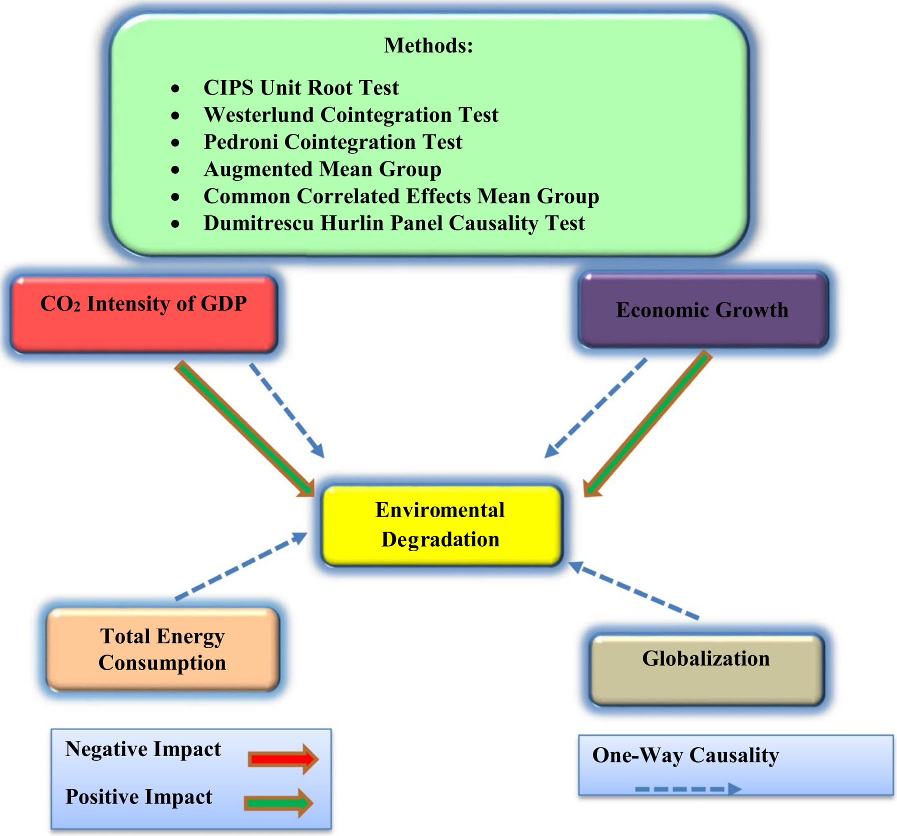

Fig. 1 Methodological framework and findings

This study confirms cross-sectional dependence, stationarity, and co-integration among variables using second-generation econometric approaches. Furthermore, the AMG and CCEMG are used in this work to explore the long-run connection, and the D–H non-Granger panel causality technique is used to establish the causal connection between the parameters. The outcomes of long-run estimations reveal that the CO_2 intensity of GDP and economic growth harms environmental quality. It implies that increasing the CO_2 intensity of GDP and economic progress is dangerous to the atmosphere of South European countries. However, the findings of energy consumption and globalization show a positive but insignificant association with CO_2 emissions. According to the D–H panel causality test results, we found a bidirectional causal connection between energy use and CO_2 and a unidirectional causal link between globalization and CO_2 and CO_2 intensity of GDP and CO_2 emissions.

Based on the research results, the respective policy proposals may be implemented to enhance the quality of the environment of the nations of South Europe. To begin, South European economies could accelerate low-carbon economic growth by implementing a variety of low-carbon techniques to form energy and resource-efficient markets. Increasing investment in attainable low-carbon initiatives. Establishing an adequate business climate necessitates the continuous use of various economic, societal, institutional, and diplomatic tools. Second, other facets of low-carbon economic advancement that are sustainable include increased manufacturing through resource preservation, energy efficiency, and renewable energy extraction. Furthermore, by bringing novel approaches to cost-effective decarbonization, South European nations can promote economic growth. Finally, the policymakers of South European countries must exercise caution when enacting initiatives that promote growth at the expense of environmental sustainability. South European policymakers should enact stricter environmental legislation in order to mitigate the effects of environmental destruction as the nation grows progressively.

Although the current work offers excellent results, additional research should be conducted using diverse environmental sustainability factors, like urbanization, trade, industrialization, population, and many more. Furthermore, as this research employed CO_2 as a proxy for environmental deterioration, future studies must explore other indicators for environmental quality.

Funding We also confirmed that this research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of data and materials The data that support the findings of this study are available from the World Bank.

Declarations

Conflict of interest The authors declares no competing interests.

Ethical approval We confirmed that this manuscript has not been published elsewhere and is not under consideration by another journal. Ethical approval and Informed consent do not apply to this study.

Consent to publication Not applicable.

Consent to participate Not applicable.

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