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Research paper

Beyond environmental Kuznets curve and policy implications to promote sustainable development in Mediterranean

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ABSTRACT

In acknowledgment of the devastating consequences of environmental deterioration, the Mediterranean members are committed to adopt the 2015 treaty action plans of the Paris Climate Agreement (COP21) as carbon dioxide emission (CO_2) are on the rise in the Mediterranean region, which seems to be a serious challenge to our world's environment. To this end, our study examined the impact of Foreign Direct Investment (FDI) on environmental degradation for the Mediterranean members for the period between 1995 to 2016. However, variables such as, financial development, economic growth, renewable energy and fossil fuel were further examined by the use cross-sectional-Panel pooled Auto Regressive Distributed Lag methodology, Augmented Mean Group (AMG) and Dumitrescu and Hurlin panel causality test was used for causality analysis. The co-integration results from Westerlund (2007) shows a long-run equilibrium relationship between highlighted variables. The empirical result revealed a negative relation between FDI and CO_2 indicating pollutant Hallo Hypothesis (PHH). Moreover, income and its square show an inverted U-Shaped curve indicating environmental Kuznets curve (EKC) hypothesis. Both financial development and renewable energy indicated an adverse association with CO_2 emission whereas fossil fuel had a positive relationship with emissions. However, there was a feedback causality among income and carbon emission as well as financial development and carbon emission. Furthermore, we observe that FDI and carbon emission, renewable energy and carbon emission, as well as fossil fuel and carbon emission were found to have one-way causal relationship. Overall, the study suggests some policy prescriptions including the implementation of conservation initiatives and the establishment of clean energy regulation and strategies for the investigated bloc.

1. Introduction

People's living conditions have changed as a consequence of global economic development in a number of areas, including technological advancements, enhanced life expectancy, higher per capita income, and greater access to education (Adebayo and Kirikkaleli, 2021; Agyekum, 2020; Agyekum et al., 2021). Increased economic activity, on the other hand, has some detrimental implications, including hardship in some countries, habitat lost, environmental destruction and deforestation, global warming, and climate change. Nations' efforts to achieve accelerated economic development also resulted in a drastic rise in CO_2 across the world. Nations also neglected the detrimental environmental implications of this process in order to achieve economic expansion. As a result of this negligence, CO_2 have grown over time (Alola et al., 2019; Adebayo, 2020; Olanrewaju et al., 2021; Zhang et al., 2020; Ramezani et al., 2020). Severe weather disasters, increasing water levels, diminishing Arctic sea ice, and other

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shifts are now being felt as a consequence of global warming. If existing emissions trends persist, global warming will reach the 1.5 °C limit between 2030 and 2052. It is believed that global warming of more than 1.5 °C would result in long-term and permanent shifts, such as habitat loss (IPCC, 2018).

Over the years, several scholars have highlighted different factors that influence environmental degradation such as economic growth, globalization, renewable energy consumption, fossil fuel, financial development, energy utilization, and foreign direct investment among many others (Yuping et al., 2021; Adebayo and Odugbesan, 2020; Bekun et al., 2021a; Kihombo et al., 2021; Shan et al., 2021). Foreign direct investment inflows (FDI) have been highlighted by scholars has one of the determinants of environmental degradation and it has grown significantly in the last 50 years, owing to trade liberalization and economic globalization. For instance, it is commonly assumed that FDIs are one of the tools for minimizing global pressures for rising utilization of energy since they allow for technical transition between nations for long-term development. FDIs have been criticized for their environmental implications, including their inspiration. Scholars also proposed that multinational corporations (MNCs) in developed nations are more likely to subcontract "dirty" sectors to developing nations with less stringent environmental controls in order to benefit from the lack of/low negative externality costs. Over the years studies have been conducted to assess the interrelationship between FDI and CO_2 emissions; however, findings are mixed. For instance, some scholars found negative FDI–CO_2 association (e.g., Ahmad et al., 2021a; Kisswani and Zaitouni, 2021; Liu and Xu, 2021). The positive FDI–CO_2 association validates the pollution haven hypothesis. On the flipside, some studies also established positive FDI–CO_2 interconnection (e.g., Xu et al., 2021; An et al., 2021; Mukhtarov et al., 2021; Gong et al., 2021). The negative FDI–CO_2 interrelation validates the pollution halo hypothesis.

Moreover, over the last two decades, significant discussion has surfaced over the rapid renewable energy development and its influence on environmental quality and economic growth (Bekun et al., 2021b; Adebayo and Kirikkaleli, 2021; Soylu et al., 2021; Sarkodie et al., 2021; Udemba et al., 2021). In terms of climate change, renewable energy sources utilization has been thought to have a major impact on sustainability of the environment by mitigating the level of GHGs emissions (Solarin et al., 2017; Kirikkaleli and Adebayo, 2020; Yuping et al., 2021). Moreover, as noted by the Shahbaz et al. (2021), investment in renewable energy sources is often seen to be less carbon-intensive than traditional energy. As a result, by supporting the use of sustainable energy, nations may improve environmental sustainability and build a globally sustainable and safe environment.

Regarding the financial development-emissions association, several research claim that FD increases CO_2. For instance, the studies of Odugbesan and Adebayo (2021) for South Africa, Oluwajana et al. (2021) and He et al. (2020) established positive FD–CO_2 interrelationship. However, some empirical works also support the claim that FD contributes to mitigating CO_2 levels. For instance, the study of Kirikkaleli and Adebayo (2020) for global economy between 1965 and 2018 established negative FD–CO_2 interrelationship. Similarly, the studies of Kihombo et al. (2021) for West Asia and Middle East nations and Ramzan et al. (2021) for Latin American countries unveiled a negative FD–CO_2 association. In addition to these inconclusive outcomes, there are scant studies conducted on Mediterranean region regarding this interrelationship. As a result, it is critical to investigate the effects of FD on CO_2 since it can play a critical role in CO_2 reduction.

Why Mediterranean region? The Mediterranean region has a vast potential for green energy (solar and wind). Besides that, the mix of electricity generation is already driven by fossil fuels, and the use of green energy is under-exploited. Nevertheless, attempts have recently been made and the Mediterranean countries have sought to incorporate diverse actions and policies to address environmental and energy issues and develop green energy. Such initiatives include Mediterranean Solar Plan (MSP), Renewable Energy Solution for the Mediterranean (RES4MED), and Strategy for Sustainable Development (MSSD). The selection of Mediterranean countries is inspired by the fact that no prior study assesses the effect of financial expansion, economic expansion, renewable energy, and fossil fuel on CO_2 emissions in Mediterranean economies.

Based on the interesting facts about the Mediterranean region and mixed findings from prior studies, the present research aims to explore the FD–CO_2 interrelationship in Mediterranean countries (MCs). The existence of a positive FDI–CO_2 interconnection poses the issue whether MCs serve as emissions shelters. On the other hand, a negative FDI–CO_2 association would imply that FDI promotes technological transition for sustainable growth. Therefore, this research sheds light on the interrelationship between CO_2 and FDI, renewable energy, and fossil fuel. The research can also offer concepts on the design and execution of potential energy and economic initiatives in the region. In order to establish the research objectives, the following research questions are proposed: (1) Can Foreign Direct Investment help in environmental sustainability in the Mediterranean countries? (2) Is there an association between economic expansion and environmental degradation in this region? (3) Does energy usage contribute to environmental emissions?; and (4) Do financial development and renewable energy utilization contribute to sustainability in the Mediterranean countries?

The present paper contributes to ongoing research in the following ways: Firstly, We utilized the Mediterranean region as a case study which few studies have been conducted on. The Mediterranean area is being challenged with growing globalization processes as well as rising energy usage, creating a significant concern in terms of environmental sustainability. As a consequence, the new research will assist policymakers pursue more realistic planning and decision-making related to environmental mitigation in general, and specifically in the Mediterranean area. Secondly, the paper employed an innovative panel data estimate technique to address the concerns of CSD and heterogeneity. Moreover, the current study adds by employing a unique CS-ARDL model to address the concerns of heterogeneity and CSD in panel data, which have been overlooked in earlier studies.

The next section presents the summary of studies conducted which is accompanied by research data and method in Section 3. The discussions and findings are presented in Section 4 while Section 5 presents the conclusion and policy suggestions.

2. Literature review

This section of the analysis are separated into two distinct parts. The first part discusses the theoretical framework of the study while the empirical review section discusses prior examination led regarding the influence of FDI inflows, economic advancement, financial development, fossil fuel and renewable energy intake on CO_2 pollution.

2.1. Theoretical framework

The pollution haven hypothesis and the pollution halo hypothesis are the most often used theories utilized to explain the association between FDI and environmental pollution. MNCs are forced to move their heavy or filthy factories to nations with advance lenient environmental laws in a way to minimize supervisory enforcement costs in their home region, according to the theory (Nathaniel et al., 2020). The incentive to globally migrate emission outputs to developing areas, according to Copeland and Taylor (1994), stems from the desire to reduce both financial and environmental costs in industrialized nations. Around the same time, in order to bring FDIs, developing nations are forced to undermine one another by decreasing the stringency of their environmental standards. These situations would culminate in a "race to the bottom" of industrialized economies, with looser guidelines. This would lead to a large rise in emissions in nations that do not have strict environmental regulations.

Grossman and Krueger (1991) described three pathways in which FDI affects emission, including the scale effect. If the composition and scale effects exceed the technique impact, the pollution haven hypothesis is supported (PHH). The pollution halo hypothesis is the exact opposite of the pollution haven hypothesis, in which the technique and composition impacts outweigh the scale effect. According to the scale effect, a rise in FDI supports economic growth while having adverse environmental consequences. The composition effect, which stresses the mechanism by which FDI affects the composition of industries and leaves the possibility to increase environmentally harmful or less polluting sectors, is the second phenomenon. According to Grossman and Krueger (1991), this process may have either favorable or unfavorable environmental consequences. The third phase is the technique effect, which means that FDI can result in pollution-reducing technological transitions as well as positive spillover to local businesses. According to the halo effect, FDI will help to reduce environmental destruction in the host nation. According to the concept of technology diffusion, this is accomplished as multinational corporations (MNCs) pass their greener technology to developing markets by FDI. One of the reasons for this is that MNCs can indicate ineffective manufacturing methods, which can lead to a long-term loss of credibility, business and prestige.

2.2. Empirical review

This section of the research tends to shed light on the interconnection regarding CO_2 pollution and FDI, economic enlargement, financial development, clean energy use and fossil fuel which is utilized as a proxy for energy intake. The reviewed studies are centered on both time-series and panel data analysis. The associations between the aforementioned variables have been examined by prior scholars; however, their findings are mixed. These mixed findings are based on the techniques used, country(ies) of study, methodology(ies) and period of study.

2.2.1. Economic growth, energy consumption and CO_2 emissions

The study of Adebayo (2020) on the association regarding CO_2 emission, energy utilization and GDP in Mexico between 1971 and 2016 disclosed that both energy utilization and economic expansion are positively connected with a rise in environmental degradation. Moreover, the wavelet coherence test uncovers a positive correlation regarding CO_2 and GDP, and between CO_2 end energy use while there is evidence of one-way causality from GDP and energy use to CO_2 emissions. Likewise, in Thailand, Olanrewaju et al. (2021) observed the connection regarding CO_2, GDP and energy usage between 1971 and 2016 using the novel wavelet coherence and ARDL technique. The empirical findings from this study uncovered that both GDP growth and energy usage impact CO_2 emission positively in the long-run and short-run which indicates that GDP growth harm the ecosystem. In Malaysia, Zhang et al. (2021) assessed the linkage among CO_2 pollutions and GDP utilizing ARDL and Gradual shift causality tests between 1970 and 2018. The outcomes from their study disclosed that real growth increases environmental degradation. Also, there is evidence of unidirectional causality from GDP to CO_2 which infers that GDPP can predict CO_2 pollutions in Malaysia.

In Thailand, utilizing the wavelet tools, Akinsola and Adebayo (2021) examined the GDP-Energy-CO_2 association and the outcomes uncovered an affirmative correlation regarding GDP, CO_2 pollutions and between energy use and CO_2 emissions which demonstrates that CO_2 emissions and energy use and GDP move together. In addition, the Toda–Yamamoto causality test discloses one-way causality from GDP and energy utilization to CO_2 emissions in Thailand. Furthermore, the study of Odugbesan and Rjoub using the MINT economies uncovered one-way causality from energy use and GDP growth to CO_2 emissions. Likewise, Awosusi et al. (2021) examined the GDP–CO_2 emissions association in South Korea using data spanning from 1965 to 2019 and using ARDL approach. The outcomes from their study disclose positive interconnection between CO_2 emissions and GDP and also one-way causality from GDP to CO_2.

2.2.2. FDI inflows and CO_2 emissions

Using selected 18 Latin American countries, Blanco et al. (2013) examined FDI–CO_2 connection between 1980 and 2007. To establish the research objectives, the investigators used panel Granger causality test and the outcomes disclose one-way causality running from FDI to CO_2 pollutions in the selected countries. Omiri et al. (2014) explored the dynamics between FDI and CO_2 pollutions in 54 nations over the duration of 1990–2011 utilizing panel techniques and established feedback causal linkage between CO_2 emissions and FDI. Using data stretching from 1974–2010, Gökmenoğlu and Taspinar (2016) evaluate the effect of FDI on environmental degradation in Turkey. The authors used ARDL and Toda–Yamamoto causality tests to ascertain this connection and the findings disclose that FDI inflows exert a positive effect on CO_2 pollution which illustrates that a rise in FDI harm the sustainability of the environment. Furthermore, there is reveals of two-way causality among FDI and CO_2 emissions. Moreover, He et al. (2020) observed the FDI–CO_2 interconnection using the bootstrap ARDL test in BRICS nations and the outcomes disclose that FDI and CO_2 pollution are connected positively implying that FDI harm the sustainability of the environment in the BRICS nations.

From a different point of view, the investigation of Ahmad et al. (2021b) on the FDI–CO_2 association in OECD economies from the period 1990 to 2014 disclosed that FDI–CO_2 association is negative and statistically significant which gives room for the support of the Pollution Halo Hypothesis in the OECD nation. Adeel-Farooq et al. (2021) in their study on the interconnection regarding FDI inflows and pollutions, uncovered that FDI inflows exert a significant and detrimental impact on the sustainability of the environment in developing countries while FDI inflows improve the sustainability of the environment in advanced economies. Essandoh et al. (2020) assessed the association between CO_2 and FDI in 52 developed and developing countries from the period 1991–2014. The investigators' utilized PMG-ARDL test and the findings uncovered that FDI inflows increase environmental degradation in emerging nations while FDI inflows decrease environmental degradation in advanced economies. Furthermore, the study of Haug and Ucal (2019) using nonlinear techniques assesses the linkage between FDI and CO_2 emissions in Turkey between 1975 and 2014. The investigators found an insignificant connection between FDI and CO_2 emissions.

2.2.3. Financial development and CO_2 emissions

Kirikkaleli and Adebayo (2020) examined the association among CO_2 pollutions and financial development using global data spanning from 1980 to 2017. They utilized the FMOLS, DOLS and frequency domain causality tests to capture this linkage and the finding discloses that financial development and CO_2 emissions are positively connection implying that financial development enhances the sustainability of the environment. Likewise using the dual adjustment, FMOLS, ARDL and frequency domain tests, He et al. (2020) evaluated the effect of financial development on CO_2 emissions in Mexico between 1990 and 2018. The outcomes of the dual adjustment approach uncover a long-run association between the variables whereas the causality technique indicated one-way causality from financial development to CO_2 emission at different frequencies. In South-Africa, Oluwajana et al. (2021) assessed the connection between CO_2 and financial development using data stretching from 1980 and 2017 and recent econometric techniques. The outcomes from this study shown an adverse connection regarding financial development and CO_2 which infers that financial enlargement curbs environmental degradation in South Africa. On the other hand, the study of Wang et al. (2020a) using CS-ARDL in G7 countries also uncovered that financial development exerts a positive impact on CO_2 pollution which signifies that a raised in financial development decreases the sustainability of the environs. Likewise, the study of Shoaib et al. (2020), in G8 and D8 countries between 1999 and 2013 disclosed that financial development has a harmful effect on sustainability of the environment in both G8 and D8 countries.

2.2.4. Renewable energy consumption and CO_2 emissions

Using the novel wavelet technique, Adebayo and Kirikkaleli (2021) assessed the linkage among CO_2 pollutions and clean energy usage between 1990 and 2015. The outcomes from their study uncovered that renewable energy usage decreases environmental degradation. Likewise, the study of Adebayo (2021) using the Asia and Pacific region as a case study established that clean energy exerts an adverse effect on CO_2 pollution. Leitão and Lorente (2020) examined the dynamics among CO_2 and clean energy in European Union (EU-28) using the FMOLS, DOLS, GMM and Dumitrescu–Hurlin causality tests. The outcomes uncover that clean energy use mitigates CO_2 pollutions and the causality test uncovers one-way causal connection from renewable energy to CO_2 pollution. In India, Kirikkaleli and Adebayo (2021) assessed the association between CO_2 and green energy using FMOLS and DOLS and the outcomes show that renewable energy usage enhances sustainability of the environment. The research of Khattak et al. (2020) in BRICS between 1980 and 2016 uncovered that renewable energy use enhances sustainability of the environment in the BRICS economies. Likewise, the investigation of Jebli et al. (2020) also disclosed that clean energy use exerts a negatively significant effect on CO_2 pollution.

3. Data and methods

This study utilized a panel data of countries from the Mediterranean area (list of countries in appendix section) starting from 1995 to 2016 with data from the World Bank development database indicator (WDI, 2020). According to Baltagi et al. (2005), that alluded to the fact that panel data approach provides superior and more robust findings outcomes to conventional time series studies, given that panel studies is a combination of both time series and cross-sectional dimension of data. The choice of the period for the investigation was guided by and limited to the accessibility of data on the countries as we provide a summary of the description of the variables in Table 1.

Carbon dioxide emissions per capita (CO_2): This variable is used as the dependent variable in the model as the proxy for the environment. The unit for measuring carbon pollutions is metric tons per capita. The a priority expectation of this variable can either be positive or negative. A positive change in carbon dioxide emissions would suggest environmental degradation whereas the negative change indicates environmental sustainability.

Income (Y): This variable is utilized as the explanatory to proxy for economic advancement across the countries under consideration. The income values are transformed from the local currencies to the United States by applying the current exchange rate. A positive change in the income values of the panel countries would indicate economic growth and vice versa.

Square of Income (Y^2): This variable is utilized as the explanatory to proxy for square o economic growth across the countries under consideration. The income values are transformed from the local currencies to the United States by applying the current exchange rate. A positive change in the square of income values of the panel countries would indicate an inverted U-Shaped curve.

Renewable energy (R): This is one of the explanatory variables in the model that is proxied for a renewable source of energy as well as a control variable in the model. Renewable energy consumption is a composition of all the renewables namely: Solar, Wind, Hydro, Tidal, Geothermal, and Biomass energies.

Fossil Fuel (FF): This is one of the explanatory variables in the model that is proxied for a non-renewable source of energy as well as a control variable in the model. Fossil Fuel of energy consumption is a composition of the following products namely: natural gas, oil, coal, and petroleum. A positive change in the fossil fuel value with regards to a priori expectation would imply a detrimental effect on the environmental sustainability of the panel countries and vice versa.

Foreign Direct Investment (FDI): This variable is used as the independent variable to proxy for overseas investment across the countries under consideration. Foreign Direct Investment is the net injection of investment opportunity running in an economy apart from the investor to gain permanent management interest (10 percent or more vote equity). It is the amount of equity capital, earnings reinvestment, long-term capital and short-term capital as indicated in the balance of trade. This sequence presents net inflows of foreign investors into the accounting economies (new investment inflows less disinvestment), and it is separated by GDP. A positive change in the FDI value with regards to a priori expectation would imply pollutant Haven Hypothesis whiles negative change will be Pollutant Hallo Hypothesis or the panel countries.

Financial Development (FD): This variable is used as the independent variable to proxy for credit to private sectors across the countries under consideration. Domestic credit of banks to the private sector corresponds of financial capital supplied to the private industry by other depositary companies, including loans, non-equity securities purchases, trade credits and other accrued liabilities which assert the repayment of a debt. These statements include loans to public companies for certain countries. A positive change in the financial development value with regards to a priori expectation would imply a detrimental effect on the environmental sustainability of the panel countries and vice versa.

Nevertheless, the descriptive statistics as well as correlation matrix are shown in table two below. The outcome reveals that, income has the highest mean, minimum and maximum of 9.19 million dollars per year, 6.7687 million dollars per year and 10.6487 million dollars per year respectively whiles, carbon emission has the least mean, minimum, and maximum values of −0.8962 metric tons per year, −2.2409 metric tons per year and 0.3202 metric tons per year respectively. Moreover, all the variables have a negative skewness value expect carbon emission. However, all the variables have a negative significant correlation

Table 1
Description of Variables.

Name of Indicator	Abbreviation	Proxy/Scale of Measurement	Source
Carbon dioxide emissions per capita	CO_2	measured in metric tonnes	WDI
Income	Y	it is proxied by the gross domestic product per capita (2010 Constant USD)	WDI
Square of Income	Y^2	it measures the square of GDP per capita	WDI
Renewable Energy Consumption	REC	% of total final energy consumption	WDI
Fossil fuel	FF	Fossil fuel energy consumption (% of total)	WDI
Foreign Direct Investment	FDI	net inflows (% of GDP)	WDI
Financial Development	FD	Domestic credit to private sector by banks (% of GDP)	WDI

NOTE: all variables are transformed to their natural logarithm form to ensure homoscedasticity of the coefficients except FDI.

with the dependent variable (carbon emission) except FDI which has a positive insignificant correlation with CO_2 emission and fossil fuel which has significant connection with the dependent variable (see Table 2).

Eq. (1) presents the model subject of our analysis, firstly in a functional form:

$$CO_2 = f(FDI, Y, FD, REC, FF) \quad (1)$$

The continuous stochastic form of the connection regarding the depletion of the environment, income, foreign direct investment, financial development, renewable energy intake and fossil fuel as Eq. (2):

$$CO_{2i,t} = \beta_0 + \beta_1 FDI_{i,t} + \beta_2 Y_{i,t} + \beta_3 FD_{i,t} + \beta_4 REC_{i,t} + \beta_5 FF_{i,t} + \varepsilon_{i,t} \quad (2)$$

Given that i and t signify the cross-sectional and time units of the study (1995–2016) as mentioned earlier, whereas ϵ captures the error term. Readers are referred to Table 1 for the explanation of other variables as presented earlier. Next, we add the square form of income to help in the estimation of the EKC which shows the inverted U-shaped connection as reported in the Eq. (3):

$$CO_{2i,t} = \beta_0 + \beta_1 FDI_{i,t} + \beta_2 Y_{i,t} + \beta_4 Y_{i,t}^2 + \beta_3 FD_{i,t} \beta_4 REC_{i,t} + \beta_5 FF_{i,t} + \varepsilon_{i,t} \quad (3)$$

where FDI, Y, Y^2, FD, REC and FF represent foreign direct investment, income, square of income, financial development, renewable energy intake and fossil fuel, respectively.

3.1. Technique for the analysis

In order to test the influence of independent variables on the dependent variable, the authors used Pesaran and Shin (1998) the cross-section ARDL model. This approach has been chosen because our smaller sample size is a feasible choice. Furthermore, it is able to provide long-term and short-term balance relations while simultaneously correcting the connected prediction errors. For this analysis, it is rational to use this method because the findings of this cross-sectional analysis are suitable for estimating long term correlations on panels' complex in nature with heterogeneity. Moreover, vis-a-vis the ARDL process, the CS-ARDL approach provides a structured form of approximation that makes it possible to recognize models that are not defined, but also errors and elements that are serially associated. This technique is successfully used by Chudik et al. (2016) in conditions where the T is not too large. The T for this analysis is not high and should therefore be used with CS-ARDL to achieve its objectives. If the parameters have mixed order of integration characteristics at I(0) or [I(1)], this model is most useful for cointegration evaluation. Estimates were rough made using several techniques. To confirm the research on Wang et al. (2020b), we used the Pesaran (2007) and IPS Im et al. (2003) developed CIPS to test a unit root so that variables assumptions were not unauthentic. Second, through a co-integration experiment in Westerlund (2007) including the presence of cross-dependence, a probability for long-run stability interactions was established. The authors used the ARDL (CS-ARDL) approach for estimating long-term relations between the variables, as the variables turned out to be co-incorporated. The Augmented Mean Group (AMG) was utilized to assess the sensitivity of the long-lasting balance relationship that was proposed by Eberhardt (2012). The methodology includes problems including endogeneity, heterogeneity, cross-sectional reliance, and unequal measurement times. These methodologies are useful because their cross-sectional measures and their specified independent variable can be improved by the less-quadratic approach applied for auxiliary projections. This method demonstrates the attributes of the model being logarithmically distributed (Pesaran, 2006). The main advantage of this research is that the sample dimensions of the dataset, however, are small and complex.

4. Empirical results

4.1. Cross-section dependency (CD) test

Unlike the widely used traditional econometric method, this study relies on the analytical research. It is necessary to take into account all the potential issues, before performing any unit root technique, cointegration tests, and long-run estimation. Hence, this analysis first established a regression equation that checked for homogeneity in the cross-section results. Disregarding what is defined in the long-time panel dataset will tip to improper assessment consequences (Gyamfi et al., 2021a; Adedoyin et al., 2021). This idea is the reason why we tested for cross-sectional dependency by utilizing the Pesaran (2015) LM test, Pesaran (2007) CD test, and the Breusch and Pagan (1980) Lagrangian Multiplier test. Issues presented by cross-sectional dependence are of concern due to the growing convergence of the global economy. Many nations are less independent of one another and have a greater vulnerability to related shocks (Hao et al., 2021; Su et al., 2020). These various states have different economies and policies, presuming that homogeneity can lead to misleading outcomes. The research evaluated the hypotheses that the cross-sectional dependency hypothesis was correct and that was valid. Outcomes in Table 3 demonstrate that from the Pesaran (2015) LM, Pesaran (2007) CD, and the Breusch–Pagan LM (1980) dependency measures, the freedom of the cross-sections is indorsed by the null assumption. Hence, all the variables are dependent on each other over time. The findings from the CD test are the basis for the new approaches used for the regression analysis.

4.2. Stationarity test

When the findings showed that the panel figures were cross-based, stationarity estimations of the second generation were unacceptable to fail to refute the null hypothesis where first-generation estimations were also run for robustness check. Thus, it became necessary to incorporate a unit root technique to resolve the cross-sectional dependence problem. Then the IPS and CIPS methods were used to help decide if a model has a unit root. Using this method, it was easier to evaluate the incorporation

Table 2
Descriptive statistics and correlation matrix analysis.

	CO_2	FDI	Y	FD	REC	FF
Mean	−0.8962	0.6887	9.1939	3.8931	2.2331	4.4168
Median	−0.9755	0.7388	9.3018	4.0015	2.4726	4.4767
Maximum	0.3202	5.6352	10.6487	5.5420	4.0245	4.6049
Minimum	−2.2409	−12.942	6.7687	1.1808	−3.8029	3.7244
Std. Dev.	0.5918	1.6576	1.1001	0.8238	1.1901	0.1947
Skewness	0.0451	−2.2444	−0.1484	−1.0062	−2.0030	−1.5894
Kurtosis	2.2617	21.376	1.4226	4.5103	8.2547	4.7429
Jarque–Bera	7.0988**	4592.171*	33.0618*	81.253*	560.3125*	168.6675*
Probability	(0.0287)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	308	308	308	308	308	308
LCO_2	1					
FDI	0.0124	1				
LY	−0.8458*	−0.0348	1			
LFD	−0.4651*	0.2636*	0.6262*	1		
LREC	−0.1630*	0.2077*	−0.0635	0.1758*	1	
LFF	0.4958*	−0.0954***	−0.1137**	0.0747	−0.4861*	1

NOTE: Authors computation: *<0.01, **<0.05, ***<0.10.

Table 3
Cross-sectional dependency (CD) estimation outcome.

Model	Pesaran (2007) CD Test	Pesaran (2015) LM Test	Breusch and Pagan (1980) LM Test
LCO_2 = f(LY,LY^2, FDI, LFD, LREC, LFF)	1.330*	−1.475**	1867.65*
p-value	(0.0034)	(0.040)	(0.0000)

NOTE: Authors computation: *<0.01, **<0.05, ***<0.10.

Table 4
Unit Root estimation.

Variables	CIPS				IPS			
	I(0)		I(1)		I(0)		I(1)	
	C	C&T	C	C&T	C	C&T	C	C&T
LCO_2	−2.221	−2.660	−5.185*	−5.264*	−0.861	0.391	−5.868*	−6.210*
LY	−1.324	−2.561	−3.713*	−3.930*	−1.767	−1.381	−4.416*	−4.331*
LY^2	−2.141	−2.162	−3.823*	−4.910*	−1.749	0.122	−5.775*	−6.097*
FDI	−3.706	−3.993	−5.344*	−5.429*	−2.495	−2.726	−7.484*	−7.397*
LFD	−2.217	−2.305	−3.626*	−3.815*	−1.336	−1.396	−3.550*	−3.803*
LREC	−0.509	−1.735	−4.008*	−4.643*	−0.369	−1.585	−4.273*	−4.841*
LFF	−2.848	−2.109	−5.244*	−5.340*	−0.987	−2.988	−5.926*	−5.890*

NOTE: Authors computation: *<0.01, **<0.05, ***<0.10.

of all parameters. These methods are suitable since they can detect heterogeneity within and between panels even though it is recognized as a very necessary or significant technique for the evaluation of the generation of the second order in panel research. The basic configuration of CIPS is as indicated in Eq. (4).

$$\Delta CA_{i,t} = \Phi_i + \Phi_i Z_{i,t-1} + \Phi_i CA_{\overline{it}-1} + \sum_{1=0}^{p} \Phi il \Delta CA_{t-1} + \sum_{i=0}^{p} \Phi il \Delta CA_{i,t1} + \mu_{it} \tag{4}$$

Whereas $CA_{\overline{it}-1}$ and $\Delta CA_{i,t1}$ denote cross-section average. The CIPS statistic is also shown below as:

$$CIPS_{2007} = N^{-1} \sum_{1=0}^{n} CDF \tag{5}$$

where, CDF is cross-sectional augmented Dickey–Fuller (CADF) given in Eq. (5).

Such methods are preferred to offer us the ability to answer the problem of weak–strength produced in a pseudo-stationary collection of data and to benefit from the additional information provided in the check outcomes by a joint cross-sectional time series for intensity. In Table 3 the findings confirm that the parameters have integration of Series one, so the results are similar.it revealed that all the variables are significant at first difference, for instance, CO_2, is identified to be stationary at position [I(1)] underneath the heterogeneity alteration system. As seen in Table 4, it showed that all the parameters were stationary at first difference indicating that the factors were suitable for study and that the effects could be used to make decision assessments.

Table 5
Westerlund (2007) Cointegration Test.

Statistics	Value	p-value
$G\tau$	−1.203*	(0.000)
$G\alpha$	−2.948*	(0.000)
$P\tau$	−3.754*	(0.006)
$P\alpha$	−2.945*	(0.000)

NOTE: Authors computation: *<0.01, **<0.05, ***<0.10.

4.3. Cointegration test results

Determining that the second-generation co-integration model is more suitable for this data necessitated the use of the proposed approach by Westerlund (2007). The second-generation time series model is sensitive enough to detect co-integration even with cross-dependence estimation problems and finds that there is no involvement of association as stated by the null assumption. The numerically represented findings from Table 5 show that the null statement must be dismissed. The results seen are long-run in nature in that they can affect the dependent factor in the long run. It says that the factors are strongly correlated with portfolio output at the 1 percent and 5 percent significant stages, and there is a long-run impact on portfolio creativity.

4.4. Long-run and short-run relationship

The investigation outcomes for the ARDL (CS-ARDL) cross-sectional technique are given in Table 6 below. Test results of the CS-ARDL equation is presented in Eq. (6).

$$\Delta TI_{i,t} = \pi_i + \sum_{i=0}^{p} \pi_{i1} \Delta TI_{i,t-1} + \sum_{i=0}^{p} \pi_{i1} AEV_{i,t-1} + \sum_{i=0}^{p} \pi_{i1} z_{i,t-1} + \mu_{it} \quad (6)$$

The cross-section averages are indicated by $Z_t = (\Delta TI_t, AEV_t)$. Where AEV_t represent the independent factors in the form of foreign direct investment, income and its square, financial development, clean energy as well as fossil fuel and Z_t represent the dependent variable CO_2 emission. Analysis from Table 6 below shows that, there is a negatively significant association regarding FDI and carbon pollution. This outcome implies that, FDI inflow in the Mediterranean countries are utilized in a way that decreases environmental degradation in the long run which is in line with the findings of Shao et al. (2019) and Jiang et al. (2018) but contrary to the findings of Assamoi et al. (2020), Sapkota and Bastola (2017) and Yang et al. (2018). However, the findings confirmed a pollutant hallo which is good for the Mediterranean countries.

We then observe a positive and negative sign for income and the square of income along with statistical significance at 1% significant level. This is an indication of an inverse U-shaped connection regarding these variables under review. The result of a positive and significant impact of income on carbon pollution and the negative and significant values of income per capita square support the EKC concept. The presence of EKC affirms the findings of Sarkodie and Adams (2018), Erdogan et al. (2020) as well as Bekun et al. (2021c). From the result, it can be seen that the EKC system functions correctly, and economic progress can worsen climate factors at the initial phase of manufacture. Since shifting through the turning point of income class, environmental emissions starts to decrease with continued economic growth. This outcome however confirms the inverted U-Shaped curve regarding income and carbon emission.

Similar to FDI, financial development which is credit to the private sector also have negatively significant relationship with carbon emission in the long run. This indicate that the Mediterranean nations are investing much of their financial development into areas where pollution production is less i.e., companies or firms which utilized much clean energy and advance technology. This finding confirms that of Tamazian et al. (2009) and Shahbaz et al. (2013) but not in supportive of Jiang and Xiaoxin (2019) as well as Wang et al. (2020a).

Moreover, a negative with significant at 5 percent level relationship is established between renewable and environment. It has been found that transition to more conservative (renewable) sources of energy guarantees better of environment irrespective of the location of the economy. This aligns with the outcomes of (Dong et al., 2017; Sebri and Ben-Salha, 2014).

Furthermore, result from the technique shows that fossil fuel exert a positive and significantly effect on pollution. The outcome shows that, a percentage change in fossil fuel intake increases pollution 2.2926% and affirms the findings of Gyamfi et al. (2020b) and Sarkodie and Adams (2018). The fossil fuel-led pollution may be due to the distribution and reliance on nonrenewable energy demand around the surveyed nations. Per the WDI (2019), the average portion of nonrenewable energy in the energy mix of the surveyed nations was 67.93 percent, whereas the share of clean energy usage was averaged at 32.07 percent in the overall energy usage. Thus further, the dominance of nonrenewable energy usage with little to no renewable contribution is an aspect of the main obstacles of ecological protection. Consequently, an aspect of the key strategy ramifications as well as consideration on the ways of increasing healthy environment and by decrease nonrenewable energy usage which hinder economic growth within the surveyed nations (see Fig. 1).

From the short run, the error correction of the estimation (ECM) expectedly came out to be negative and significant. FDI from a different view has a negatively significant relation with carbon emission whiles square of income has positively significant connection with carbon emission.

Lastly, the results from the AMG which is used as a sensitivity check are reliable with the out of the CS-ARDL long-run result (see Table 7).

Table 6
CS-ARDL technique.

Variables	Coefficient	STD. Error	P-value
FDI	−0.0029*	[0.0018]	(0.0058)
LY	0.1275*	[0.0377]	(0.0000)
LY^2	−3.10e*	[4.92e-]	(0.0002)
LFD	−0.0613**	[0.0172]	(0.0015)
LREC	−0.0076**	[0.0242]	(0.0200)
LFF	2.2926*	[0.1048]	(0.0000)
Short Run			
ECM-1	−0.4635*	[0.0985]	(0.0000)
FDI	−0.004161**	[0.0034]	(0.0261)
LY	−0.1145	[0.1437]	(0.4262)
LY^2	1.18e-**	[7.68e-]	(0.0260)
LFD	0.0499	[0.0510]	(0.3286)
LREC	0.0370	[0.0614]	(0.5469)
LFF	4.1150	[5.1487]	(0.4251)

NOTE: Authors computation: *<0.01, **<0.05, ***<0.10.

Table 7
Sensitivity check with AMG.

Variables	Coefficient	STD. Error	P-value
FDI	−0.00316*	[0.00423]	(0.005)
LY	0.18322*	[0.13434]	(0.003)
LY2	−2.58e*	[4.43e−11]	(0.000)
LFD	−0.02744**	[0.02855]	(0.036)
LREC	−0.0181*	[0.07414]	(0.007)
LFF	1.0303	[0.49266]	(0.036)
Wald test	576.83*		(0.000)

NOTE: Authors computation: *<0.01, **<0.05, ***<0.10.

4.5. Dumitrescu and Hurlin causality test

The Dumitrescu and Hurlin panel causality test is reported in Table 8. The panel causality technique is required by the requirement to evaluate the Granger non-causality moving from the dependent variables to the independent variable as hypothesized in the examination of Dumitrescu and Hurlin (2012) in a heterogeneous panel dataset. Following the importance of testing for causality in empirical studies (Balsalobre-Lorente and Leitão, 2020; Bekun et al., 2021a,b; Gyamfi et al., 2021c; Onifade et al., 2020, 2021; Rjoub et al., 2021; Roudi et al., 2019) we report the test results in Table 8. From the table it can be observed that, there is a feedback causality regarding income and carbon pollution as well as financial development and carbon pollution. Nevertheless, the remaining that is FDI and carbon emission, renewable energy and carbon emission and fossil fuel and carbon emission were found to have one-way causal relationship.

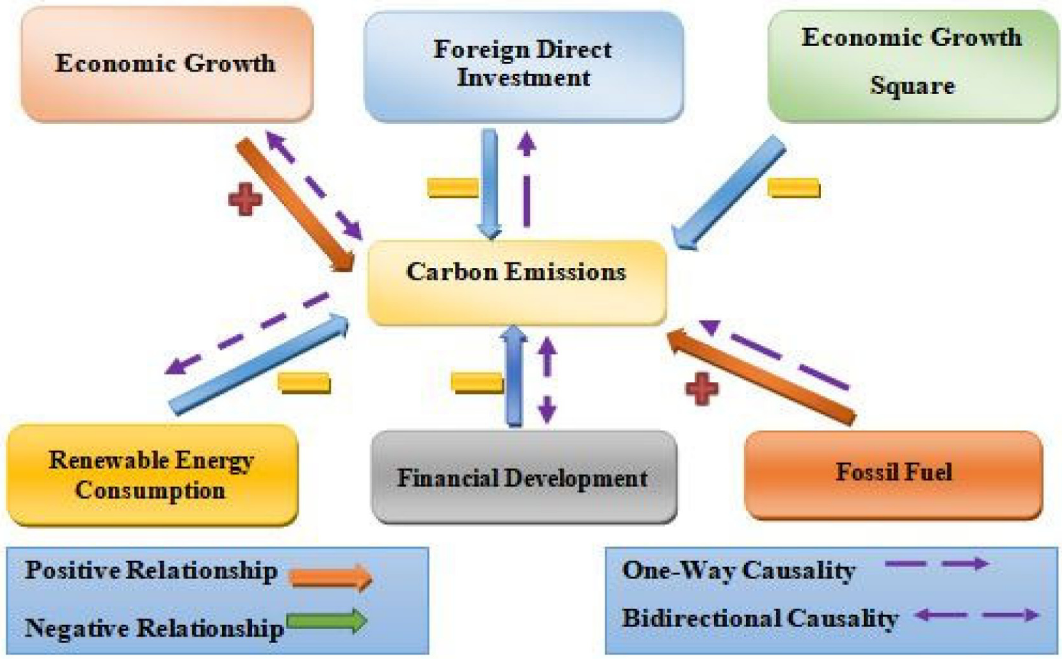

Fig. 1. Key Findings from long run analysis and causality directions.

Table 8
Dumitrescu and Hurlin panel causality test.

	W-stat.	Zbar-stat.	p-value	CAUSALITY FLOW
FDI→ LCO_2	1.7566	−0.7651	(0.4442)	LCO_2→FDI
LCO_2→ FDI	4.7174*	3.3458	(0.0008)	
LY→ LCO_2	3.5665***	1.7479	(0.0805)	LCO_2↔ LY
LCO_2→ LY	3.8423**	2.1307	(0.0331)	
LFD→ LCO_2	6.2963*	5.5381	(3.E-08)	LCO_2↔LFD
LCO_2 → LFD	4.0213**	2.3794	(0.0173)	
LREC→ LCO_2	2.5292	0.3075	(0.7584)	LCO_2→ LREC
LCO_2→ LREC	5.3292*	4.1953	(3.E-05)	
LFF→ LCO_2	3.2594	1.3215	(0.1863)	LCO_2→LFF
LCO_2→ LFF	6.1464*	5.3300	(1.E-07)	

NOTE: Authors computation: *<0.01, **<0.05, ***<0.10.

5. Conclusion and policy implications

At the COP 21 in Paris, the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a historic consensus on environmental issues addressing and accelerating and improving efforts and initiatives to guarantee a secure and carbon-free future. The Paris Agreement draws on it and gathers all states united for the first moment, by means of increased finance for underdeveloped nations, to excellent collaborative efforts to address and adjust to environmental shift. It also sets a fresh direction for the sustainable environment strategy. The Mediterranean nations acknowledge the responsibility of enhancing the ecological consequences of Carbon emission and are therefore increasingly devoted to a sustainable development-environment. However, this analysis exploited the connection regarding carbon pollution, income, square of income, foreign direct investment, financial development, renewable energy, and fossil fuel of Mediterranean countries for the period of 1995–2016.

The present study utilized cross-sectional dependence techniques, Westerlund (2007) co-integration technique, cross-sectional ARDL and augmented mean group (AMG) whiles the Dumitrescu and Hurlin panel causality test was used for causality purposes. The co-integration outcome from Westerlund (2007) shown a statistically significant cointegration relationship among the study's variables. Moreover, FDI shown a negative significant relationship with pollution which indicated a Pollutant Hallo Hypothesis. Income on the other hand had positive relationship with emissions wiliest its square had negative relationship with emissions. This result also shown the presence of EKC indicating the inverted U-Shaped curve. Both financial development and renewable energy indicated a negative relationship with emissions which fossil fuel had a positive relationship with emissions. From the short run, the error correction of the estimation (ECM) expectedly came out to be negative and significant. FDI on the other hand has a negative and significant relation with carbon emission whiles square of income has positive and significant relationship with carbon emission

Furthermore, from the Dumitrescu and Hurlin panel causality test, there was a feedback causality between income and carbon emission as well as financial development and carbon emission. Nevertheless, the remaining that is FDI and carbon emission, renewable energy and carbon emission and fossil fuel and carbon emission were found to have one-way causal relationship. Base on the outcomes from this analysis, the following recommendation are suggested for policy makers:

- For Mediterranean countries, various policy considerations can be established. Firstly, our findings on the breakdown of foreign production can have significant impacts on the Mediterranean countries. In order to prevent being pollution havens, Mediterranean states should meet the requirements of the global market. For example, raising the entrance barrier of dirty industry, controlling exports of pollution-producing products and encouraging new export comparative edge. In addition, the Mediterranean states must progressively and effectively adapt the economic growth trend to accomplish balanced and stable progress through the supply-side change.
- Next, one of several program's "project-based" frameworks is the Clear Development Mechanism (CDM), aiming to facilitate cleaner assistance to emerging nations This framework must be used entirely by Mediterranean countries to drive the adoption of technological advancements for energy conservation and environmental regulation.

- Moreover, decision makers in the Mediterranean countries should encourage sustainable and healthier forms of energy for the economies to minimize reliance on fossil fuel emission in the region. This can be done by the efficient utilization of renewable energy's environmental assets (such as solar, wind power, and hydraulic energy, among others).
- Lastly, environmental advancement is important through ongoing research and development expenditure in energy to match the pace of foreign direct investment, financial development and economic operations.

Moreover, although this analysis and its findings provide guidance into the PHH discussion, a number of weaknesses could be discussed in subsequent surveys. First, several countries should be chosen as study samples to do more rigorous empirical testing on PHH in relation to the Mediterranean economies. Second, additional measures of environmental efficiency should be introduced to illustrate the effect of the incoming FDI to enhance current debate Last but not least, study into various countries is a valuable addition to group comparative study.

CRediT authorship contribution statement

Bright Akwasi Gyamfi: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Data curation. **Tomiwa Sunday Adebayo:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Data curation. **Festus Victor Bekun:** Conceptualization, Methodology, Writing – original draft, Data curation. **Ephraim Bonah Agyekum:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Data curation. **Nallapaneni Manoj Kumar:** Formal analysis, Writing – review & editing, Data curation, Funding. **Hassan Haes Alhelou:** Formal analysis, Writing – review & editing, Funding. **Amer Al-Hinai:** Formal analysis, Writing – review & editing, Funding.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

See Table A.1.

Table A.1
List of countries.
Source: Authors' computation

Albania	Greece
Algeria	Israel
Bosnia	Morocco
Croatia	Turkey
Cyprus	Tunisia
Arab republic of Egypt	Spain
France	Italy

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