Foreign Direct Investment–CO2 Emissions Nexus in Middle East and North African countries: Importance of Biomass Energy Consumption

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ABSTRACT: This study examines the association between foreign direct investment (FDI) and carbon emissions for the Middle East and North African (MENA) region in 1990–2015, including biomass energy consumption as an additional determinant of carbon emissions. We apply the generalized method of moments (GMM) to validate the existence of the pollution haven hypothesis (PHH). The N-shaped association is also validated between FDI and carbon emissions. The link between economic growth and carbon emissions is inverted-U and N-shaped; that is, it satisfies the environmental Kuznets curve (EKC) hypotheses. Biomass energy use lowers carbon emissions, and the causality analysis reveals that FDI causes CO_2 emissions. Clearly, the results confirm the existence of a feedback effect between economic growth and carbon emissions. The connection between biomass energy use and CO_2 emissions is also bidirectional. The empirical findings suggest policy makers to design comprehensive trade and energy policies by targeting the cleaner production practices, for not only to ensure environmental sustainability, but also to fulfil the objectives of sustainable development goals.

Keywords: Foreign Direct Investment, Carbon Emissions, Middle East and North Africa, Generalized Method of Moments, Biomass Energy

1. Introduction

In the last decade, the Middle East and North African (MENA) region has experienced rapid economic development as consequence of natural resources. These economies have transitioned from being agricultural to industrial, and finally, to service-driven economies, along with increase in foreign direct investment (FDI)[1] (Charfeddine and Mrabet, 2017). However, this development has not been attained without cost — a heavy toll paid by the region's ecosystem. Economic growth patterns driven by intensive energy use and foreign investment in dirty industries have led to degradation (Arouri et al., 2012; Omri, 2013; Farhani and Shahbaz, 2014; Sinha and Sen, 2016; Kahia et al., 2017; Paramati et al., 2017). MENA remains in an early stage of industrialization, which is characterized by an increase in manufacturing production. There is a consensus in the necessity of adopting optimal economic and energy policies to prevent and control environmental degradation in this region. We chose MENA countries as a sample for this study based on different factors. First, the MENA region generates around 39% of crude oil and gas and a variety of non-oil fuels. It also has a high availability of mineral and non-mineral natural resources. Energy production and consumption from these sources generate 85% of all greenhouse gas (GHG) emissions in MENA (Charfeddine and Mrabet, 2017; Kahia et al., 2017). In 2013, MENA's emissions were estimated to be more than 2 million metrics tons of CO_2 equivalent, which represented more than 6% of the worldwide emissions from fossil fuel combustion (Boden et al., 2011; Farhani, 2013). Lastly, we also need to mention that MENA countries have not signed the Kyoto protocol, which was a mandate for keeping the emissions below a predefined limit. Owing to these reasons, the present study has focused on MENA countries.

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[1] Foreign direct investment (FDI) are the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term and short-term capital as shown in the balance of payments.

Figure-1 reflects the evolution of CO_2 emissions (in metric tonnes), gross domestic product (GDP) per capita (in US dollars), and FDI inflows (in US dollars) in 17 selected MENA countries[2] for 1990–2015. A huge share of global transactions involving petroleum products are derived from this region (Farhani and Ben Rejeb, 2012). MENA is also home to abundant non-fuel minerals and non-mineral resources. Algeria, Morocco, Tunisia, Jordan, and the Syrian Arab Republic produce more than 60% of the world's phosphate. Iran is very rich in a variety of natural resources, while Morocco contains over 30% of the world's phosphate rock and controls 40% of the international phosphoric acid trade. Mauritania has iron, copper, and gypsum; Israel and Jordan own potash. Qatar is a chief exporter of ammonia and urea; Egypt and Sudan produce cotton. The Syrian Arab Republic produces tobacco; and Yemen is a significant exporter of coffee (Farhani and Shahbaz, 2014).

In addition to offering substantial natural resources, MENA countries have also emerged as one of the most profitable settings for renewable energy generation projects (CEP, 2016). Despite the potential to expand renewable sources, they only make up 1% of the MENA's energy mix; in contrast, 20% of global energy use is derived from renewable sources (Jalilvand, 2012; Kahia et al., 2017). In the MENA region, the investment in renewable energy projects mainly comes from governments, which usually withstand the energy market by subsidizing energy prices for end-users.

Figure-1. CO_2 Emissions, Income and FDI in the MENA (1990–2015)

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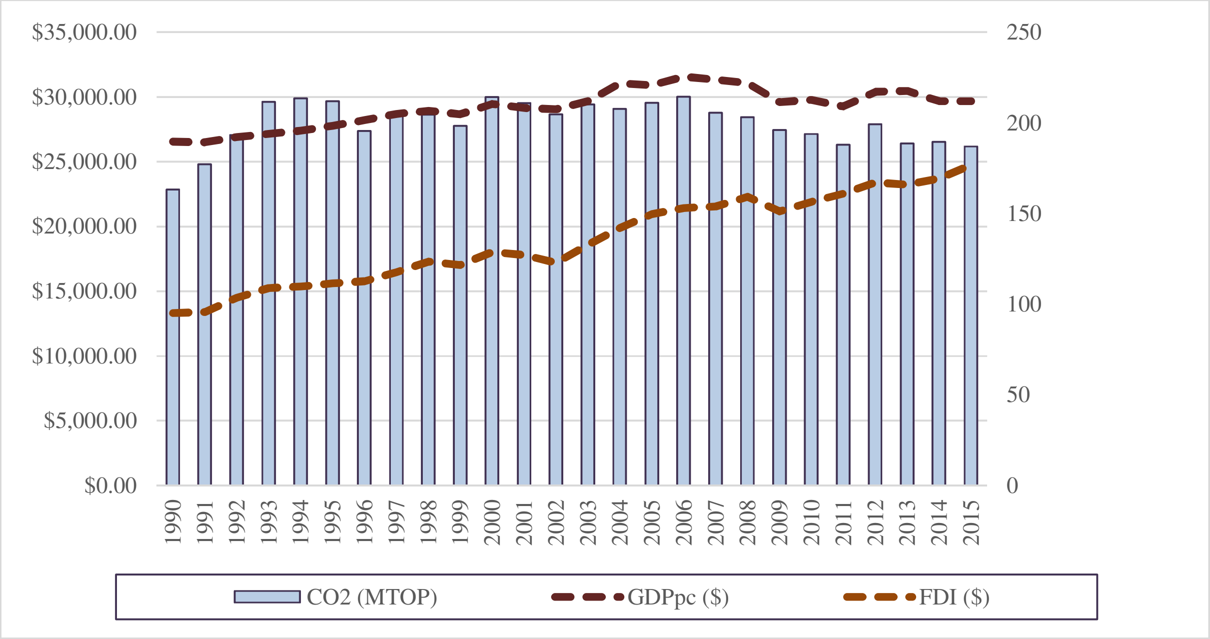
[2] Algeria, Bahrain, Egypt, Ethiopia, Iran, Iraq, Israel, Jordan, Kuwait, Libya, Morocco, Oman, Qatar, Saudi Arabia, Sudan, Tunisia, the United Arab Emirates (UAE), and Yemen.



Notes: Main Axis GDPpc (U$D); FDI(U$D/100), Second Axis CO$_2$ *(MTOP)*
Source: OECD (2018), WDI (2018).

In accordance with these supportive actions, private investments in renewable energy sources should be encouraged (Kahia et al., 2017; Shahbaz et al., 2018). Thus, it is necessary to avoid failures and bankruptcies, and improve the system of incentives for the promotion of renewable energy use (e.g. capital subsidies, feed-in tariffs, investment tax credits, or training incentives, among others). Additionally, MENA governments should promote regulatory and market incentives, such as tradable clean development instruments, competitive bidding processes, and tax incentives (OECD, 2013). These mechanisms can help endorse economic growth by guaranteeing that the resultant energy mix would be sustainable and efficient (REN21, 2013).

While taking about sustainability and efficiency, it should be remembered that the standard of production processes followed in a nation plays a major role in shaping the future of sustainability of that particular nation. Moreover, the world is ushering age of sustainable development goals (SDGs), which the nations have to fulfill by the end of 2030. In light of this incident, it becomes necessary to assess the existing energy and other economic policies of a nation, so that the capability of that nation towards the fulfillment of SDG objectives can be evaluated. More than the methodological aspect, this study aims to look into the policies for sustainable development in MENA countries, by focusing at cleaner production processes. Extant literature shows a limited analysis of the impact of renewable energy projects in emerging regions, with a special focus on MENA (Kahia et al., 2017). Our study empirically explores the role that biomass energy and FDI play in controlling CO_2 emissions, following an economic growth-environment degradation nexus. We establish how FDI extrapolates directly and indirectly to environmental degradation. We attempt to characterize the economic stage of the region through a validation or negation of the pollution haven hypothesis (PHH) in MENA. This paper offers a four-fold contributions to existing literature on energy.

1. We analyze the connection between FDI and CO_2 emissions by including additional determinants, such as economic growth and biomass energy use in carbon emissions function for MENA. The PHH, is also explored in the context of Environmental Kuznets Curve (EKC) hypothesis, which shows the connection between economic growth and carbon emissions.
2. We apply panel unit root and cointegration tests to confirm the stationary and cointegration between the variables.
3. We employ the generalized method of moments (GMM) to discover the impacts of foreign direct investment, GDP, and biomass energy consumption on per capita CO_2 emissions.
4. We investigate the causal associations between CO_2 emissions and other explanatory variables by means of a non-parametric causality test.

Our empirical results confirm the EKC hypothesis in the MENA region. The PHH is also confirmed between FDI and environmental degradation. We also confirm an N-shaped relationship, which exists not only between economic growth and carbon emissions, but also between FDI and carbon emissions. Biomass energy consumption leads to the fall in CO_2 emissions. The non-parametric causality analysis divulges a bidirectional causal nexus between economic growth and carbon emissions. FDI generates carbon emissions, while biomass energy use causes FDI. Based on these empirical findings, we have recommended several ways to achieve the different SDG objectives, which can prove to be beneficial for the MENA countries, and in the literature of environmental economics, this study has shown a way how cleaner production can be a vehicle to achieve SDG objectives for the MENA countries. Since the days of millennium development goals, comprehensive policy designing in the MENA countries has been a problem, and researchers have identified this issue (Sakmar et al., 2011; Abou-Ali and Abdelfattah, 2013). Apart from the contextual and methodological contributions, this study contributes towards the policy design, as this is the first ever study in literature to discuss the policy perspectives for implementation of SDG objectives in the MENA countries considering the cleaner production practices.

The rest of our paper is organized as follows. Section 2 reviews extant literature that supports our main hypotheses. Section 3 analyses the underlying methodological framework, data construction, and econometric procedure. Section 4 reports our empirical results. Finally, the concluding remarks and policy implications of our empirical results are drawn in section 5.

2. Literature review

2.1 Economic growth–CO_2 emissions nexus

The theoretical underpinning of the EKC hypothesis is that deterioration of environmental quality is a non-linear function of economic activity until a certain income level is reached and then improvements in environmental quality begin to appear. This behavior indicates that, in a developing stage of a nation, deterioration of environmental quality rises until a critical point is reached, beyond which economic systems experiment a decline in environmental degradation. One approach to explain this is through an inverted-U shaped association between income and ecological fortification, supported by the generally accepted EKC hypothesis (Grossman and Krueger, 1991; Sinha and Shahbaz, 2018). Other studies examine different behaviors of this model (for a detailed review, please see Shahbaz and Sinha, 2019). Several studies have obtained an N-shaped EKC, according to which the relationship between income and ecological fortification is positive until the first turnaround point, and then it becomes negative as it approaches the second turnaround point, beyond which it turns positive again. In other words, economic systems can experience a stage of environmental correction after a situation where income directly impacts environmental degradation, such as the adoption of new energy regulations; however, if these economies don't adopt the necessary measures, they will again experience an ascending emissions pattern (Álvarez and Balsalobre, 2017). The final stage in this pattern is regarded as sturdy development process with a dip in economic growth rate which occurs as a result of weak environmental fortification policies (Torras and Boyce, 1998; Álvarez et al., 2017; Balsalobre et al., 2018, Sinha et al., 2018). This stage can occur when successive improvements are exhausted, and technical obsolescence leads to the need for new pollution-reducing technologies (Balsalobre and Álvarez, 2016). Shahbaz and Sinha (2019) have given a detailed literature survey discussing this issue.

This behavior reflects how economic growth impacts environmental process through scale, composition, and technical effects. While the *scale effect* reflects how a rise in manufacturing will worsen environmental quality in initial phase of development (Torras and Boyce, 1998), at the second phase of development, a structural shift to heavy industries increases this deterioration, which then encourages a shift toward light manufacturing. This transition to less-polluting activities, which brings about an upturn in environmental quality, reflects the *composition effect* (Hettige et al., 2000). The *technical effect* reflects the adoption of cleaner technologies at a later phase of development. The technical effect is closely connected with the N-shaped EKC (Álvarez et al., 2017; Balsalobre et al., 2018), with the assumption that environmental quality starts to deteriorate again at a low growth rate. In this phase, composition and technical effects are surpassed by the scale effect, and thereby, lead toward technical obsolescence.

2.2. FDI and economic growth–CO_2 emissions relationship

Extant literature warns that FDI inflows can damage the environment and environmental regulations, especially in locations fraught with pollution-intense industries and where the environmental standards are more permissive. Abdouli and Hammami (2017) have studied this phenomenon in developed nations. Globalization has accelerated structural changes and economic measures, which have promoted the integration of developing economies. Similarly, we attempt to confirm the rise in pollution-intense industries in MENA through the validation of the PHH.

There exists a competition between emerging economies for offering enticing investment opportunities that provide direct funding capital to accelerate economic development through technology transmission, and productivity gains (Lee, 2013). Researchers have simultaneously examined the impact of FDI on environmental quality and economic growth (Nguyen and Nguyen, 2007; Anwar and Nguyen, 2010; Azman-Saini et al., 2010; Lau et al., 2014; Omri et al., 2014; Abdouli et al. 2018; Liu and Lin, 2019)[3]. In support of the PHH in MENA countries, researchers have also focused solely on FDI's impact on environmental quality (Neequaye and Oladi, 2015; Shahbaz et al., 2015). According to the PHH, the scale effect is predominant, while the pollution

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[3] Details of these studies are provided in Appendix 1.

halo hypothesis maintains that societies and environment are controlled by the technical effect[4]. By contrast, the composition effect focuses on pollution. Therefore, for developing nations, it is difficult to discover any evidence supporting the PHH. When a country's cost of legal enforcement of pollution regulations is less than other production costs, that country can gain a competitive edge (Copeland and Taylor, 2003). Labor-intensive manufacturing activity is comparatively not as ecologically harmful, when compared with its capital-intensive counterparts. In such a scenario, technology diffusion by means of FDI inflows aids developing nations in replacing old pollution-causing technology (Gallagher, 2004, 2009). In this context, studies by Ouyang and Lin (2015) and Shahbaz et al. (2015) have shown the evidence in favor of the PHH, whereas Al-Mulali and Tang (2013), Zhang and Zhou (2016), and Paramati et al. (2016) have put forward counter evidence. A recent study by Liu et al. (2017) demonstrates that FDI inflows can possibly reduce CO_2 emissions, and they have advocated the utilization of advanced clean technology acquired by means of FDI. On the other hand, Bakhsh et al. (2017) have recommended that FDI should not be encouraged at the cost of environment. In addition, Solarin et al. (2017) have shown that FDI contributes to a rise in CO_2 emissions in Ghana. Similarly, Koçak and Şarkgüneşi (2017) confirmed the pollution haven and EKC hypotheses in Turkey.

2.3. Biomass energy use and economic growth–CO_2 emissions relationship

Finally, an IEA (2016) report shows that developing nations prefer *biomass energy consumption*, whereas more developed nations steer toward cleaner alternatives. This reduction in biomass energy consumption along the growth trajectory can be validated by the EKC hypothesis

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[4] The scale effect shows how higher production generates more emissions. Thus, increases in FDI inflows could imply an ascending degradation process; otherwise, the composition (or structural) effect reflects changes in the sectoral composition of a nation, as a consequence of the economic paradigm shift. Hence, positive or negative effects resulting from the composition effect depend on the productive specialisation, the environmental standards, or competitiveness of a country (Cole and Elliot, 2003). When the countries increase the adoption of new and more efficient technologies, the technical effect accelerates the transition to the developed phase (Stern, 2004). In other words, the technical effect reflects the enforcement of climatic by-laws and cleaner technologies, which are expected to have a positive impact on the environment (Pazienza, 2015).

(Foster et al., 2000; Victor and Victor, 2002). Based on the efficiency of land utilization, generation of feedstock and their sustainability, Fischer et al. (2010) observe the variance of biomass energy efficiency among EU nations. On the other hand, other studies lay aside the negative environmental impact of biofuels to focus on the energy-saving advantages, such as reducing ambient air pollution, and focus on the low production costs associated with biofuels (Okimori et al., 2003; Johnson, 2009; Reinhardt and Falkenstein, 2011; Acaroglu and Aydogan, 2012; Bilgili, 2012; Ahmed et al. 2016)[5]. However, recent evidence on Next Eleven (N11) countries by Sinha et al. (2017) contradicts this. Mixed results are observed by Adewuyi and Awodumi (2017) in selected African countries. For some countries, biomass energy use adversely affects carbon emissions, while in other countries, the impact is trivial. Their overall findings suggest that inefficiency of biomass energy use is reflected in its role in augmenting CO_2 emissions. Therefore, we cannot reach any consensus regarding this association.

In the course of the review of literature, we have not come across any study, which is carried out on the MENA countries focusing at the sustainable development at large. The studies conducted in this pursuit have produced dissociated results, and therefore, these studies cannot give a wholesome picture about the way to address the SDG objectives. There lies a research gap in terms of policy prescription for the MENA countries in order to attain the objectives of SDGs, and the present study addresses that particular gap, while considering the cleaner production practices as the major vehicle to attain these objectives.

3. Theoretical modelling and data collection

Grossman and Krueger (1991) report that ecological fortification is an inverted-U shaped function of economic growth, and subsequent to this study, empirical evidence of this association

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[5] Details of these studies are provided in Appendix 1.

has been extensively outlined in the literature of the EKC (Shafik and Bandyopadhyay, 1992; Stern et al., 1996; Stern, 2004; Dinda, 2004; Shahbaz and Sinha, 2019). The EKC's scheme suggests that the deterioration of environmental quality rises with extent of economic activity until a certain point, beyond which an ascending income level leads to a recovery of environmental quality (Selden and Song, 1994).

Our study suggests that FDI can have a possible impact on carbon emissions through scale, technique, and composition effects, even though extant literature on this association doesn't offer irrefutable evidence. For example, Liu et al. (2018) validate the presence of both the PHH and pollution halo hypothesis. Similarly, Koçak and Şarkgüneşi (2017) sanction the existence of EKC and PHH, in Turkey. The impact of biomass energy consumption is, however, ambiguous. Bilgili et al. (2016) argue that fossil fuel usage increases carbon emissions and deteriorates environmental quality, and vice versa. Thereby, extending the model of Panayotou (1993), this discussion leads us to construct an empirical model using an inverted-U shaped EKC framework, as shown below:

$$\ln C_{it} = \beta_0 + \beta_1 \ln Y_{it} + \beta_2 \ln Y_{it}^2 + \beta_3 \ln F_{it} + \beta_4 \ln F_{it}^2 + \beta_5 \ln B_{it} + \varepsilon_{it} \tag{1}$$

Where, *C* is the per capita CO_2 emissions, *Y* is the per capita GDP, *F* is the per capita FDI, *B* is the per capita biomass consumption, ε is the stochastic error, *i* is the cross sections, and *t* is the time series. All the variables are log-transformed. The novelty of our study is found in its support of an N-shaped EKC, following the trilateral nexus between economic growth, FDI, and CO_2 emissions. Equation 1 also includes biomass energy consumption as an indicator of carbon emissions. The N-shaped EKC model illustrates how economic systems reached a level of income (i.e. first turnaround point) and also experience a dip in their pollution levels with ascending level of income (de Bruyn and Opschoor, 1997; Sengupta, 1997). The traditional inverted U-shaped EKC can be explained by considering FDI as a proxy of economic growth, as it indicates the level of economic activity in a nation (Manzoor and Chowdhury, 2017; Yan and An, 2017). The linear association described in the literature suggests that a rise in FDI directly impacts economic growth, whereas in the case of a cubic association, FDI and economic growth have a direct relationship only at extreme levels of FDI (Manzoor and Chowdhury, 2017). Extending the model of Sinha et al. (2017), the empirical model that explains the N-shaped EKC framework between the variables is constructed as follows:

$$\ln C_{it} = \alpha_0 + \alpha_1 \ln Y_{it} + \alpha_2 \ln Y_{it}^2 + \alpha_3 \ln Y_{it}^3 + \alpha_4 \ln F_{it} + \alpha_5 \ln F_{it}^2 + \alpha_6 \ln F_{it}^3 + \alpha_7 \ln B_{it} + \varepsilon_{it} \quad (2)$$

In Equation 2, where C_{it} denotes per capita CO_2 emissions (an indicator of deterioration in environmental quality), Y_{it} is real GDP per capita (indicator of growth), F_{it} is real FDI per capita, B_{it} is biomass energy consumption, and ε_{it} is the error term.

In Equation 2, when α_1, α_2, and α_3 are respectively and significantly positive, negative, and positive, this indicates the presence of an N-shaped EKC, which may amplify the income-pollution relationship in the long run (Shafik and Bandyopadhyay, 1992; Selden and Song, 1994; Grossman and Krueger, 1995; Torras and Boyce, 1998). Balsalobre and Álvarez (2016) provide a comprehensive theoretical background of this type of EKC. Similarly, the N-shaped EKC is confirmed between FDI and carbon emissions if $\alpha_4 > 0$, $\alpha_5 < 0$, and $\alpha_6 > 0$. It implies that carbon emissions increase, decreases, and rise at initial, maximum, and higher levels of FDI.

In order to bring forth additional insights to the study, we have formulated the following models in keeping with the study by Sinha et al. (2017):

$$\ln C_{it} = \rho_0 + \rho_1 \ln Y_{it} + \rho_2 \ln Y_{it}^2 + \rho_3 \ln Y_{it}^3 + \rho_4 \ln F_{it} + \rho_5 \ln F_{it}^2 + \rho_6 \ln F_{it}^3 + \rho_7 \ln B_{it} + \rho_8 \ln F_{it} * Y_{it} + \varepsilon_{it} \tag{3}$$

$$\ln C_{it} = \theta_0 + \theta_1 \ln Y_{it} + \theta_2 \ln Y_{it}^2 + \theta_3 \ln Y_{it}^3 + \theta_4 \ln F_{it} + \theta_5 \ln F_{it}^2 + \theta_6 \ln F_{it}^3 + \theta_7 \ln B_{it} + \theta_8 \ln F_{it} * Y_{it} + \theta_9 \ln B_{it} * Y_{it} + \varepsilon_{it} \tag{4}$$

The interaction between (a) FDI and economic growth and (b) biomass energy use and economic growth demonstrate how the economic cycle extrapolates the effect of these variables on CO_2 emissions. In Equations 3 and 4, we include the interaction effects in order to analyze, if the economic cycle increases or moderates the effect that FDI and biomass exert on CO_2 emissions. If the coefficients ρ_8, θ_8, and θ_9 show a negative sign, it implies that the economic cycle reduces the effect of coefficients ρ_4, θ_4, and θ_7 of FDI and biomass energy use. These variables have been included to explore the effect of moderation under the generally accepted EKC framework.

Our study involves yearly data from 1990-2015 on CO_2 emissions (metric tons), real GDP (constant 2011 US dollars), and foreign direct investment inflows (constant 2011 US dollars) are taken from the World Development Indicators (World Bank, 2017). The data on biomass energy consumption is taken from *materialflows.net*. The descriptive statistics and correlations among the model parameters are provided in Table 1. We find that FDI is more volatile than biomass energy consumption, but it is less volatile than carbon emissions. We also find that economic growth is positively correlated with CO_2 emissions. Biomass energy consumption negatively correlates to CO_2 emissions, while FDI and carbon emissions are positively correlated. FDI, biomass energy consumption, and economic growth are all positively correlated, and these associations are statistically significant.

Table 1. Descriptive statistics and pair-wise correlations

Variables	Mean	Stand. Dev.	Minimum	Maximum
lnC	1.4412	1.6961	-3.2073	4.2625
lnY	9.5897	1.2990	6.2446	11.8654
lnF	9.8733	2.6792	3.8082	13.5383
lnB	9.5532	2.1046	4.3911	12.9615
Variables	lnC	lnY	lnF	lnB
lnC	1.0000			
lnY	0.2676	1.0000		
lnF	0.1224	0.3911	1.0000	
lnB	-0.0480	0.13201	0.2877	1.0000

4. Estimation strategy

4.1. Unit root tests

The estimation of the empirical model starts with testing the unit root properties of the variables. Now, according to the assumption of cross-sectional dependence, we proceed with Levin–Lin–Chu, Breitung, Im–Pesaran–Shin, and Fisher's augmented Dickey–Fuller (ADS) unit root tests. Levin et al. (2002) recommend a panel unit root test (LLC) as an augmentation of the ADF unit root test:

$$\Delta y_{it} = \varphi_{it}\beta_{i,t-1} + \rho * y_{i,t-1} + \sum_{j=1}^{ni} \varphi_{ij}\Delta y_{i,t-j} + \varepsilon_{it} \qquad (6)$$

where y is the variable under consideration, φ covers individual deterministic components, ρ is the autoregressive coefficient, ε_{it} is the stochastic error, and n is the lag length. The LLC test considers

ρ to be persistent across the cross sections (Breitung, 2000). Im et al. (2003) protracted the LLC test by allowing ρ to diverge across cross sections (IPS-test):

$$\Delta y_{it} = \varphi_{it}\beta_{i,t-1} + \rho_i * y_{i,t-1} + \sum_{j=1}^{ni} \varphi_{ij}\Delta y_{i,t-j} + \varepsilon_{it} \tag{7}$$

Furthermore, the Fisher tests recommended by Choi (2001) utilize these time-series unit root tests within the panel framework. The advantage of this measure lies in aggregating each series' p-value derived out of the unit root tests, as opposed to averaging individual test statistics (Im et al., 2003). For the LLC, Breitung, IPS, and Fisher unit root tests, non-stationary across cross-sections (H_0: $\rho_i = 0$) constitute the null hypothesis against the alternate hypothesis of stationarity (H_1: $\rho_i < 0$).

4.2 Westerlund (2007) cointegration test

We apply Westerlund's (2007) panel cointegration test approach to check for cross-sectional dependence and heterogeneity to analyze the dynamic cointegration relationship among the model variables. Westerlund's (2007) test is generally applied for a short time series, producing reliable and robust results. This test circumvents the common factor restriction issue and is designed to test the null hypothesis of no cointegration by inferring whether the error-correction term in a conditional error-correction model is equal to zero. To check the cointegrating association between $y_{i,t}$ and $x_{i,t}$, we have estimated the subsequent error-correction model:

$$\Delta y_{it} = \delta_i' d_t + \alpha_i\left(y_{it-1} - \beta_i' x_{i,t-1}\right) + \sum_{j=1}^{P_i} \alpha_{ij}\Delta y_{i,t-j} + \sum_{j=0_i}^{P_i} \gamma_{ij}\Delta x_{i,t-j} + \varepsilon_{it} \tag{8}$$

Where d_t contains the deterministic element, and cointegration is expressed by $y_{it-1} - \beta_i' x_{i,t-1} = 0$. α_i measures the velocity of adjustment, and cointegration is assured by $\alpha_i < 0$, whereas $\alpha_i = 0$ falsifies the presence of cointegration.

The test statistics are segregated into group statistics (Gt) and panel statistics (Pt). While the former does not require the error-correction information, the latter pools information from the cross-section wide error-correction term.

$$G_t = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)};\ and\ G_\alpha = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \tag{9}$$

where $\hat{\alpha}_i$ is the probabilistic approximation for *i*th element, $SE(\hat{\alpha}_i)$ is the respective standard error, and $\hat{\alpha}_i(1) = 1 - \sum_{j=1}^{P_i}\hat{\alpha}_{ij}$. Moreover, these test statistics are asymptotically normal, and possess significant small-sample properties. Additionally, these tests can take care of the heterogeneity issue and cross-sectional dependence by bootstrapping.

$$P_T = \frac{\hat{\alpha}}{SE(\hat{\alpha})};\ P_\alpha = T_{\hat{\alpha}} \tag{10}$$

Where, $\hat{\alpha}$ is the standardized speed of correction and $SE(\hat{\alpha})$ is the standard error. The null hypothesis to be investigated is that there is no cointegration for at least one cross section for the Gt and all cross-section for Pt.

4.3 Generalized method of moments

In our study, the motivation to employ GMM for mathematical modelling is that the estimates are correct and robust without the impact of serial correlation in stochastic terms. This technique not only takes care of unobserved fixed effects, but also removes endogeneity by introducing a correlation between stochastic error and model parameters, and, in doing so, transforming the stochastic error to *white noise* (Halkos, 2003). Additionally, GMM considers all model parameters, along with the lagged dependent variable, to be exogenous, and therefore, they considered usable instruments.[6] GMM also controls for the issues of endogeneity and heteroskedasticity, generating efficient parameter estimates (Arellano and Bond, 1991). The correlation between model parameters and instrumental variables eliminates the association between model parameters and error term. Through eradicating endogeneity, we put back the forms of orthogonality toward the model parameters to realize *unbiased and reliable estimates* (Halkos, 2003). Arellano and Bond (1991) and Arellano (1993) utilize this method to empirically assess mono-equation and system together. We select GMM for our study because, (a) in the absence of MLE, this method suggests a straightforward alternate for other estimators, (b) it encapsulates a number of classical estimators, and thereby, allows us to appraise and equate them, (c) the robustness of this method comes from its non-reliance on the distribution of stochastic errors, and (d) it is an asymptotically unbiased and reliable estimator, which controls for heteroscedasticity, despite the matrix of pairwise orthogonal elements.

5. Discussion of empirical results

As a first step of the estimation process, stationarity of the variables is checked by employing the unit root tests. Prior to application of this tests, the Pesaran (2004) test is used to verify the interdependence of the cross-sections in the data, and the results are recorded in Table 2. Alternate hypothesis of cross-sectional dependence is confirmed through the empirical results, signifying

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[6] In our study, powered terms of urbanisation and inflation are used as instruments. The source of data for both them is the World Bank Indicators (World Bank, 2017).

independent cross-sections across the panel, and thereby, confirming the applicability of the first-generation panel unit root tests.

Table 2. Results of cross-section dependence test

Variables	Lags			
	1	2	3	4
lnC	-1.268 (0.916)	-0.935 (0.944)	-0.620 (0.963)	-0.626 (0.982)
lnY	-1.252 (0.780)	-0.722 (0.871)	-0.522 (0.897)	-0.173 (0.985)
$\ln Y^2$	-2.042 (0.811)	-1.326 (0.837)	-1.041 (0.968)	-0.873 (0.999)
$\ln Y^3$	-1.937 (0.906)	-1.254 (0.956)	-1.003 (0.985)	-0.845 (0.999)
lnF	-2.091 (0.450)	-1.500 (0.575)	-1.976 (0.669)	-1.174 (0.711)
$\ln F^2$	-1.945 (0.443)	-1.993 (0.487)	-2.016 (0.580)	-1.635 (0.692)
$\ln F^3$	-2.061 (0.130)	-1.935 (0.210)	-2.007 (0.221)	-1.679 (0.621)
lnB	-1.937 (0.372)	-1.411 (0.481)	-1.523 (0.840)	-1.308 (0.973)
lnF*Y	-2.351 (0.117)	-1.935 (0.262)	-1.980 (0.416)	-1.890 (0.808)
lnB*Y	-1.295 (0.389)	-1.984 (0.790)	-1.812 (0.898)	-1.677 (0.919)

Note: t-bar values are reported; p-values are within parentheses.

Table 3. Unit root analysis

Variables	LLC		Breitung		IPS		Fisher-ADF	
	Level	First Diff.	Level	First Diff.	Level	First Diff.	Level	First Diff.
lnC	-1.0015	-10.7060^a	1.6350	-8.8211^a	-1.1347	-12.8446^a	2.5731	72.5095^a
lnY	1.3063	-5.6890^a	7.5483	-5.6560^a	5.4863	-9.8882^a	-1.3691	45.4646^a
$\ln Y^2$	1.6473	-5.5764^a	7.6387	-5.6586^a	5.7737	-9.8169^a	-1.4638	44.8874^a
$\ln Y^3$	1.9912	-5.4566^a	7.7254	-5.6558^a	6.0592	-9.7385^a	-1.5518	43.8841^a
lnF	-1.2247	-22.0040^a	3.4433	-6.3837^a	-0.4553	-11.3338^a	0.5352	15.7165^a
$\ln F^2$	-0.8617	-21.3830^a	3.5639	-6.3633^a	-0.1973	-11.1919^a	-0.2131	11.7458^a
$\ln F^3$	-0.4864	-2.7459^b	3.6739	-2.3358^c	0.0535	-3.8932^a	-0.6378	5.6065^a
lnB	0.9273	-10.1391^a	4.5206	-6.2231^a	1.1251	-12.6154^a	-0.6945	76.2215^a
lnF*Y	0.6046	-7.1336^a	3.7255	-6.7439^a	0.7331	-11.0701^a	0.7840	55.4047^a
lnB*Y	-0.5068	-9.2650^a	5.8925	-5.7844^a	2.5529	-12.4155^a	-1.8413	73.3799^a

Note: ^{a} value at 1% significance level; ^{b} value at 5% significance level; ^{c} value at 10% significance level.

We explore the order of integration of the variables using four first generation panel unit root tests (see Table 3). The empirical results show that all the variables are non-stationary at level and stationary at the first difference, indicating that all of the variables are integrated to order one; that is, they are I(1) in nature. Next, we examine the possibility of any cointegrating association using the Westerlund (2007) test of cointegration; results are recorded in Table 4. The test statistics indicate that the cointegrating association is significant, thereby confirming a long-run association. With this evidence, we can proceed to the GMM analysis (see Table 5).

Table 4. The Westerlund (2007) cointegration test

Statistic	Value	Z-value	P-value	Robust P-value
G_t	-3.053	-4.432	0.000	0.000
G_a	-11.405	-0.910	0.181	0.000
P_t	-11.504	-3.666	0.000	0.000
P_a	-9.382	-1.896	0.029	0.000

Table 5. GMM estimation results

Independent Variables	Model I	Model II	Model III	Model IV
lnY	3.3163^a	12.3427^a	3.7666^a	19.2312^a
$\ln Y^2$	-0.1807^a	-1.2224^a	-0.3471^c	-1.8552^a
$\ln Y^3$	-	0.0381^a	0.0102^b	0.0576^a
lnF	0.3249^a	0.3586^c	0.5575^a	0.6144^b
$\ln F^2$	-0.0199^a	-0.0683^a	-0.0413^b	-0.1036^a
$\ln F^3$	-	0.0035^a	0.0028^a	0.0050^a
lnB	-0.1514^a	-0.1813^a	-0.1682^a	0.1550
lnF*Y	-	-	-0.0513^a	-
lnB*Y	-	-	-	-0.0348^b
Constant	-16.4810^a	-44.3013^a	-19.1624^a	-68.7611^a
Hansen's J statistics	1.35148	1.39081	0.7250	0.9050
DWH Test statistics	18.1742^a	22.5561^a	71.1877^a	75.8636^a
Shape of EKC	Inverted-U-shaped	N-shaped	N-shaped	N-shaped
Turnaround Point(s)	$ 9,664.93	$ 3,521.64 $ 552,741.24	$ 7,958.04 $ 894,782.54	$ 6,266.79 $ 337,460.24

Inflection Point	-	\$ 44,119.77	\$ 84,384.35	\$ 45,986.87

Note: ^{a} value at 1% significance level; ^{b} value at 5% significance level; ^{c} value at 10% significance level.

The results reported in Table 5 confirm that the linear and squared terms of real GDP per capita have positive and negative effects on carbon emissions. We can visualize how CO_2 emissions rise ($\beta_1 > 0$) along with ascending per capita income (Y_{it}). After that, CO_2 emissions decrease ($\beta_2 < 0$). This shows that an increase in carbon emissions by 3.3163% is impacted by a 1% rise in real GDP per capita, and the squared term of the latter has a negative coefficient, thereby validating the delinking of carbon emissions at higher levels of economic growth in the MENA region. This shows an inverted U-shaped EKC for CO_2 emissions in the MENA region. These results, which confirm the EKC empirical evidence in the region, are consistent with previous literature (Al-Mulali, 2011; Farhani et al., 2014; Sahli and Ben Reje, 2015; Abdallh and Abugamos, 2017). Al-Mulali (2011) and explore the influence of oil consumption on economic growth for MENA countries, demonstrating the presence of EKC for CO_2 emissions. Abdallh and Abugamos (2017) validate the presence of EKC hypothesis in the MENA region. Conversely, Ozcan (2013) invalidated the EKC hypothesis for 12 MENA countries.

Our empirical results also reflect that for the linear term, FDI directly affects CO_2 emissions, whereas the negative effect can be seen in the case of the squared term. We note that, initially, FDI increases CO_2 emissions ($\beta_3 > 0$), and at later stages of development, CO_2 emissions decrease ($\beta_4 < 0$) after FDI reaches a certain level. This shows that an increase in carbon emissions by 0.3249% is impacted by a 1% rise in FDI per capita, and squared term of the latter has a negative coefficient, thereby validating the delinking of carbon emissions at higher levels of FDI in the MENA region. We note an inverted U-shaped association between FDI and carbon emissions, which validates the presence of PHH. This segment of findings is in the similar line with the findings of Shahbaz et al. (2015) and Solarin et al. (2017).

The nexus between biomass energy use and carbon emissions is negative ($\beta_5 < 0$) and significant, suggesting biomass energy consumption contributes positively to ambient air quality by lowering carbon emissions in MENA countries. The implementation of advanced biomass conversion technologies could reduce the environmental impact of numerous pollutant biomass wastes. Furthermore, governments should encourage the acquisition of non-polluting inputs restructure trade policies. Biomass reduces the cost of generating energy in the region. While the price of fossil fuels is influenced by external factors, and fluctuates accordingly, biomass energy has a very stable production cost. Conversely, renewable energy use would help to reduce energy import dependency. Lastly, governments in this region should improve administrative structure, which is necessary for effective capital account liberalization and FDI inflow. These regions must act against corrupt practices, strengthen the policies of property rights for public goods, and improve other environmental aspects (Abdouli et al., 2018). These empirical findings are similar to Reinhardt and Falkenstein (2011), Bilgili (2012), and Shahbaz et al. (2017). On the contrary, Ahmed et al. (2016), Sinha et al. (2017), and Adewuyi and Awodumi (2017) noted the positive effect of biomass energy use on carbon emissions.

We have also considered cubic specifications of the explanatory variables in Model 2. Estimation results are in Table 5. Our findings show that α_1 , α_2, and α_3 are positive, negative, and positive, respectively, and thereby validating the presence of an N-shaped EKC. This finding is in line with literature (Álvarez et al., 2017). For an N-shaped EKC, deterioration of environmental quality starts at the beginning phase of economic growth, rises with income growth, and then starts to come down after a certain income level is achieved. In the last phase, characterized by high development and low growth rate, the pollution level begins to increase again as a consequence of technological obsolescence (Álvarez et al., 2017). At the inflection point of the income level between the turnaround points, i.e. X(1) and X(2), a gradual decrease in environmental fortification takes place, as the scale effect starts to prevail again (Balsalobre and Álvarez, 2016; Balsalobre et al., 2018; Shahbaz et al., 2018). This inflection point allows us to understand how economic systems need to make additional reforms in terms of environmental protection and to delay technological obsolescence where the composition and technical effects are surpassed by the scale effect (Balsalobre and Álvarez, 2016).

Similarly, linear, squared, and cubic specifications of FDI are included in Model 2 to investigate the possibility of an N-shaped association between FDI and CO_2 emissions (see, Grossman and Krueger, 1995; Cole and Elliott, 2003; Liang, 2006; Pazienza, 2015). Table 5 reflects empirical results, which show that α_4, α_5, and α_6 are positive, negative, and positive, respectively, and thereby, imply an N-shaped relationship between FDI and CO_2 emissions. These empirical results support the findings of Yan and An (2017). Although some studies consider the positive effect of FDI over the technical effect (Pazienza, 2015), results of the present study show that, in MENA nations, employment of technical advances are insufficient in the short-term correction of CO_2 emissions. This finding complies with the fact that attracting FDI inflows will ensure economic growth through fossil fuel energy consumption (scale effect), and thereby, leading toward a rise in CO_2 emissions (Frankel and Romer, 1999). In other words, the scale effect dominates the industry in these emerging countries, confirming the PHH for MENA.

To reinforce this result, the interaction[7] between FDI and income reveals direct impacts of both the variables on CO_2 emissions. This indicates that, in the absence of authoritarian environmental protocols and forfeits for polluters in this stage of economic development for MENA, FDI is a part of pollutant manufacturing firms (He, 2006; Liang, 2006; Neequaye and Oladi, 2015).

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[7] The interaction effect tries to verify the robustness of the relationship between the model parameters and the dependent variable (Cohen et al., 2003).

Consequently, with economic growth, investment in clean industries and service sectors[8] will increase stringent environmental regulation, and by extension, diminish ecological fortification (Managi, 2012). We look at the impact of interaction between income and biomass energy use on CO_2 emissions and find that the impact is negative and significant (for more detailed discussion on this association, see Sinha et al., 2017). This conclusion implies that an ascending economic cycle reduces the dampening impact of biomass consumption on CO_2 emissions (Foster et al., 2000; Victor and Victor, 2002; Sinha et al., 2017). Under an ascending economic trend, an economic system's improvements in energy efficiency leads to a decline in carbon emissions (Kasperowicz, 2015; Sinha et al., 2017). Our findings confirm that along the course of economic growth, an effective pollution control policy will reduce CO_2 emissions by means of clean energy use (Bilgili, 2012; Lin and Moubarak, 2014; Adewuyi and Awodumi, 2017). Figure 2 presents the conceptual scheme.

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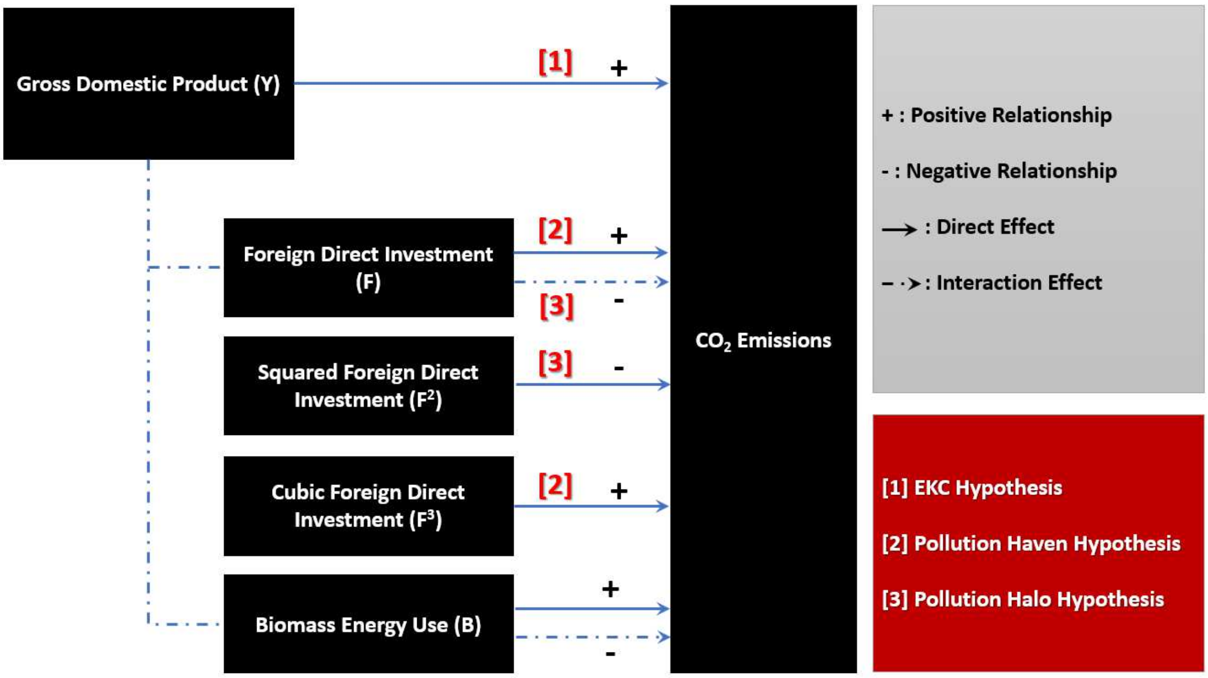
[8] According to Cole and Elliot (2003), sectors with high capital investment and concentration of pollution are significantly related.

Figure-2. Conceptual Scheme



In order to examine the causal association among the model parameters, we utilize a non-parametric causality test, i.e. pair-wise DH causality test, and the empirical results are provided in Table 6. The results show a bidirectional causal association between economic growth and CO_2 emissions, which is consistent with Halicioglu (2009). Moreover, unidirectional causality runs from FDI to CO_2 emissions, which is supported by Antweiler et al. (2001), Cole and Elliott (2005 2011), Kim and Baek (2011), and Behera and Dash (2017). A bidirectional causal association is found between biomass energy consumption and CO_2 emissions, consistent with Schmalensee et al. (1998). Lastly, unidirectional causality exists from FDI to economic growth, and from biomass energy consumption to FDI, as suggested by Mudakkar et al. (2013) and Azam et al. (2015).

Table 6. Pair-wise Dumitrescu–Hurlin panel causality analysis

Null Hypothesis	W-Stat.	Zbar-Stat.	Prob.
lnY does not homogeneously cause lnC	4.54179	3.72392	0.0002

lnC does not homogeneously cause lnY	3.29402	1.68158	0.0927
lnF does not homogeneously cause lnC	3.94199	2.74218	0.0061
lnC does not homogeneously cause lnF	1.82513	-0.72271	0.4699
lnB does not homogeneously cause lnC	5.24941	4.88216	1.E-06
lnC does not homogeneously cause lnB	3.35996	1.78950	0.0735
lnF does not homogeneously cause lnY	4.41562	3.51742	0.0004
lnY does not homogeneously cause lnF	2.41572	0.24397	0.8073
lnB does not homogeneously cause lnY	2.81717	0.90106	0.3676
lnY does not homogeneously cause lnB	4.79945	4.14566	3.E-05
lnB does not homogeneously cause lnF	3.45466	1.94451	0.0518
lnF does not homogeneously cause lnB	3.14115	1.43136	0.1523

6. Implications for theory and practice

By far, we have analyzed the association between GDP, FDI, biomass energy consumption, and CO_2 emissions for the MENA countries, and the empirical analysis has brought forth several insights regarding the cleaner production and sustainable development practices in these nations. These aspects have never been looked into from the perspective of sustainable development in the MENA countries, and we will explain the implications of the results in this section. The FDI and GDP have been found to have N-shaped associations with the CO_2 emissions, whereas the biomass energy consumption has been found to have negative impact on CO_2 emissions. In view of these results, it can be assumed that the persisting economic growth pattern in the MENA countries is not environment-friendly and is harmful for sustainable development in these nations. Therefore, the policymakers of these nations have to redesign the energy and trade policies in order to safeguard the environment and ensure sustainable economic development. Over the years, the researchers have been advocating about the positive impact of alternate energy sources on environmental quality (Mizsey and Racz, 2010; Ingrao et al., 2016; Schober et al., 2018; Hassan et al., 2019). As these nations are still at emerging phase, therefore implementation of high-end renewable energy solutions might prove to be harmful for economic growth. Sinha et al. (2017)

have demonstrated this aspect in case of Next-11 emerging economies. Owing to this fact, these nations have to rely more on biomass solutions. Following the route of technology trade, these nations can have access to cleaner and improved biomass solutions, which can cater as a viable replacement of the fossil fuel-based energy solutions. As the MENA countries are characterized by energy poverty, as indicated by Khodr and Ruble (2013), Aliyu et al. (2018), Edomah (2019), and several other researchers, these nations need to achieve energy efficiency through alternate energy sources, and if possible, in an endogenous way.

Saying this, it is also needed to be remembered that it might take time to develop endogenous alternate energy solutions, and therefore, the policymakers of these nations should focus on developing green trade policies and increase the trade activities for sustaining the environmental quality. The interaction between FDI and GDP has found to have negative impact on CO_2 emissions, and it shows that the economic growth pattern in these nations requires green trade policies for reduction of CO_2 emissions. In the quest of the improvement in environmental quality through alternate energy solutions, these nations should discourage the fossil fuel import through import substitution policies, for safeguarding both environmental quality and trade balance. The FDI should be considered as a route for importing cleaner production technologies in the nation, and the government should provide financial subsidies to the industries, which use the improved biomass solutions in the production processes. In this way, the biomass energy solutions can pave the way for implementing the alternate energy solutions across the nations, and both the households and industries should be taken together in this process. The policymakers also should encourage public-private partnerships for increasing the awareness about energy efficiency and the benefits of clean energy solutions (Foxon and Pearson, 2008; Carrillo-Hermosilla et al., 2010;

Hancock et al., 2018). This might help these nations to set the background for the development of endogenous alternate energy solutions.

As the MENA countries have not signed the Kyoto protocol, therefore, they need to pave the way for achieving sustainable development goals (SDGs) in a more succinct and inclusive manner. In keeping with the global sustainable development scenario, the energy and trade policies of these nations should be designed, so that the following SDG objectives can be attained: (a) SDG 7, i.e. affordable and clean energy, (b) SDG 8, i.e. decent work and economic growth, and (c) SDG 13, i.e. climate action (UNDP, 2017). When the alternate energy generation will be carried out endogenously in these nations, and the fossil fuel import will be substituted by the import of cleaner technologies, then not only energy efficiency and environmental quality will be improved, but also the vocational opportunities will rise, which will in turn add to the income of these nations. This can be a first stepping stone towards the implementation of the SDG objectives by 2030, and cleaner production processes can act as the major catalyst in this process.

7. Conclusion

This study has explored the trilateral association between gross domestic product (GDP), foreign direct investment (FDI), biomass energy consumption, and CO_2 emissions for the Middle East and North African (MENA) region in 1990–2015. The empirical results reflect that economic growth and carbon emissions show an inverted-U relationship, that is, the Environmental Kuznets Curve (EKC) hypothesis. Evidence of the Pollution Haven Hypothesis (PHH) is authenticated by means of the inverted U-shaped association between FDI and CO_2 emissions. Furthermore, the results reveal an N-shaped EKC for the MENA region during the study period. Similarly, FDI and carbon emissions show an N-shaped relationship for this panel. The causality analysis confirms bidirectional causality between economic growth and CO_2 emissions, biomass energy consumption and CO_2 emissions, and unidirectional causality from FDI to CO_2 emissions.

The empirical evidence shows that, in the MENA region, ascending income levels negatively impact environmental quality. Although MENA countries, being developing economies, did not sign the Kyoto protocol, it is necessary for these countries to assume the same challenges of controlling pollution levels, promoting regulation measures connected with energy innovation measures in order to increase efficiency and reduce pollution levels. In this performance, the role that FDI inflows play on environmental quality is essential. In medium-term, FDI inflows could exert a positive impact through the enactment of new strategies in order to attract clean foreign capital. During the past few decades, MENA countries have attracted dirty FDI inflows related to petroleum and multiple-domain energy. These movements have accelerated the negative effect of FDI inflows on CO_2 emissions. It is known that some MENA countries have resorted to relaxing regulations in order to attract investments, but in order to reduce the subsequent environmental degradation, these same governments should now aim at enforcing stricter environmental regulations. An observable lack of institutional capacity, financial means, and, in some cases, of political will, reinforced by an efficient investor lobbying, hamper the efforts toward effective environmental regulations. Therefore, policy makers should regulate clean FDI inflows in order to enhance green technology transfer and promote renewable sources in the region. These actions are linked with a specialization process, which converts old and dirty sectors into new and clean ones; otherwise biomass energy sector can be an alternative to decrease foreign oil dependency because it is a renewable, abundant source produced in the MENA region.

The empirical analysis shows that MENA countries need to implement more efficient policies in the context of their "sustainable development" strategies to attract cleaner and more energy efficient industries. These actions should be linked with environmental, political, and social policies. Therefore, the MENA region should consider the improvement of a low-carbon energy system by promoting renewable energy sources, more efficient energy processes, incentives, and regulatory mechanisms, in order to attract clean investment and reduce environmental degradation. In doing so, companies would be incited to introduce new technology and refurbish existing installations to improve environmental performance. This suggests that FDI can improve environmental management practices under a sustainable development context. The regulatory measures should promote clean biomass energy as an alternative to the traditional energy sector. These actions would imply employment opportunities, enhanced energy security, augmented economic growth, development of strong export industries, and in extension, additional environmental welfares (Domac et al., 2005). Our results show that biomass energy consumption is ecologically viable, and government initiatives toward promoting this energy source can become a feasible alternative of fossil fuel. This behavior is justified by the transition from dirty biomass use to more effective biomass energy uses. However, this shift at the industrial and household levels simultaneously is not possible as it may slow down the economic growth trajectory.

The present status of biomass energy consumption in MENA countries shows that this energy source is predominantly used in households, making it easier for the government to promote it at this level. Cleaner biomass solutions are comparatively costly, and therefore, governments should introduce them to households at subsidized rates. Bioenergy plays a leading role in developing countries: it needs to be modernized in terms of cost, efficiency, and emissions. Several bioenergy options, as bioenergy cycles, MSW, rice husk, and agro-residues, among others, have great potential for decreasing carbon emissions. The reduction of carbon emissions depends on the efficiency of the generation technology and on how much fossil fuel is used to produce biomass.

Consequently, the MENA governments should reduce conversion efficiency and feedstock availability via biomass innovation measures.

Yet, bringing down the level of emissions calls for the transformation energy policies from fossil fuel to clean energy solutions. This will likely cause a decline in revenue surplus due to a rise in revenue expenditures. This can be compensated by introducing tax on polluting industries, which consume fossil fuel energy. This move might have a two-fold consequence. Once the attractiveness of polluting industries reduces because of the pollution tax, they will try to shift toward cleaner and alternate energy sources. It might appear that governments will have to invest substantially in renewable energy solutions. However, this initiative may affect renewable energy promotion. Whenever polluting industries start shifting toward renewable energy sources, FDI also follows a similar path, as it might have larger returns on invested capital. Therefore, investment in renewable energy solutions will not have any negative consequences on economic growth.

Our study confirms the low carbon development hypothesis, which suggests that the economic cycle helps reduce inefficiency in the energy sector. The promotion of clean energy technologies by each region is necessary to modify the energy mix, making it cleaner. In order to make this process a smooth one, governments should modify regulatory approaches, which could promote cleaner energy and protect the environment.

Subsequently, we suggest a number of possibilities, which might encapsulate an array of approaches to be mulled over by the government in order to preserve ecological balance in the MENA region. Empirical evidence suggests the implementation of some energy measures related to more efficient processes, the promotion of renewable sources and regulations to make the implementation of foreign clean industry in host countries more attractive. To enhance ecological effectiveness, the responsible governmental authorities should seek to expand their capitalization facilities. They must increase technical efforts to reduce the scale effect and less-polluting technologies; otherwise, MENA policymakers should promote more restrictive environmental regulations and clean renewable sources (e.g. wind or solar). Then, it might prove to be effective to revamp ecological protection strategies and institutions, compared to restraining FDI and globalization activities that harm ecological quality.

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