MODELING THE DETERMINANTS OF SUSTAINABLE GREEN GROWTH IN THE MENAT REGION: USING THE DCCE-MG APPROACH

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Abstract. The attempt of ensuring that economic growth is becoming greener with additional efficient use of natural capital which is captured in green growth has gained the interest of researchers, but studies in this regard on MENAT countries are scant. Thus, this study attempted to model the determinant factors of green growth in the MENAT countries using data from 1990 to 2019 and employed the Westerlund and Edgerton (2008) panel cointegration test to examine the cointegration among the variables of interest, and employed DCCE-MG technique to establish the significance of the determinant factors, while FMOLS and DOLS were utilized for robustness check. The result from the panel cointegration test revealed an existence of cointegration relationship between the variables in cases of "cross-sectional dependency" and structural breaks, which suggests that the variables move together in the long-run. Moreover, the findings from DCCE-MG estimates revealed that foreign direct investment, economic growth, renewable energy and institutional quality drives sustainable green growth in the MENAT countries, while population was found to exert negative impact on sustainable green growth. The study provides some information that will assist the policymakers in the MENAT countries to balance sustainable green growth, economic growth, internationalization, institutional quality, environmental cost, and population.
Keywords: *sustainable development, environmental quality, economic development, environmental regulation, energy use*

Introduction

Middle Eastern and North African countries including Turkey (MENAT) constitute heterogeneous traits in natural resources, geography, income levels, political and social structures (FAO, 2015; UNICEF, 2021), as well as common context of environmental challenges and trans-boundary conflicts (Abumoghli and Goncalves, 2021). According to Abumoghli and Goncalves (2021), environmental stresses have been one of the notable features in the history of the region and have shown an increasing trend in relation to development patterns in the present time. The environmental stresses among which environmental pollution is expected to exacerbate owing to developments could possibly heighten the climate change (Abumoghli and Goncalves, 2021; De Châtel,

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2014; Hungate and Koch, 2015), especially given that the region is one with high vulnerability to its impacts (IPCC, 2013). Meanwhile, this challenge of rising temperature and its attendant implication on livelihoods around the globe have put "sustainable development" (SD) as the top priority in international discourse (IPCC, 2018). The search for ways to tackle this challenge has been on the priority list of most countries and regions and stakeholders which became evident in the renewed actions towards a better environment by the Paris Agreement and 2030 Sustainable Development Agenda (OECD, 2020), with the suggestion that the agenda is for all nations. Meanwhile, even though almost all nations are committed to the agenda, significant variations are observed in the level at which nations are going in the direction of sustainable green growth. For instance, Australia and Belgium are the countries among OECD members that are experiencing a significant increase, while Portugal and Turkey are not showing significant efforts in this regard.

The consideration of the significant role of green growth in the preamble of sustainable development has been of interest to various stakeholders. The green growth in scope is more than the environment as it concerns the development of the economy. A substantial amount of importance in the economic growth paradigm is captured in the "green growth" phenomenon. Samad and Manzoor (2015) described green growth "as a process of greening the conventional economic system and as a strategy to arrive at green economy" (p. 2). This definition is congruent with the position of OECD (2011) which defines green growth as "fostering economic growth and development while ensuring that natural assets continue to provide resources and environmental services on which the intergenerational well-being of humankind relies". Given the multi-dimensional characteristic of environmental issues and the fact that these issues cannot be addressed with "one size fit all" strategy in this time of increasing economic activities, this present study investigates different set of factors that could drive green growth in the MENAT region. According to OECD (2020), green growth is about ensuring that economic growth is becoming greener with additional efficient use of natural capital. The indicator for green growth monitors progress towards a sustainable greener economy, and achievement of this implies the utilization of natural assets for economic growth in a sustainable manner, with the aim of moving in the direction of an economy that results in human well-being and decrease inequalities among people in the long-run without the exposure of unborn generations to environmental risk (OECD, 2018).

Despite the significant role of green growth towards green economy, its determinant factors have not been exhaustively investigated, especially within the MENAT region. Hence, the questions remain that: (i) what are the factors that could drive the sustainable green growth within the MENAT region? (ii) is there cointegration among these variables? These are the questions to be answered in this present study which constitute the study objectives. The MENAT region is one of the regions in the world that has experienced one of the fastest population growths (Lange, 2019). The region in 2019 accounted for a total population of 540 million (World Bank, 2021), with US$9,200 average GDP per capita, which was though below the global average of US$10,900 it is projected to reach about US$22,900 by 2050. These are indications that the region is experiencing development which could possibly increase their energy demand. Energy consumption is noted in the literature as one of the significant contributors to carbon emissions which results to greenhouse gas emissions (Adebayo et al., 2021; Odugbesan & Aghazadeh, 2021; Rjoub et al., 2021a, b, c). The MENAT countries are noted for

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accommodating 60% of the world oil reserves and 45% of natural resources which are used for production resulting to carbon emissions (Muhammad, 2019). In addition, according to IEA (2019), the energy-related CO_2 emissions per capita in 2018 were 5.7 t CO_2/capita which is projected to reach 5.97 t CO_2/capita by 2050. This current study would be helpful to make appropriate policy direction for the achievement of sustainable green growth which will ensure the economic growth and reduction in carbon emission shifting the MENAT countries towards green economy.

To the best knowledge of the authors, no comprehensive study has been conducted within the context of the MENAT region to address the determinant factors of sustainable green growth in the long-run, therefore this study will address the gap and thus constitute the motivation of this study. This study will address this gap by modeling carbon productivity (the ration between GDP and the quantity of CO_2 emissions) as dependent variable, and variables like economic factor, internationalization factor, energy-related factor, and institutional quality in reference to previous studies were employed as independent variables (Cosbey, 2011; OECD, 2011, 2012; Tawiah et al., 2021) with the use of “Dynamic Common Correlated Effects-Mean Group” (DCCE-MG). This technique has several advantages among which are: the ability to account for both heterogeneous and homogeneous coefficients; it supports instrumental variable regressions; it controls for “cross-sectional dependence”; appropriate in case of unbalanced panels; utilized “Jack-knife correction method” and “recursive mean adjustment”; and, has the potential of correcting for small sample bias. In order to ensure the robustness of our findings, “Dynamic Ordinary Least Square” (DOLS) regression and “Modified Ordinary Least Square” techniques were employed. The main contribution of this study lies in the novelty of the subject, the choice of estimation techniques and the area of study (MENAT region). Therefore, this present study is aimed at filling the gap in the environmental sustainability literature by investigating the significance of foreign direct investment, economic growth, renewable energy, institutional quality and population as a determinant of sustainable green growth in the MENAT countries with the aid of a novel dynamic panel data estimator which has the capability of addressing the cross-dependency issue in panel data estimation. The remainder of the paper is structured as follows: The “Literature Review” section presents the review of relevant studies capturing green growth determinants. The “Materials and Methods” section presents data description, sources and econometric model, while the estimation methods and findings are presented in the “Estimation Procedures” and “Results” sections, respectively, with important recommendations suggested in the “Conclusion” section.

Literature review

This study aims to empirically investigate the significance of economic development, foreign direct investment, renewable energy, and the institutional quality as a determinant factor for sustainable green growth in the context of the MENAT region, where population was utilized as the control variable. The pairwise nexus among the main study variables will be discussed on the basis of the following strands.

Economic growth and environment

The causal link between the environment and economic development was addressed with the “Environment Kuznet Curve” (EKC) developed by Grossman and Krueger

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(1995) which considered it to be an “inverted hum-shaped curve”. The study posited that the increase of the environmental deterioration is proportional to income, while it starts decreasing when the curve gets to a plateau of the income threshold. This claim was sustained in some studies who argued that economic growth below the turning point has effect on CO_2 emissions, but when the turning point is crossed by economic growth, the environment quality is improved (Ardakani and Seyedaliakbar, 2019; Chen et al., 2019; Odugbesan & Aghazadeh, 2021; Xie and Liu, 2019). Another study by Wang (2011) examined the causal implication of economic growth on CO_2 emissions for 138 nations using a data from 1971 to 2007 and employed “error correction model”, and a “feedback hypothesis” is supported in the study. This finding was similar to another panel study involving 25 OECD countries to examine long-run two-way causalities between per capita CO_2 emissions and GDP between the period from 1980 to 2010 (Jebli et al., 2016). Similar study by Peng et al. (2016) used a sample data from 16 Chinese provinces across three regions between the periods from 1985 to 2012 to examine the impact of GDP on CO_2 emissions. The study revealed that GDP granger cause CO_2 emissions in 15 of the 16 provinces studies, as well as finding a feedback relationship between GDP and CO_2 emissions for one of the provinces. In addition, the evidence of the devastating impact of economic growth on the environment was demonstrated in some previous studies (Adebayo et al., 2021; Adedoyin et al., 2020; Cai et al., 2018; Odugbesan et al., 2020; Pata, 2018; Shahbaz et al., 2013). Meanwhile, some studies demonstrated that increase in economic growth sustains the environment by decreasing CO_2 emissions (Alam and Kabir, 2013; Rahman et al., 2020). For instance, a joint contribution of investment and economic growth on environmental quality was demonstrated in the study of Wang et al. (2019), and the study opined that “emission mitigation policies that encompass the efficient use of energy, clean technology investment, and promotion of labor standard will cut down the rising emissions”. Similar study by Mikayilov et al. (2018) showed a significant positive relationship between economic growth and a sustainable environment in Azerbaijan, which corroborates the position of Chang and Hao (2017) who found a positive interaction between environmental performance and economic growth in OECD and non-OECD countries. Though, the empirical studies on green growth is scant, a recent study by Tawiah et al. (2021) that investigated the determinants of green growth in developed and developing countries demonstrated a significant positive impact of economic growth on green growth and concluded that the result differs between developed and developing countries. Besides, literature suggests that several studies which are country-specific and panel studies presents support and opposing evidences on the EKC hypotheses.

Foreign direct investment and environment

From the literature, the impact of “foreign direct investment” (FDI) on environment seems to be heterogeneous, and the impact sometimes could be indirect. For instance, the study of Li et al. (2019) opined that “market-seeking FDI” reacts to market size, while the “efficiency-seeking FDI” reacts to technical endowment. This position was evident in the study of Pao and Tsai (2011) who demonstrated that FDI has a positive effect on productivity while exerts negative influence on the environment. The impact of FDI on the environment is mainly dualistic. For instance, the study of Asghari (2013) and Al-Mulali and Tang (2013) opined that the entrance of FDI into a country comes with consequence like environmental pollution to the host countries; while on the other

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hand, the entrance can bring cleaner technologies, stimulate productivity, transfer of technologies and appropriate management practices that will contribute to the environmental quality improvement of the host countries (Abdouli and Hammami, 2018; Al-Mulali and Tang, 2013; Hettige et al., 1996; Omri, 2014). From another perspective, the impact of FDI on environment may be different between developed and developing countries, owing to the fact that advanced level of technology evolution has already being achieved in developed countries. In addition, the stringent environmental regulations in developed countries typically enable the utilization of cleaner technologies, as well as advanced "environmental-management systems" for the optimization of their FDI activities. Meanwhile, this stage is yet to be achieved in the developing countries. The introduction of FDI into some developing countries is often accompanied with environmental pollution owing to the relaxed environmental regulations, which is congruent with the "pollution haven hypothesis" (Baek, 2016; Seker et al. 2015; Shahbaz et al., 2015). Meanwhile, some studies that validates "pollution halo hypothesis" believes that FDI exerts positive effect on environment through the introduction of eco-friendly techniques of production (Al-Mulali and Tang, 2013; Seker et al., 2015), and substantial environmental performance is possible for developing countries as suggested by Cole (2008) through the entrance of FDI with more advanced technologies and development of "environmental-management systems". Moreover, while Ayamba et al. (2019), Li et al. (2019), and Tawiah et al. (2021) found no significant effect of FDI on environmental performance in their respective studies, the study of Awodumi (2020) demonstrated that FDI inflows into West African countries hampers environmental efficiency.

Renewable energy and environment

Studies abound on the relationship between renewable energy and environment. While some studies demonstrate a positive influence of renewable energy on the environment (Akella et al., 2009; Apergis et al., 2010; Farhani and Shahbaz, 2014; Jebli and Youssef, 2017; Majeed and Luni, 2019), as well as ensuring sustainability (Prandecki, 2014), some studies argued that renewable energy exerts negative impact on the environment (Al-Mulali et al., 2016; Belaid and Youseef, 2017; Bilgili et al., 2016; Dogan and Ozturk, 2017; Ito, 2017; Jebli and Youssef, 2017; Kahia et al., 2019; Sharif et al., 2019; Sulaiman et al., 2013; Zoundi, 2017). Meanwhile, insignificance impact of renewable energy on emissions was reported in the study of Al-Mulali et al. (2015), as well as its significant positive effect on green growth was reported by Tawiah, Zakari, Adedoyin (2021). The argument of the studies that believes in the positive influence of renewable energy on the environment is that renewable energy does not emit pollutants; has a "substitution effect"; not prone to depletion unlike fossil fuel; and, with renewable energy, thermal pollution which is caused by conventional sources of energy production can be avoided. In spite of the significant positive effects of renewable energy on the environment, some studies argued that it has a potential of exerting negative effect on the environment. Among the concerns of studies in this category is that combustible renewables and waste for instance are not clean energy use. Jebli and Youssef (2017) opined that if these types of energy use constitute major share in the sources of renewable energy, then there could be increase in emissions. In addition, biofuels, solar, wind geothermal energy for instance require large expanse of land and water, and with the limited land and water availability, the ecological footprint will increase as a result of the renewable energy resources which will in turn contribute to environmental degradation (Al-Mulali et al., 2016). The review of studies on

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the relationship between renewable energy and environmental quality showed mixed results and were inconclusive. Meanwhile, renewable energy as a determinant of sustainable green growth is less explored in the literature.

Institutional quality and environment

The institutional quality according to Odugbesan and Rjoub (2019) and Rjoub et al. (2021c) includes rule of law, control of corruption, regulatory quality, political stability, government effectiveness, and voice and accountability have the potential of promoting or retarding green growth. According to Salman et al. (2019), an economic activity will be promoted with a well-established institutional quality while it can as well reduce CO_2 emissions (Sarkodie and Adams, 2018). Similarly, Ibrahim and Law (2016) opined that "high institutional quality is more beneficial in improving a sustainable environment through the effect of trade than in low institutional quality". In addition, the compliance of firms with environmental laws is possible with quality institutions. However, some studies argued that growth of firms could be hindered with stringent environmental regulations enforcement. For instance, Nguyen et al. (2018) observed that a strong enforcement could result to a less innovation and creativity towards environmental improvement. Similarly, some studies opined that environmental protection regulations could be counterproductive to economic growth and development (De Angelis et al., 2019; Wolde-Rufael and Weldemeskel, 2020). Meanwhile, the evidence in this regard is fragile. For instance, the study of Abid (2017) demonstrates the significant negative effects of government effectiveness and democracy on the environment and argued that "democratic institution paves way for foreign investment at the expense of the environment". This position corroborates the study of Kinda (2011) who observed that environmental regulations are being avoided by foreign investors, which motivates them to invest in a country where such policies are not in place and thus increase the pollution. Meanwhile, an insignificant effect of institutional quality on green growth was demonstrated in the study of Tawiah et al. (2021).

Materials and methods

Data

This study employed data from 1990 to 2019 in Middle East and North African countries including Turkey. This study started with the 21 countries mostly recognized under this category (FAO, 2015; UNICEF, 2021). Meanwhile, 8 countries were dropped owing data unavailability, as well as having variables with more than three years consecutive missing values. The final sample of this study covers 13 countries which are: Algeria, Egypt, Iran, Iraq, Jordan, Lebanon, Libya, Morocco, Saudi Arabia, Tunisia, Turkey, United Arab Emirate and Yemen. This study utilized carbon productivity as a proxy for green growth which is the dependent variable and in congruent with the literature (Cigu et al., 2020; Hu and Liu, 2016; Tawiah et al., 2021). Carbon productivity according to OECD (2020) is established as an inclusion in the assessment of economic growth of environment "consumption", being the "ratio between GDP and the quantity of CO_2 emissions". The GDP per capita was included as a determinant factor and a proxy for measuring the effect of economic development on green growth. FDI was used as a proxy to measure how the international activities drives green growth and it measured by the "net inflow of foreign direct investment as a percentage of GDP". Moreover, renewable

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energy was used to determine the type of energy consumption effect on the green growth, while institutional quality index was developed using principal component analysis method to examine the effect of institutional quality effect on sustainable green growth. The six institutional quality indicators (rule of law, control of corruption, regulatory quality, political stability, government effectiveness, and voice and accountability) developed by Kaufmann and Kraay (2018) is the most widely used proxy for measuring institutional quality (Odugbesan and Rjoub, 2019; Tawiah et al., 2021; Tunyi et al., 2020). As for the control variable, population was used to control the effect of human activities on green growth in line with the position of Aller et al. (2015) who opined that large population exerts significant impact on the environment. The data for green growth was sourced from OECD database, while the data for FDI, GDP per capita, renewable energy and total population were sourced from World Development Indicators, and institutional quality data were sourced from World Governance Indicator.

From the descriptive statistics presented in *Table 1*, maximum carbon productivity is 6.37 USD/kg, with the minimum of 0.687 USD/kg, while the mean value of 3.413 USD/kg with a standard deviation of 1.213 does not suggest a wide dispersion from the mean by the countries in the sample. Statistics on FDI shows a mean value of 2.654% of GDP, the highest and lowest values among the country being 23.537% and -4.337% of GDP respectively with a standard deviation of 3.606 which indicate a moderate dispersion from the mean by the countries in the sample. The standard deviation of 6.067 indicates a wide dispersion from the sample mean which is 5.078, while the highest and lowest renewable energy are 23.05% and 0.006% of the total final energy consumption of the sampled countries. On average, the intuitional quality index of the sampled countries is -0.019, where the maximum and minimum values are 1.960 and -2.329 respectively with a standard deviation of 0.972 which indicate no wide dispersion from the sample mean. The group statistic for per capita GDP of the sampled countries revealed a mean value of US$9386.55, with a US$64864.72 and US$785 maximum and minimum, respectively with a standard deviation of 13234.96 which suggest a wide dispersion from the sample mean. Finally, the group statistic for population shows an average value of 29 million, while the maximum and minimum population was around 92 million and 25 million with a standard deviation value of 25 million which indicate a wide dispersion from the mean value. The variations in the number of observations as presented in *Table 1* shows the unbalanced nature of the sample data.

Table 1. *Descriptive statistic*

Variable	Mean	Max.	Min.	Std. dev.	Obs
Carbon productivity	3.413	6.37	0.687	1.213	383
Foreign direct investment	2.654	23.537	-4.337	3.606	389
Renewable energy	5.078	23.505	0.006	6.067	338
Institutional quality index	-0.019	1.960	-2.329	0.972	312
GDP per capita	9386.547	64864.72	785.34	13234.96	381
Total population	29931641	92442547	2539126	25455447	390

Model specification

The modeling of determinant factors of sustainable green growth within the context of 13 selected MENAT countries was performed in this present study from 1990 to 2019, and the empirical model is stated as follows:

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$$\text{Green growth} = f(\text{Determinants}_{it} + \text{Control variable}_{it}) \quad \text{(Eq.1)}$$

where green growth is the carbon productivity (CO_2*_Prod*); determinants are GDP per capita (*GDP_PC*), foreign direct investment (*FDI*), renewable energy (*RE*), institutional quality index (*IQI*); and control variable is total population (*TP*). In its explicit form, *Equation 1* is expressed in *Equation 2* with the conversion of variable that could create bias due to outliers to natural logarithm. Thus, *Equation 2* is expressed as:

$$CO_{2_{Prod}} + \alpha_0 + \beta_1 FDI_{it} + \beta_2 RE_{it} + \beta_3 IQI_{it} + \beta_4 lnGDP\_PC_{it} + \beta_5 lnPOP_{it} + \varepsilon_{it} \quad \text{(Eq.2)}$$

where α represent intercept, natural logarithm is denoted with *ln*, *i* and *t* denotes the number of countries and time dimension, while represent the parameters to be estimated and ε is the error term.

Estimation procedures

In order to address the study objectives as expressed in *Equation 2,* series of procedures were followed and blend of analytical techniques which has been used in previous studies (Pala, 2020; Rahman, 2020) were deployed to ensure consistency of the estimates.

Cross-sectional dependency (CSD) test

First, the CSD test was applied to determine the appropriate method to be applied. According to Ditzen (2016) and Odugbesan and Rjoub (2020), panel data analysis has some advantages that range from suitable degree of freedom, high efficiency of estimates, and the low occurrence of multicollinearity among the variables. But, owing to the close proximities of the countries and given the likelihood of sharing common characteristics, the risk of “cross-sectionally dependent” panel is very high. Pesaran (2004) opined that biased results and inferences could happen where the data has “cross-sectional dependence” (CSD). This issue can be addressed with the use of Pesaran (2004, 2007) test for “cross-sectional dependency” which is applicable to both small and large panels. In reference to Pesaran (2004, 2007), the H_0 of no CSD which can be rejected at 1%, 5%, and 10% levels is stated as:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{k=i+1}^{N} \hat{\rho}_{i,k} \right) \quad \text{(Eq.3)}$$

Slope homogeneity test

Moreover, the validity of con-constancy of slope homogeneity in the parameters among the units which according to Gunduz (2017) instigates the significance of “slope heterogeneity” was performed using “slope homogeneity test” developed by Pesaran and Yamagata (2008). This test is an extension of the $\tilde{\Delta}$ test (Swamy, 1970) which is applicable to “a cross-section that is relatively small to the time dimension”, while the one by Pesaran and Yamagata (2008) is applicable to “panels with relatively large/small cross-section (*N*) to the time dimension (*T*). Meanwhile, the test can be applied to both unbalanced and balanced data, and the standardized statistics is given as:

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$$\tilde{\Delta} = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{\hat{d}_i - k}{\sqrt{2k}}\right) \quad \text{(Eq.4)}$$

The test is asymptotically Δ~N (0,1) with a H_0 of slope homogeneity, d_1 denotes difference between *N* estimator and the pooled estimator $\left(\left(\hat{\beta}_I - \hat{\beta}_{WFE}\right)' \frac{X_{il} M_{ti} X_i}{\hat{\sigma}^2} \left(\hat{\beta}_I - \hat{\beta}_{WFE}\right)\right)$, and the test can be expressed in terms of normally distributed errors utilizing “mean-variance bias-adjusted $\hat{\Delta}$" (Bersvendsen and Ditzen, 2020) as:

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\sum_{i=1}^{N}\hat{d}_i - K}{\sqrt{Var(\hat{z}_i T)}}\right) \quad \text{(Eq.5)}$$

where $Var(\hat{z}_i T) = \frac{2k(T-K-1)}{(T-K+1)}$.

Panel unit root tests

The “cross-sectional augmented Im, Pesaran, and Shin (CIPS)” (Im et al., 2003) and “cross-sectional augmented Dickey–Fuller (CADF)” tests developed by Pesaran (2007) were applied in this study, owing to the presence of “cross-sectional dependence”, hence, the data is subjected to second-generation unit root test. In reference to Pesaran (2007), these tests are capable of accounting for “cross-sectional dependence” among the units in the panel, and the equation for CADF is expressed as follows:

$$\Delta y_{it} = \alpha_i + d_i y_{i,t-1} + c_i \Delta\bar{y}_{t-1} + b_i \Delta\bar{y}_t + u_{i,t} \quad \text{(Eq.6)}$$

where the variable being tested is denoted with z_{it}.

The augmented variant of Im et al. (2003) unit root test (CIPS) is stated as:

$$CIPS(N,T) = \bar{T} = N^{-1}\sum_{i=1}^{N} t_i(N,T) \quad \text{(Eq.7)}$$

where the numbers of units and years are represented with *N* and *T* respectively. The unit root test for heterogeneous panels is presented at the left-hand side of *Equation 7*, while term t_i is the “Ordinary least squares (OLS)”, *t-ratios* employed in cross-sectional averaged “augmented Dickey-Fuller (ADF) regression is presented in the right-hand side of *Equation 7.*

Panel cointegration tests

This present study employed panel cointegration test developed by Westerlund and Edgerton (2008) which allowed for cross-sectional dependence, serially correlated errors, and structural breaks in both intercept and slope. The test was developed based on the study of Gregory and Hansen (1996). Hence two LM based statistics are defined by Westerlund and Edgerton (2008) which are stated as follows:

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$$LM_{\varphi}(i) = T\hat{\varphi}_i \left(\frac{\hat{\omega}_i}{\hat{\sigma}_i}\right) \quad \text{(Eq.8)}$$

$$LM_{\tau}(i) = \frac{\hat{\varphi}_i}{SE(\hat{\varphi}_i)} \quad \text{(Eq.9)}$$

where the least square estimate of φ_i with $\hat{\sigma}_i$ as its estimated standard error is denoted with $\hat{\varphi}_i$, while the estimated long-run variance of Δv_{it} is denoted with $\hat{\omega}_i^2$, and the estimated standard error of $\hat{\varphi}_i$ is represented with $SE(\hat{\varphi}_i)$.

Dynamic common correlated effects-mean group (DCCE-MG)

This study employed DCCE-MG proposed by Ditzen (2016, 2018) to test for the long-run relationship among the variables in this study. According to Ditzen, DCCE-MG has several advantages among which are: the ability to account for both heterogeneous and homogeneous coefficients; it supports instrumental variable regressions; it controls for “cross-sectional dependence”; appropriate in case of unbalanced panels; utilized “Jack-knife correction method” and “recursive mean adjustment”; and, has the potential of correcting for small sample bias. The equation for DCCE-MG is stated as:

$$y_{i,t} = \theta_i y_{i,t-1} + \beta_i x_{i,t} + \sum_{I=0}^{PT} \delta'_{i,I} \bar{Z}_{t-I} + \varepsilon_{i,t} \quad \text{(Eq.10)}$$

where $\bar{Z}_t = (\bar{y}_t \bar{y}_{t-1} \bar{x}_t)$. Therefore, the MG estimates are: $\hat{\pi}_{MG} = \frac{1}{N}\sum_{i=1}^{N} \hat{\pi}_i = (\hat{\theta}_i, \hat{\beta}_i)$.

Dynamic OLS and fully modified OLS

The DOLS and FMOLS techniques were employed in the study to test for the robustness of our estimates. The former is “parametric approach in which lags and leads are introduced to cope with the challenges of cross-sectional dependence irrespective of the order of integration and the existence or absence of cointegration,” while the latter is “a non-parametric approach that is utilized to deal with serial correlation”. The extension of DOLS techniques to panel data analysis is in line with the study of Kao and Chiang (2001), and the model specification is expressed as:

$$y_{i,t} = \beta'_i x_{i,t} + \sum_{j=-q}^{q} \delta_{ij} \Delta x_{i,t+j} + \gamma li' Dl_i + \varepsilon_{i,t} \quad \text{(Eq.11)}$$

where q represents the lags, number chosen using a suitable information criterion. This study finds this technique suitable owing to its potential of providing a robust correction of endogeneity in the independent variables. Similar to DOLS, the use of FMOLS is in reference to Pedroni (2001) which opined that the technique gives consistent estimates of the parameters in small sample data, and it also controls for possible endogeneity of the independent variables and serial autocorrelation. Hence, FMOLS for the *i*-th units is expressed as:

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$$\beta_i^* = (X_i' X_i)^{-1}(X_i' y_i^* - T\delta) \quad \text{(Eq.12)}$$

where y^* represent the transformed endogenous variables, the parameter for autocorrelation adjustment is denoted with δ while T represent the years.

Results

CSD test result

The results presented in *Table 2* reveal the rejection of H_0 of no cross-sectional dependency at less than 1% for carbon productivity, FDI, renewable energy, GDP per capita, and total population, while it was rejected at less than 10% for institutional quality index. This outcome implies that any shock in one of the 13 selected MENAT countries may be transmitted to other countries in the panel.

Table 2. *CD test*

Variable	CD-test	*p*-value
Carbon productivity	31.79	.0000
Foreign direct investment	18.33	.0000
Renewable energy	7.07	.0000
Institutional quality index	1.85	.064
GDP per capita, log	14.17	.0000
Total population, log	47.89	.0000

Slope homogeneity test result

The results from the slope homogeneity test presented in *Table 3* shows that the H_0 of homogeneity slope is rejected at less than 1%. This indicates the existence of heterogeneity across the sample countries and as such a heterogeneous panel technique like DCCE-MG is appropriate.

Table 3. *Pesaran and Yamagata (2008) slope homogeneity test*

	Delta	*p*-value
$\tilde{\Delta}$	10.72*	0.0000
$\tilde{\Delta}_{adj}$	12.81*	0.0000

Panel unit root tests results

The results from both the CADF and CIPS are presented in *Table 4* which shows that the null hypothesis of unit root is rejected for almost all the variables at first difference except GDP_PC that is failed to reject the null hypothesis of unit root for CADF. In summary, all the variables are integrated of order 1.

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Table 4. *Panel unit root test*

	Level		1st Difference	
Variables	CADF	CIPS	CADF	CIPS
Carbon_Prod	0.450	-1.409	-4.323**	-6.962**
FDI	1.421	-1.605	-2.410*	-8.303**
RE	1..210	-1.350	-3.260**	-7.906**
IQI	0.210	-0.903	-4.308**	-7.109**
lnGDP_pc	-3.210**	-1.768	-	-4.321**
lnPOP	2.001	-1.382	-3.337*	-8.021**

Carbon_Prod = carbon productivity, FDI = foreign direct investment, RE = renewable energy, IQI = institutional quality index, lnGDP_PC = logarithm of gross domestic product per capita, lnPOP = logarithm of total population. *, ** denotes 10% and 5% significance level.

Panel cointegration result

The results from Westerlund and Edgerton (2008) panel cointegration test as presented in *Table 5* shows that the test statistics are significant at 5% significance level which indicate rejection of H_0 of no cointegration, except $Z_t(N)$ statistic for level shift. The outcomes imply the existence of cointegration relationship between the variables in cases of “cross-sectional dependency” and structural breaks, which suggests that the variables move together in the long-run.

Table 5. *Westerlund and Edgerton (2008) cointegration test*

Model	$Z_\varphi(N)$	$Z_\tau(N)$
No break	-4.520**	-10.112**
Level shift	-3.048**	-0.789
Regime shift	-3.522**	-3.445**

**5% significance level

DCCE-MG result

From the estimates of DCCE-MG presented in *Table 6*, the main determinants without control variable is presented in column 1 and 2, while the full results that includes control variable is presented in column 3 and 4. The FDI is positive and significant at 5% confidence level, indicating a positive effect of FDI on green growth in the long-run. The coefficient and sign for FDI remain unchanged in column 3 when population is added as control variable. This implies that increase in FDI in MENAT countries promotes green growth in the long-run. The finding is congruent with the assumption of “pollution halo hypothesis” which believes that entrance of FDI into a country can bring cleaner technologies, stimulate productivity, transfer of technologies and appropriate management practices that will contribute to the environmental quality improvement of the host countries. In addition, the finding is congruent with the positions of some studies that demonstrated similar finding in their studies (Abdouli and Hammami, 2018; Al-Mulali and Tang, 2013; Omri, 2014; Seker et al., 2015). Meanwhile, the finding contrasts the finding of Baek (2016), Seker et al. (2015), and

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Shahbaz et al. (2015); as well as those studies that showed an insignificant effect of FDI on the environmental quality (Ayamba et al., 2019; Tawiah et al., 2021).

The result from the estimation of renewable energy as a determinant of green growth as presented in *Table 6* shows renewable energy as a significant determinant of green growth at 5% confidence level. Meanwhile, the variable becomes insignificant when population is added to the model. The result implies that an increase in renewable energy in MENAT countries with regulated population will promote green growth in the long run. This finding is consistent with previous studies (Jebli and Youssef, 2017; Majeed and Luni, 2019; Tawiah et al., 2021) who argued that renewable energy is more beneficial to the environment. Meanwhile, the finding is in contrast with some studies (Al-Mulali et al., 2016; Belaid and Youssef, 2017; Kahia et al., 2019; Sharif et al., 2019) who argued that renewable energy has potential of exerting negative influence on environmental quality because it requires large expanse of resources like land and water that are limited in supply, and this can increase ecological footprint with attendant effect on the environment.

Table 6. *DCCE-MG results*

	(1)		(2)	
Variables	**Coefficient**	**t-statistics**	**Coefficient**	**t-statistics**
FDI	0.079	2.770**	0.060***	8.357
RE	0.271	2.948**	-0.019	-0.583
IQI	0.026	0.367	0.827***	7.017
lnGDP_pc	2.558	5.923**	5.409***	9.501
lnPOP			-0.019***	5.29

Carbon_Prod = carbon productivity, FDI = foreign direct investment, RE = renewable energy, IQI = institutional quality index, lnGDP_PC = logarithm of gross domestic product per capita, lnPOP = logarithm of total population. ** and *** denote 5% and 1% significance level

The output from the investigation of institutional quality as a determinant of green growth reveals non-significance of the coefficient, but when the control variable is added, it becomes positive and significant at 1% confidence level. This finding indicates that institutional quality promotes green growth in MENAT countries in the long run when population is controlled. This is consistent with the study of Ibrahim and Law (2016) and Sarkodie and Adams (2018) who argued in their respective study that a well-established institutional quality can reduce CO_2 emissions, but in contrast to the studies of De Angeli et al. (2019), Nguyen et al. (2018), and Wolde-Rufael and Weldemesle (2020), who suggest strong environmental regulations could result to less innovation and creativity towards environmental improvement, which can as well be counterproductive to development; as well as the study of Tawiah et al. (2021) who showed insignificant relationship between institutional quality and green growth.

As expected, the finding from the estimation of GDP per capita as a determinant of green growth as presented in *Table 6* reveal to be positive and significant. This is an indication that GDP per capita promotes green growth in MENAT countries in the long run at 5% confidence level. The sign of the parameter remains unchanged in column 3 when population is controlled. The finding is congruent with some previous studies (Ardakani and Seyedaliakbar, 2019; Chen et al., 2019; Mikayilov et al., 2018; Rahman et al., 2020; Wang et al., 2019; Xie and Liu, 2019), but contrasts to some studies

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(Adebayo et al., 2021; Adedoyin et al., 2020; Cai et al., 2018; Pata, 2018; Tawiah et al., 2018) who opined that increase in economic development has a devastating effect on the environment. Finally, the estimates for the control variable as presented in *Table 6* shows that population is a significant determinant of green growth. The negative and significant coefficient of the variable indicates that a percentage change in population will reduce the green growth of MENAT countries by 0.019% at less than 1% confidence level. This finding supports the position of Aller et al. (2015) who opined that large population exerts significant impact on environment, as well as the study of Tawiah et al. (2021) who established similar finding in their study.

Robustness check

The results from the FMOLS and DOLS techniques as presented in *Table 7* indicate that foreign direct investment, renewable energy, economic development promotes green growth in MENAT countries in the long run, while population exerts negative impact on the green growth of the sample countries in the long run. Generally, the estimates from FMOLS and DOLS estimations are in tandem with those of DCCE-MG, except for institutional quality that is not significant. The insignificance of the variable in the estimations of FMOLS and DOLS could be because the dependence among the sample countries has been controlled by the DCCE-MG technique. Thus, solely reliance on estimates from FMOLS and DOLS techniques could lead to a flawed outcome and bias inference.

Table 7. *FMOLS and DOLS results*

	FMOLS		**DOLS**	
Variables	(1)	(2)	(1)	(2)
FDI	0.067*	0.049**	0.190**	0.273**
RE	0.096*	0.065*	0.149***	0.225**
IQI	0.077	0.109	-0.084	0.078
lnGDP_pc	1.744**	1.881***	1.252**	9.795**
lnPOP		-1.368***		-3.803***

NCarbon_Prod = carbon productivity, FDI = foreign direct investment, RE = renewable energy, IQI = institutional quality index, lnGDP_PC = logarithm of gross domestic product per capita, lnPOP = logarithm of total population. *, ** and *** denotes 10%, 5% and 1% significance level respectively

Conclusion

This study investigates the significance of foreign direct investment, economic development, institutional quality, and renewable energy as determinant factor for green growth using an unbalanced panel data of 13 selected MENAT countries over the period 1990-2019. We used an innovative panel data estimator (DCCE-MG) that addresses cross-sectional dependency issue among the sample countries, as well as FMOLS and DOLS to ensure robustness of our estimates. Our findings provide sufficient evidence to address the study objectives which are: (i) to determine the significance of determinant factor for green growth in MENAT countries, and (ii) to examine the cointegration among the variables. The results from the Westerlund and Edgerton (2008) test show a cointegration relationship between green growth, foreign direct investment, economic

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development, renewable energy, institutional quality and population in cases of cross-sectional dependency and structural breaks. These findings address second objective of this study, and then conclude that the variables have potential of moving together in the long run. Moreover, the estimate from DCCE-MG addresses the first objective of this study which intends to examine the determinants factors of green growth in MENAT countries. The findings show that foreign direct investment, renewable energy, institutional quality, and GDP per capita promotes green growth, while population exerts a devastating effect on green growth in MENAT countries. This suggests that foreign direct investment, GDP per capita, renewable energy, institutional quality, and population are significant determinants of green growth in MENAT countries. In view of these, it becomes imperative for the countries in the region to pay more attention to inflow of foreign direct investment into their countries, implementation of institutional quality, the economic growth, as well the control of population, because of the heterogeneous nature of the countries (FAO, 2015; UNICEF, 2021); but as a region, owing to their common context of environmental challenges and trans-boundary conflicts (Abumoghli and Goncalves, 2021), especially as noted by Odugbesan and Rjoub (2019, 2020) sustainable development goes beyond a boundary.

An important policy implication in line with the findings from this study is that the results above do not provide concerted information for policy makers in these countries alone, but also individual details for each country's stakeholders since the result of heterogeneity implies that each countries country in the panel of the MENAT region may develop its green growth policies. Moreover, the government of the sample countries and policymakers should tread carefully in choosing international business policies towards green growth by ensuring that the entrance of such investment into their country is beneficial and not detrimental to the host country environment which could create pollution. Against this backdrop, employment of minimal foreign investment with stringent supervision is suggested, so as not to give room for foreign investors' exploitation. In reference to the finding on GDP per capital as a significant determinant, the sample countries should maintain high level of GDP per capita as this will drive the sustainability of green growth in the respective country through the purchase of eco-friendly products. Another policy implication on the renewable energy as a determinant factor is that policy makers should promote renewable energy through grant offers and loans to investors in this industry, as well as tax holiday which would give leverage to the investors and thus contribute to the reduction of emissions, and consequently achieve sustainable green growth. In reference to the institutional quality, policy makers should ensure that a well-established institutional quality is in place but not too strict to avoid the trap of being counterproductive to economic growth and development (De Angelis et al., 2019; Wolde-Rufael and Weldemeskel, 2020). Finally, the policy makers should put in place a policy that will address the geometrical growth of population in the MENAT countries which showed in this study to have a devastating effect on achieving green growth. Therefore, we encourage the government and policymakers to ensure that the population is checked in order to achieve sustainable green growth in the region.

Though, this study contributes significantly to the debates on investigating the determinants of green growth, meanwhile it is not devoid of limitation. The limitation lies in the number of determinant variables and control variable. Future studies can expand the model and add more variables, and also disaggregate the institutional quality to ascertain which of the six dimensions actually contribute to sustainable green growth.

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The investigation of more possible determinants of sustainable green growth is to avoid the omitted variable bias that could arise from the limited number of variables used in this study. Nevertheless, this study can help policy makers to balance sustainable green growth, economic growth, internationalization, institutional quality, environmental cost, and population.

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