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Research Article

Carbon Dioxide Emissions and Its Socio-Economic Drivers Nexus: Empirical Evidence from MENA Countries

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Abstract

Carbon dioxide emissions is one of the main climate change causes. Nowadays is considered as one of the most important environmental degradation and air pollution in the world. The relationship between CO_2 emissions and their socio-economic determinants is investigated in this study. It uses empirical analysis of significant impact of the economic growth, the tourism development, the globalization, the population health, the population growth and the energy consumption on our interest variable. Thus, we're going to select an econometric model, an Autoregressive Distributed Lag model (ARDL) applied to a sample of 10 MENA countries. Our aim is to measure, long-run and short-run impact of the number of arrivals, the Foreign Direct Investment, government health expenditures, the energy consumption and the population growth rate on the CO_2 emissions. All variables are observed from 1995 to 2020. The methodology adopted in this work is as followed: First, the statistical indicators for the sample are calculated. Secondly, the temporal series stationarity is checked by realizing tests of first and second generation. The Pedroni ARDL and Pesaran cointegration tests are then applied. Finally, Granger causality for panel data is used. The causality analysis between variables is carried out using the Dumitrescu and Hurlin's test. Findings reveal that, in the long term, tourism sector and energy consumption have significant and positive impact on CO_2. But the economic growth and population growth influenced it negatively and they are statistically significant. In the short term, the dependent variable is statistically impacted by economic growth. The degrees and magnitude of the individual effects of the various variables on the Carbone dioxide emissions vary from country to an other. There are bidirectional and unidirectional relationships causality between different variables. Our findings can be helpful for policy makers seeking to achieve the sustainable development goals in MENA region.

Keywords

CO_2 Emissions, Socio-Economic Factors, ARDL Model, MENA

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1. Introduction

The climate change issue is a major problem both on the national and the international scale. It has been one of the most discussed topics during the last decades [1-3].

However, many factors have contributed to its development [4-6]. Accordingly, it is generating negative impacts related to the environment quality.

Let's mention pollution adverse effects, derived from an increased (CO_2) carbon dioxide emissions. This problem is always at the heart of the debates. It is a result of many factors such as the economic sector development, social factors, and energy use [7-9].

This study focuses mainly on the environment quality and some Sustainable Development Goals. The objective is to quantify the impact of economic development and social factors on carbon dioxide emissions and to determine the existing relationships between variables in short and long-term. The socioeconomic factors are: the tourism sector, the economic growth, the government health expenditures, the energy consumption, the population growth and the Flow Direct Investment in MENA countries, during 1995-2020.

As a result of the insufficiency of the relationship studies between the previous mentioned variables and the CO_2 emissions in the MENA region; this study aims to fill this empirical gap by addressing the following areas:

What impacts does the variables under review have on the carbon dioxide emissions in the MENA region? Is there a causality between the dependent variable and the explanatory variables in this region?

This paper is structured as follows: the literature review section presents a detailed review of the literature on the connection between different variables model. This is followed by the methodology section which presents data and methodology used to achieve the study target. The empirical findings section is devoted to develop the study results. This paper ends with the conclusion section.

2. Literature Review

Prior research has diligently endeavored to assess the relationship between carbon dioxide emissions and their socio-economic drivers. In this respect, the expansion of a country's economic activity can be quantified by a wide range of economic indicators, including: wealth, the tourism sector development.

This section regroups two parts. The former underlines the impact of some socio-economic factors on carbon dioxide emissions; while the later highlights the causal links between these variables and our interest variable.

Almost all of the empirical studies that have addressed this issue are based on an ARDL model, although a few studies have used a non-linear model [10-12].

2.1. The Impact of Socio-Economic Factors and Energy Consumption on Carbon Dioxide Emissions

Socio-economic factors chosen in this study, in order to explore their impacts on CO_2 emissions, are: economic growth, health capital, tourism sector, globalization and population growth.

Ullah [13] investigated the impact of trade openness, health expenditures, and renewable energy in Pakistan from 1998 to 2017. Their findings indicated a positive impact of trade openness and a negative impact of renewable energy. Ganda [14] conducted a similar study and discovered that health expenditure had an overall negative impact at an aggregated level. At disaggregated level, the private health expenditure had a negative impact, while the domestic general health expenditure had a positive impact. Additionally, bidirectional causality was observed between current health expenditure and CO_2 emissions. Belloumi and Alshehry [15] investigated the impact of trade openness on sustainable development in Saudi Arabia. The main findings revealed that, in the short term, trade openness did not significantly affect economic growth and environmental quality. However, in the long term, it contributed to an increase in CO_2 emissions.

Several scholars have investigated the relationship between FDI and environmental quality, yielding a spectrum of diverse results. Ahmed et al. [16], Naz and Tariq [17] reported a positive effect in the Asian region from 1995 to 2020. The second study findings suggested either a negative impact from: tourism and economic growth, whereas a positive effect was observed from energy consumption, and population, aligning with the results of Wahyudi et al. [18]. Khan et al. [19], in developing countries, and Voumik and Ridwan [20] reached a positive association between CO_2 emissions and each of the variable: population growth and FDI, in Argentina from 1972 to 2021. Javed et al. [8] demonstrated that economic growth, FDI, energy consumption and exports have a positive impact. Tukhtamurodov, et al [9] were interested in BRICS countries over the period from 1996 to 2020. Their findings are similar and demonstrated it in the short term. In both the short and long term, the impact of trade openness and energy consumption on CO_2 emissions is evident, whereas economic growth demonstrates no significant influence.

Other studies emphasize a negative impact of FDI on CO_2 emissions. Amoah et al [21] provide valuable insights within this discourse, focusing on 30 Sub-Saharan Africa countries. Moreover, Basuki and Stioningrum [22], found a long-term negative impact between FDI, energy consumption, economic growth and CO_2 emissions in Indonesia, from 1980 to 2021.

Recently, the empirical results of Uddin et al. [23] confirmed this result for low and lower middle-income countries.

Finally, Apergis [24] posited heterogeneous effect in BRICS countries and concluded the absence of Granger causality between two variables FDI and CO_2 emissions. In the same respect, Boamah et al. [25] proved heterogeneous effects of FDI and a positive impact between economic growth and CO_2 emissions in 41 African countries from 2005 to 2019. Tahir [26], focused on Pakistan from 1990 to 2022, and his results indicate a negative impact between FDI and CO_2 emissions, while concurrently revealing a positive impact between FDI, economic growth and CO_2 emissions in the long term.

A substantial body of empirical studies has underscored the positive impact of the tourism sector on our variable of interest. Notably, Tang [27] and Hu [28] have explored this phenomenon in China. Raihan [29] focused on Singapore, while Alaganthiran et al. [30] have expressed their interest in Sub-Saharan Africa countries. Akbulaev [31], in his analysis encompassing the years 1995 to 2019 and including Morocco, Zimbabwe, Mauritius, and Ethiopia as a sample.

In their study spanning from 1997 to 2021, Voumik et al. [32] focused on the impact of energy consumption and tourism in 10 African countries. Their results unveiled a positive association among the dependent variable, tourism, and GDP. Renewable energy had a negative impact. In the study of Khan et al. [33] findings diverged; tourism exhibited a negative impact, whereas economic growth and energy consumption demonstrated a positive impact.

The extensive discourse on the relationship between economic growth and environmental quality has produced various research findings. Examining emerging economies from 2000 to 2019, Bu and Ali [34] discovered that health expenditures, economic growth, and population exert positive influences on CO_2 levels. In a distinct study focused on Latin American countries spanning 2000 to 2020, Galvan et al. [5] investigated the impact of economic growth, FDI, and trade on CO_2 emissions. Authors highlighted that the effects are contingent upon the income level of the country: higher-income nations exhibited a strong positive impact, middle-income trap countries demonstrated a weak positive impact. Tourism services had a low impact.

In the scope of low-Income countries, the empirical results of a study conducted by Martial et al. [35] show that economic growth, population growth and energy consumption had a positive impact on CO_2 emissions; whereas tourism had a negative impact on CO_2 emissions.

In the findings reported by Sultana et al. [36], it is revealed that renewable energy consumption has a negative impact on CO_2 emissions in the Next 11 countries. Conversely, GDP, population growth, and globalization were identified as factors with a positive impact.

In the case of Majekodunmi et al. [37] in Malaysia, contrary to prevalent assumptions, the authors posit that population growth and the integration of green technology exhibited an adverse association with CO_2 emissions. Paradoxically, exports and economic development emerge as catalysts for increased carbon emissions in the long term. This complex interplay between factors is further echoed in the investigations conducted by Alkasasbeh et al. [38] within Middle Eastern nations, where akin repercussions concerning the nexus between economic growth and CO_2 are identified.

Findings of Marselina and Prasetyo [39] exhibited a divergence in their findings. Within high-income countries, economic growth exerted a negative influence on CO_2 emissions, while population growth demonstrated a positive impact. Conversely, within low-income countries, population growth, FDI, and economic growth contributed positively to CO_2 emissions.

In the context of China, India and USA, Ahmed et al. [40] explored the influence of economic growth, population growth and energy consumption on CO_2 emissions. The principal findings elucidated that energy consumption and renewable energy exhibit a negative impact on CO_2 emissions, albeit with varying degrees of intensity.

In the study conducted by Aydin [41] within G8 countries from 1990 to 2018, the findings revealed that economic growth had no impact in the majority of the countries. In contrast, energy consumption was observed to have a positive impact. Conversely, FDI and trade openness had no effect on CO_2 emissions in certain countries; while manifesting a heterogeneous impact in others. This stands in contradiction to the observations made by Gershon et al [42], where a negative impact on CO_2 emissions resulted from energy consumption in SSA countries. Additionally, the study undertaken by Ibadullaev, et al. [43] illustrated a positive impact stemming from non-renewable energy consumption.

2.2. Causality Link Between Variables and CO_2 Emissions

This second part of literature review, is devoted to examine previous research that has been devoted to investigating the causal relationship between CO_2 emissions and relevant contributing factors.

Numerous scholars have extensively investigated the intricate relationship among the tourism sector, economic growth, and carbon emissions. Sharif et al [44], focused on Pakistan case. Study findings reveal a positive long run relationship between CO_2 and tourist arrivals. They distinguish a uni-directional one between CO_2 emission, tourist arrivals, economic growth and foreign direct investment.

Voumik et al. [32] examined the interplay between economic growth, population growth, FDI and CO_2 emissions in Argentina spanning the years 1972 to 2021. The findings revealed a significant relationship, with long-term implications suggesting a positive impact from population growth, FDI, and economic growth. However, in the short term, GDP and renewable energy demonstrated a negative influence.

In their study spanning the years 1980 to 2020, Yousaf Raza et al. [45] focused on Bangladesh. Noteworthy findings include a unidirectional causality between energy consumption and CO_2 emissions in the long and short term. On a contrasting note, economic growth and urbanization were found to amplify CO_2 emissions. The short-term dynamics further elucidated a causality pattern, indicating a direct influence from energy, economy, and urbanization to CO_2 emissions. Ullah et al. [6], were interested in to Turkia, and investigated The Impact of Economic Growth, Natural Resources, Urbanization and Bio capacity on the Ecological Footprint. Their findings show: i) the economic growth and biological capacity contribute to the increase of Ecological Footprint in the short and long term. ii) In the short term, there are unilateral causalities from economic growth to EFP, from biocapacity to economic growth. In the long term, some bidirectional causalities from EFP, urbanization and bio capacity to EFP.

Balli et al. [46], focused on Mediterranean countries spanning the period from 1995 to 2014. The empirical outcomes unveiled a positive long-term association between the tourism sector, economic growth, and CO_2 emissions. Moreover, a two-dimensional relationship emerged between the tourism sector and economic growth, particularly in the context of Morocco and Turkey.

The study conducted by Jiaqi et al. [47] provided insights into the direct and indirect impacts of tourism on CO_2 emissions. Their findings indicated a direct positive influence of tourism on CO_2, but also highlighted an indirect negative impact. Concurrently, economic growth was exerted a positive influence.

In the study conducted by Adams, al [48] results are: i) consumption and economic growth contribute to CO_2 emissions. ii) There is a bidimensional relationship between CO_2 emissions and energy consumption, economic policy uncertainty and CO_2 emissions, economic growth and CO_2 emissions; iii) there is a one way causality from CO_2 emissions to geopolitical risks.

Within the context of China, numerous scholars scrutinized the intricate interplay among carbon emission, health expenditures, and economic growth. Noteworthy investigations by Sasana et al. [49] and Usman et al. [50] demonstrated a significant correlation between CO_2 emissions and government health expenditures. These results are similar to Wang et al. [51] and Li et al. [52]. Furthermore, the two first studies identified a unidirectional causality, establishing a relationship among CO_2 emissions, economic growth, and both government and private health expenditures. Additionally, Xiu et al. [53] affirmed a significant relationship and causality from the CO_2 emission to the health expenditures in the medium term. Li [52] focused on BRICS nations during the period 2000 – 2019. The results indicated a positive causality between economic growth and CO_2 emissions in the short run and a similar positive link between the interest variable and health expenditure. Indeed, reverse causality was identified, indicating an impact from health expenditure on economic growth.

Contrastingly, Tinoco [54] findings in a study spanning 23 developing countries from 2001 to 2019 indicate that GDP, energy consumption and CO_2 emissions exhibit any discernable relationship. In the exploration of the interconnections among economic growth, health expenditure, energy consumption, and CO_2 emissions, Ozturk [55] and Raihan and Tuspekova [29] emphasized unidirectional causality from CO_2 emissions to the tourism sector and accompanied by a positive relation.

Examining the causal dynamics within the interest variable, the economic growth and FDI, Donkor [7] focused on Countries in north and south Africa spanning the period from 2000 to 2016. The study revealed a bidirectional causality between CO_2 and economic growth in North Africa. Additionally, a bidirectional causality was identified between FDI and economic growth in this region. Conversely, South Africa exhibited unidirectional causality, with economic growth influencing FDI.

Within the timeframe of 1980 to 2020 and focusing on five Middle Eastern countries, Alkasasbeh et al. [38] observed a bidirectional relationship between CO_2 emissions and economic growth. Additionally, the study identified unidirectional causality from energy consumption to economic growth and from CO_2 emissions to energy consumption in this regional context. While, Sirag and Talha [56], In their study focusing on selected Arab nations, reported a long-term positive effect of real GDP per capita on CO_2 emissions.

In the examination of Granger causality among CO_2 emissions, (FDI), energy consumption, and GDP, Bunnag's [57] study yielded the following outcomes: i) No evidence of cointegration among the variables; ii) A bidirectional causal relationship between energy consumption and GDP, and between GDP and CO_2 emissions; iii) A relation between energy consumption and GDP; iv) A unidirectional relationship between FDI and CO_2 emissions, FDI and energy consumption, FDI and GDP, and GDP and energy consumption.

Ageli [58] found no long-run cointegration relationship among the variables. Aydin [41] reported the following findings: no causal relationships were identified between CO_2 emissions, economic growth and energy use. However, a unidirectional causality was observed from CO_2 emissions to FDI.

Findings of Javed, et al [8], uncovered a unidirectional causality running from energy consumption to CO_2 emissions. Encompassing Romania, Chirilus and Costea [59], stressed that FDI don't Granger cause CO_2 and there is a linear relationship between CO_2 and economic growth. On the other hand, Gyamerah and Gil-Alana's [60] research in Western and Central, spanning from 1970 to 2020, yielded that: Electricity consumption, economic growth, and CO_2 emissions are cointegrated. In the long run, electricity consumption and economic growth exert a more significant impact on CO_2 emissions. In the short run, electricity consumption and economic growth do not cause CO_2 emissions.

3. Materials and Methods

This section delineates the methodological framework employed in our study, encompassing: an exploration of the underlying theoretical foundations model, the presentation of our sample and the specification of our chosen econometric model.

To contextualize our model presentation, a quick assessment of the MENA region's environmental predicament is necessary. Notably, research on environmental degradation in this region has been limited, with studies by Balli et al. [46] in Mediterranean countries and specific examinations by Khalfaoui et al. [61], Sirag and Talha [56], Mahmood et al. [62], Ashour et al [63]. El Aloui, and Hassane [64] highlighted the interaction between economic growth and environmental factors, particularly in Morocco, Algeria, Tunisia, and Egypt.

3.1. The General Scope of the MENA Countries

Before presenting the model, a briefly description of the environmental situation of the countries is firstly given in this paragraph.

Péridy et al. [65] conducted a comprehensive study on climate change in the MENA region, revealing alarming consequences. They found that these countries are the most affected by the negative consequences of climate change. countries face challenges such rising temperatures, decreased rainfall, natural resource scarcity, and pollution. These environmental shifts have adverse effects on fauna, flora, ecosystems, agriculture, and related service sectors.

Despite governmental measures and commitments like the Copenhagen Accord, climate change issues persist in the region. Governments, acknowledging the severity, have implemented various strategies, yet the challenges endure, necessitating ongoing efforts.

With a primary focus on pollution, MENA countries actively work to minimize carbon dioxide emissions. A low CO_2 growth rate emerges as a positive influence on the regional economy, leading to productivity gains, improved air quality, and increased energy efficiency. This emphasis on emissions reduction aligns with international efforts but does not entirely mitigate the persistent challenges posed by climate-related issues.

Abumoghli, and Goncalves [66] emphasized that environment challenges in MENA region are diverse, such as: water scarcity, air pollution, inadequate waste management …Devkota et al [67] mentioned that MENA countries are faced to climate change and climate smart agriculture challenges.

3.2. Data Sources and Sampling Method

In this study, the impact of distinct socioeconomic factors on environmental degradation, is investigated, focusing on the relationship between carbon dioxide emissions and contributing elements revealed in our literature review.

In this aim, and based on a thorough literature review for our model, the following variables were selected:

Tourism Sector: The selected proxy variable is *the number of international tourist arrivals.* Climate change: in our study the environmental quality, is measured using carbon dioxide emissions. Economic Growth: Chosen Indicator: is related to *Gross Domestic Product per capita*. Energy Demand: is identified using the proxy variable of *energy use*.

Globalization Dimension: For this factor, the proxy variable used is foreign direct investment (FDI). Social factors had two indicators: The population growth and Health capital: it is represented by the financial axis, specifically *government health expenditures as a percentage of total government spending.*

Empirical validation is conducted, using annual time series from 1995 to 2020 for 10 MENA countries: Tunisia, Morocco, Lebanon, Kuwait, Jordan, Iran, Bahrain, Algeria, Israel, and Egypt. The selection of this time frame is based on the availability of all data series, with data collection beginning in 1995 due to the limited accessibility of data during earlier periods.

This research utilized two principal data sources: The World Development Indicator (WDI) Database and the World Health Organization.

3.3. Model Specification and Econometric Methods

Our approach to the research question was inspired by previous research: Haseeb et al. [68], Ganda [14], and Voumik and Ridwan [20]. The existing body of empirical research on the interconnection among carbon dioxide emissions, the tourism sector, economic growth, health expenditures, FDI, population growth, and energy consumption in MENA countries is limited. Consequently, our study is distinctive in its comprehensive examination of these factors concurrently. In aligning with established reference studies during the model specification, the following relational framework is incorporated:

$$CO_2 = f\text{ (socioeconomic factors)} \quad (1)$$

$$= f\text{ (the tourism sector; the economic growth; the health capital; the energy consumption; the demographic dimension; the globalization)} \quad (2)$$

The data definition is reported in Table 1.

Table 1. *Characteristics of the data employed Variables.*

Variable	Definition	Units
CO_2	Carbon dioxide emissions	Kilotons (Kt)
TA	Tourist Arrivals	International tourist arrivals number
EN	Energy use	Kg of oil equivalent per capita
GDP	Gross Domestic Product	$ US constants de 2010
HE	Domestic General Government Health Expenditure	Percentage
FDI	Foreign Direct Investment	Percentage
PG	Population growth	Percentage

Source: Author`s compilation

Below mathematical writing of the equation (2) for the linear form:

$$CO2_{it} = \alpha_0 + \alpha_1 TA_{it} + \alpha_2 GDP_{it} + \alpha_3 EN_{it}$$
$$+\alpha_4 HE_{it} + \alpha_5 PG_{it} + \alpha_6 FDI_{it} + \varepsilon_{it} \quad (3)$$

i: 1,…, 10; t = 1995-2020.

Employing E-Views 12 software, the econometric analysis was systematically executed, and detailed procedural guidelines were delineated subsequently. To maintain coherence with macroeconomic data, the study adopts the natural logarithmic transformation for all variables.

This is a simple panel with ARDL model. After the logarithmic transformation, the following equation is to estimate:

$$LCO2_{it} = \alpha_0 + \alpha_1 LTA_{it} + \alpha_2 LGDP_{it} + \alpha_3 LEN_{it}$$
$$+\alpha_4 LHE_{it} + \alpha_5 Ln\,PGit + \alpha_6 Ln\,FDIit + \varepsilon_{it} \quad (4)$$

i: 1,…, 10; t = 1995-2020.

In addition, ε_{it} is the error term. $(\alpha_0, \alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_{5,}\alpha_6)$ denote the coefficients to estimate.

The econometric methodology employed in this study unfolds systematically. Initiating with, a graphical analysis assesses the temporal evolution of model variables across the entire sample. Subsequently, entailing the calculation of statistical indicators. Due to the time series nature of the data, a significant emphasis is placed on scrutinizing the stationarity of these indicators through first- and second-generation tests to panel models, following the framework proposed by Hurlin and Mignon [69]. Finally, the study evaluates enduring associations between variables through the ARDL framework, incorporating the Granger causality test.

Given our sample size constraints (T < 50 and 30), the ADF results are considered less reliable. Econometric tests applied for stationarity variables are: Im, Pesaran, and Shin, Bai and Ng, and Pesaran, the Breusch Pagan LM test. For the CSD test based and Panicca test (Bai and Ng (2004, 2010)).

After confirming cointegration at different orders, the study proceeds to estimate the long-run coefficients using the ARDL model. Following the Pedroni two-step approach, a panel ARDL model is employed. The first phase involves testing the existence of both short and long-run relationships between the model variables. The second phase, examines causality direction in panel data and accounts for cross-sectional dependence.

The Dumitrescu Hurlin test assesses whether one time series is used to forecast another, assuming both are stationary. In this study, this test is allowed to identify causal relationships between the dependent variable and different explanatory variables.

The estimated panel ARDL is as follows:

$$\Delta LCO2_{it} = \delta_0 + \sum_{k:1}^{K} \delta_k \Delta LCO2_{i(t-k)} + \sum_{j:1}^{J} \alpha_j \Delta TA_{i(t-j)}$$
$$+\sum_{l=1}^{L} \theta_l \Delta EN_{i(t-l)} + \sum_{p=1}^{P} \varphi_p \Delta GDP_{i(t-p)} + \sum_{q=1}^{Q} \gamma_q \Delta HE_{i(t-q)}$$
$$+\sum_{r=1}^{R} \psi_r \Delta FDI_{i(t-r)} + \sum_{s=1}^{S} \lambda_s PG_{i(t-s)} + ECT_{i(t-1)} + \mu_{it} \quad (5)$$

Where the first difference operator, denoted by Δ, is applied to the variables. $\delta_k, \alpha_j, \theta_l, \varphi_p, \gamma_q, \psi_r$ and λ_s are the model unknown parameters with lag levels K, J, L, P, Q, R and S respectively. ECT is the lagged error-correction term obtained from the Model (2) concerning long-term cointegration. μ_{it} are the models' errors.

These parameters are integral to the model's structure. Additionally, the model accounts for potential causality in opposite directions, although in our study, specifically focuses on one causality direction with CO_2 carbon dioxide emissions as the dependent variable.

The short-term causality test between variables is formulated as follows:

$$H_0\!: \alpha_j = 0 \; for \; j = 1, \ldots., J \;\; H_1\!: \; \alpha_j \neq 0 \; for \; at \; least \; one \; j$$

By referring to Pedroni (1999, 2004), the long-term causality test is performed on the basis of the ECT term significance in model.

$$\Delta LCO2_{it} = \beta_0 + \beta_1 LCO2_{it-1} + \beta_2 LTA_{it-1} + \beta_3 LGDP_{it-1} + \beta_4 LEN_{it-1} + \beta_5 LHE_{it-1} + \beta_6 LFDI_{it-1} + \beta_7 LPG_{it-1}$$

$$+ \sum_{k=1}^{K} \gamma_1 \Delta LCO_{2it-k} + \sum_{j=1}^{J} \gamma_2 \Delta LTA_{it-j} + + \sum_{p=1}^{P} \gamma_3 \Delta LGDP_{it-l} + \sum_{l=1}^{L} \gamma_4 \Delta LEN_{it-p} + \sum_{q=1}^{Q} \gamma_5 \Delta LHE_{it-q}$$

$$+ \sum_{r=1}^{R} \gamma_6 \Delta LFDI_{it-r} + \sum_{s=1}^{S} \gamma_7 LPG_{it-s} + \varepsilon_{i,t}; \quad (6)$$

i: 1,..,10 t: 1995 -2020.

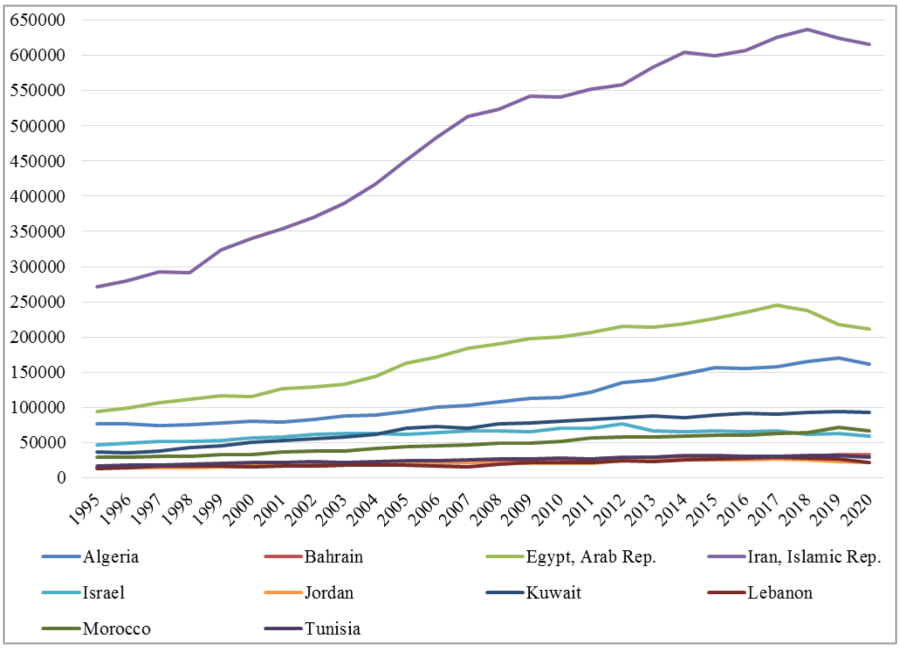
Where Δ: the first difference, K, J, L, P, Q, r and s are the optimum lag length. β_0: the constant; $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$: the short-term effects; $\gamma_1, \gamma_2, \gamma_3, \gamma_4, \gamma_6, \gamma_7$; the long-term dynamics of the model, and $\varepsilon \approx \text{iid}(0,\sigma)$: the error term.

4. Results

The results section should provide an accurate and concise. This section, is devoted to present the findings of analyses, encompassing preliminary, stationary, cointegration, and causality assessments conducted on our database.

4.1. Preliminary Data Analysis

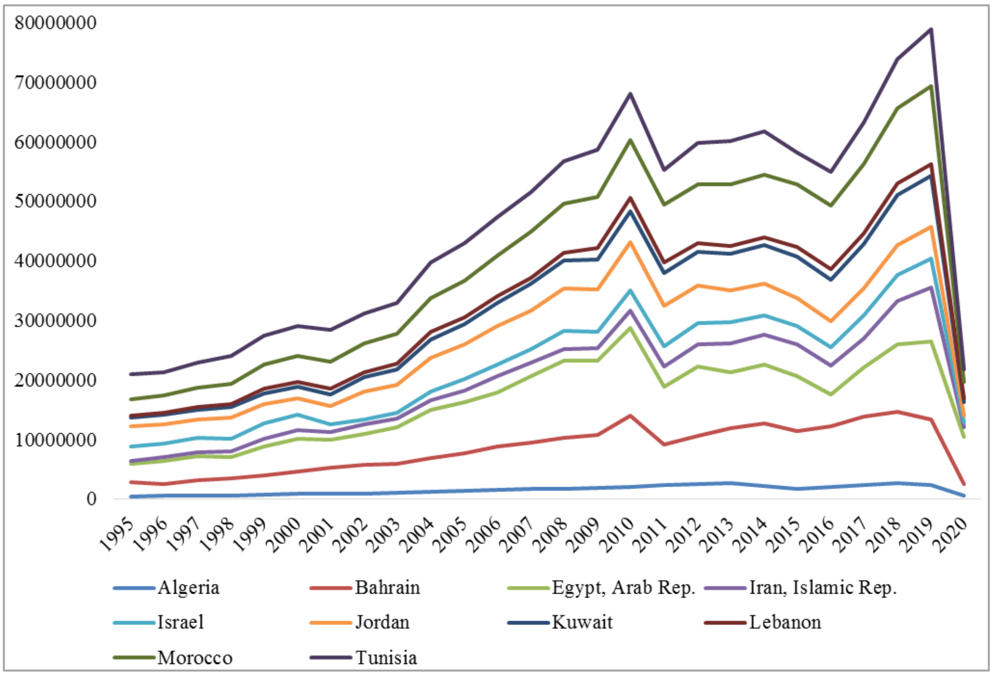
The graphical examination of the collected data in MENA countries from 1995 to 2020, unveils variations in model variables. It is obvious that data experiences fluctuations according to the temporal dimensions or instantaneous cut. A detailed scrutiny of the curves representing model variables, is provided below.



Source: author`s estimates

Figure 1. *The carbon dioxide emissions trends in some MENA countries (1995-2020).*

This study addresses environmental degradation caused by CO_2 emissions. Admittedly, it varies over time and from one country to another within the MENA region over the period 1995-2020. By referring to figure 1, Iran distinguishes itself with the most elevated levels of air pollution, accompanied by a noteworthy surge in CO_2 emissions throughout recent decades. Egypt, Algeria, and Kuwait, although demonstrating escalating fluctuations, exhibit a lesser degree of environmental impact compared to Iran. In contrast, Lebanon, Tunisia, Jordan, and Bahrain portray relatively steady and low levels of environmental degradation, characterized by minimal temporal variation. The holistic examination of the entire sample reveals a collective susceptibility to air pollution, aligning with corroborative evidence found in prior studies, notably those conducted by the UN Environmental Program [66].

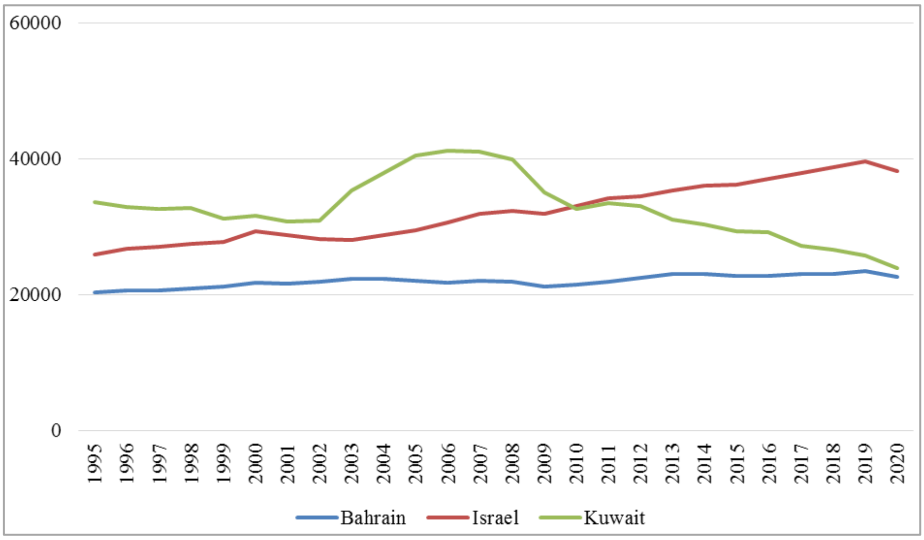


Source: author`s estimates

Figure 2*. The tourist arrival number evolution in some MENA countries (1995-2020).*

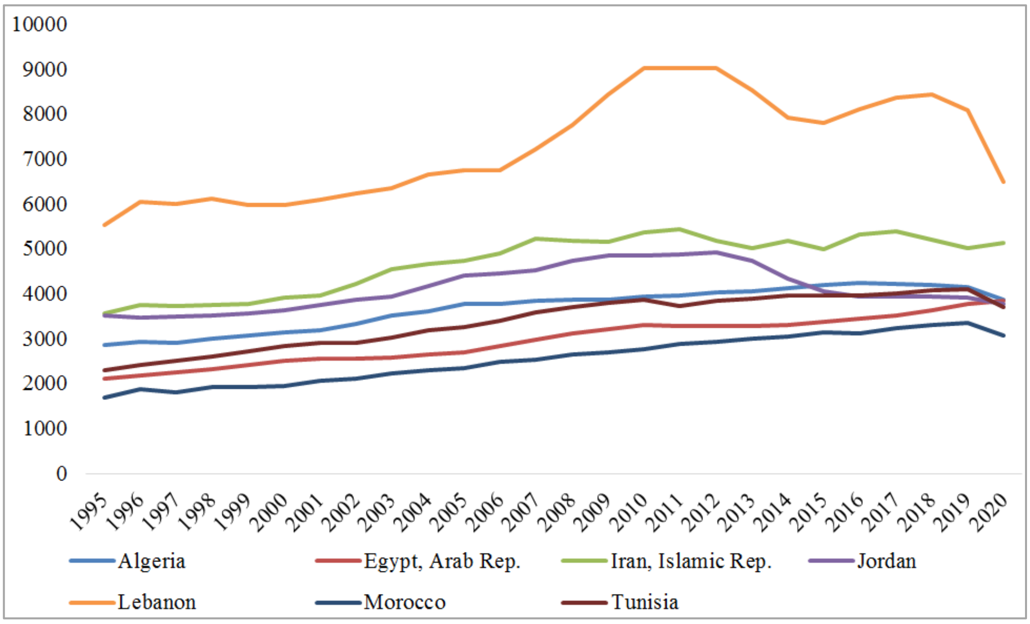
Curves related to tourist Arrivals correspond to figure 2. The subsequent examination of the curves reveals a consistent upward trajectory of tourist arrivals throughout the observed period, with two notable exceptions: the Arab Spring in 2011, marked by political tumult, and the advent of the COVID-19 pandemic in 2019, resulting in a substantial decline in international tourist numbers. Hopfinger [70] study provides detailed insights into the repercussions of the Arab Spring on the tourism sector within the MENA region. The subsequent contraction in international tourist arrivals during the COVID-19 pandemic serves as a poignant reminder of the sector's vulnerability to external shocks.

In our examination, Tunisia and Morocco stand out prominently, showcasing the highest growth rates within the tourism sector. In contrast, Algeria and Bahrain emerge as less frequented destinations in the MENA region over the analysed period. It is noteworthy that Mediterranean countries hold a distinguished status as leading global tourist destinations, significantly contributing to the advancement of the tourism sector in specific MENA nations. The observed trends in tourism reveal discernible fluctuations across countries, influenced by various factors.



Source: author`s estimates

Figure 3*. The evolution of economic growth in the high-income countries in the MENA region (1995-2020).*

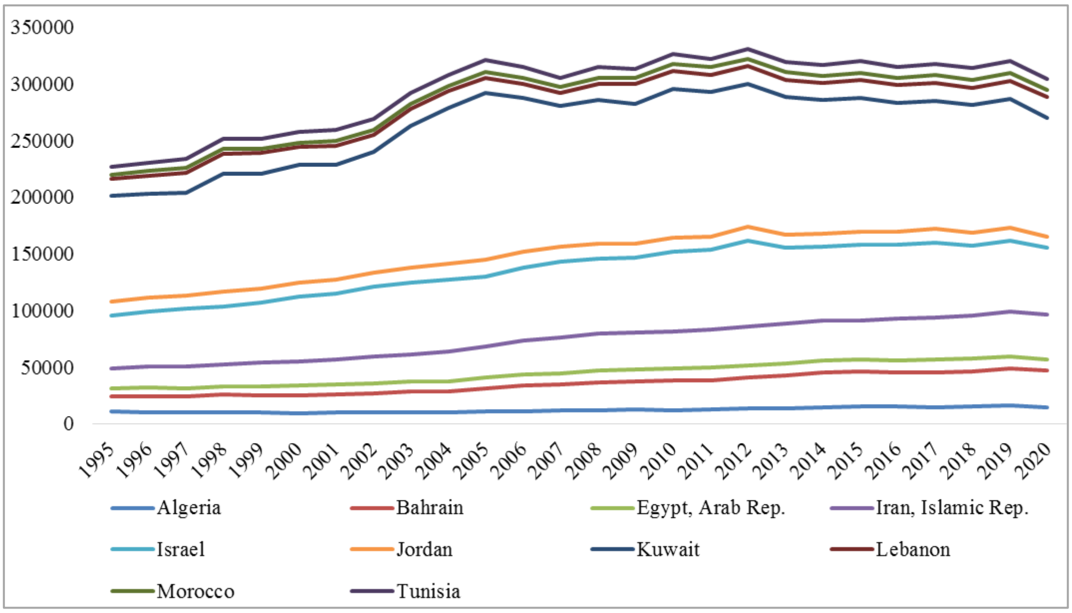


Source: author`s estimates

Figure 4*. The economic growth evolution in some lower middle income level MENA countries (1995-2020).*

Economic growth: Our subsequent analytical phase entails an examination of economic growth curves within the MENA region, utilizing Figures 3 and 4. The countries in our sample are classified into high income (30%) and low income (70%). The assessment reveals significant variations in growth rates across countries over the study period.

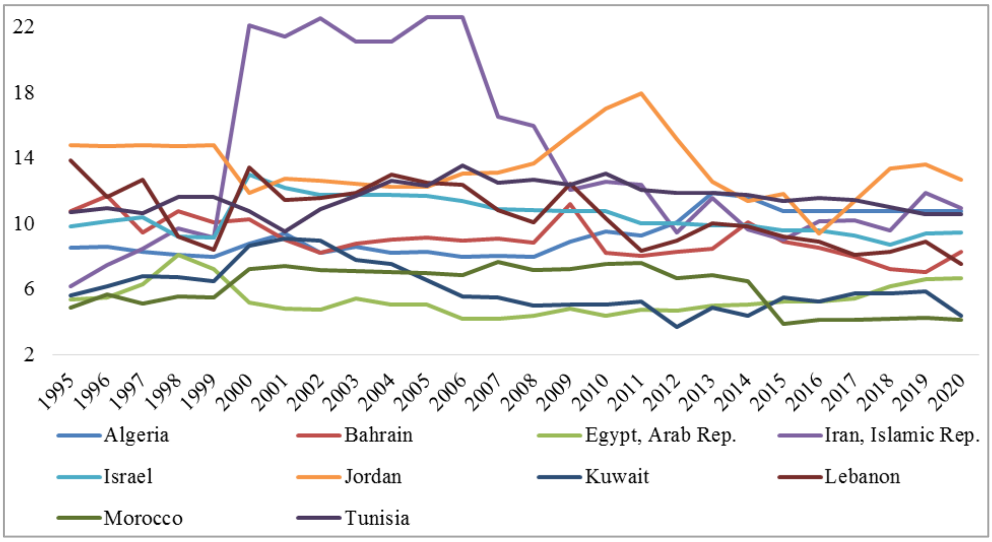
Examining the real GDP trajectory across the entire period, an overall upward trend is observed, interrupted only by specific periods. Despite this general growth, there exists an inherent imbalance among nations within the region. While most countries experience moderate growth rates, a nuanced perspective emerges as certain nations undergo substantial economic expansion with high growth rates, while others encounter comparatively low or consistent rates of growth. Lebanon stands out prominently with the highest growth rate within the high-income classification. In contrast, Morocco, Tunisia, Egypt, and Algeria demonstrate comparable levels of economic development. This economic landscape is characterized by a dual aspect, with both positive and occasionally negative fluctuations indicative of expansion and recessionary phases.



Source: author`s estimates

Figure 5*. Trends in some MENA countries' energy consumption (1995-2020).*

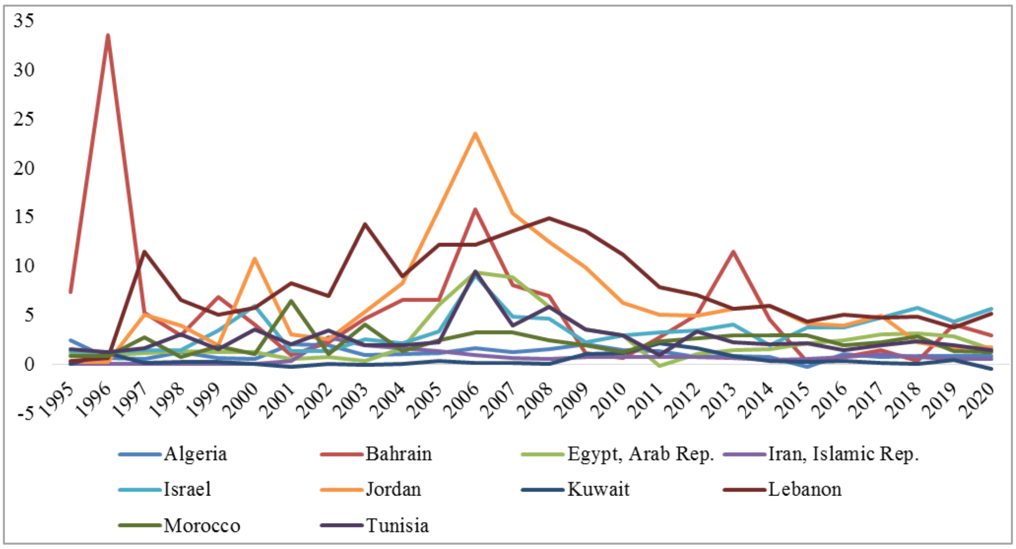
In the context of energy consumption, the fifth graph elucidates the progression from 1995 to 2020 in the MENA region. Notably, Algeria emerges as the lowest energy consumer, while conversely, Lebanon, Morocco, Tunisia, and Kuwait stand out as the countries with the highest energy demand.



Source: author`s estimates

Figure 6*. The Government health expenditure evolution in some MENA countries (1995-2020).*

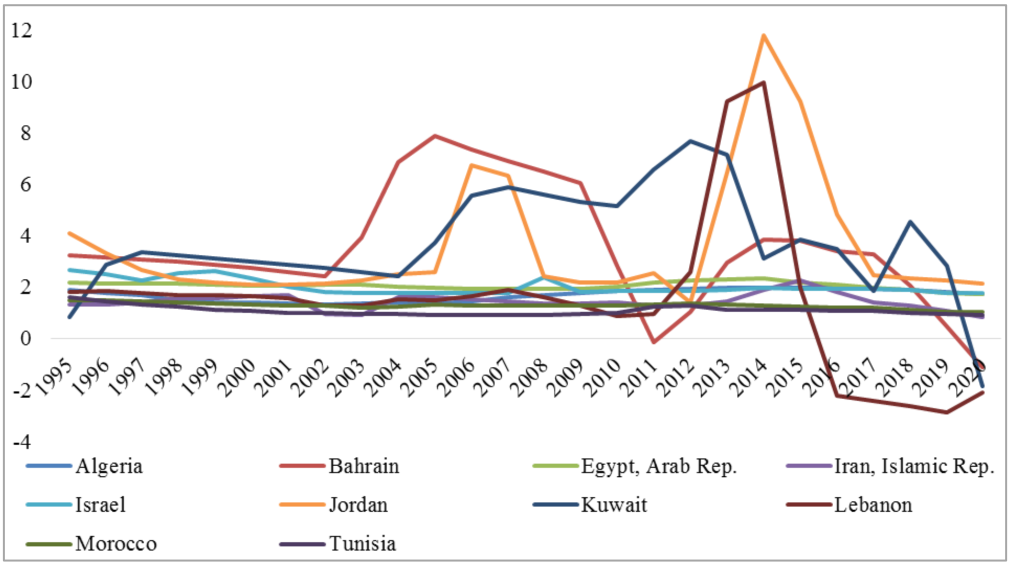
Concerning trends in health expenditure, the sixth graph delineates the constrained role of government in financing the health systems across MENA countries. Notably, the respective share fluctuate within the range of 2% to 14% for the majority of nations.



Source: author`s estimates

Figure 7*. The FDI evolution in some MENA countries (1995-2020).*

In the context of FDI trends, notable observations emerge. Jordan emerges as the foremost recipient of FDI. The impact of the Arab Spring is conspicuously reflected in the seventh graph, wherein declining FDI rates are discernible across all countries during this period of political upheaval. Moreover, a discernible trend unfolds wherein certain nations exhibit notable susceptibility to the liberalization phenomenon, as evidenced by elevated FDI rates, while others manifest comparatively lower rates.



Source: author`s estimates

Figure 8*. The population growth evolution in some MENA countries (1995-2020).*

Finally, the significance of the concluding graph pertaining to population growth becomes evident. Over the past decades, discernible negative population growth rates are observed in the cases of Lebanon, Kuwait, and Bahrain within this examined sample. Conversely, Jordan stands out with the highest demographic growth rate among the countries considered.

The statistical indicators presented in Table 2 offer a thorough overview of various model variables within the MENA region for the period 1995-2020.

Table 2*. The descriptive statistics of all variables.*

	CO_2	TA	GDP	EN	HE	FDI	PG
Mean	103043	4585219	11550	40053.4	9.5	3.3	2.2
Max	637433.7	14731000	41161	168704	22.6	33.5	11.8
Mi	13304.9	424000	1692.8	3795.3	3.7	-0.5	-2.9
St.Dev	140472	3228167	11956.9	49560.2	3.5	4	1.8

Source: Author`s compilation

4.2. Econometric Tests

After calculating indicators, it's suitable to examine the variables stationarity by applying tests based on trends and constants. Table 3 presents the results of both the CD test and LM test, rejecting the null hypothesis of no cross-sectional interdependence. Notably, the probability value falls below the critical threshold of 0.05.

Table 3*. Cross section dependence test.*

Test	Statistics	P-value
LM (Breusch Pagan)	478.68	0.000*
Pesaran CSD	21.02	0.000*

Note: *Means significance at 1% level
Source: Author`s compilation

The results of the stationarity tests for the model variables are summarized in appendix. The AIC criterion determines the number of lags selected.

The outcomes of the (IPS) test unveil that LCO_2 and LPOP demonstrated stationarity at the level, whereas LAT, LGDP, LEN, LHE, LFDI, and LPOP achieved stationarity through the first difference. Concurrently, the (LLC) test results indicate that only LAT and LHE became stationary after the first difference.

According to Pesaran's (CIPS) unit root test, LAT, LHE, LFDI, and LPOP were identified as stationary at the level, contrasting with LCO_2, LGDP, and LEN, which attained stationarity through the first difference. The (PANIC) unit root test further revealed that only LEN and LFDI achieved stationarity at the first difference.

After testing the stationarity of the model variables, it is imperative to establish their order of integration. The findings suggest a mixed order of integration among the variables, with some integrated into I (1) and others into I (0). Based on these results, the panel ARDL model emerges as a suitable approach for further investigation.

The test results of Pedroni's residual cointegration are, presented in the following table 5, they reveal the rejection of the null hypothesis, indicating a significant long-term causal relationship between the variables at a 5% significance level.

Table 4. *Pedroni's cointegration test results.*

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	**Prob.**	**Statistic**	**Prob.**
Panel v-Statistic	1.85**	0.03	1.12	0.13
Panel rho-Statistic	2.71	0.99	2.1	0.98
Panel PP-Statistic	-1.18	0.12	-3.72***	0.000
Panel ADF-Statistic	-1.3*	0.09	-3.67***	0.000

Alternative hypothesis: individual AR coefs. (between-dimension)		
	Statistic	**Prob.**
Group rho-Statistic	3.05	0.99
Group PP-Statistic	-5.44***	0.000
Group ADF-Statistic	-4.15***	0.000

Note: ***, **, and* denote significance respectively at the 1%, 5%, and 10%.
Source: author`s estimates

In analyzing Pedroni's test results, there is a significant outcome: six out of the 11 statistics achieve statistical significance, leading to the rejection of the null hypothesis. Consequently, as a deduction, the variables under consideration are cointegrated, suggesting no long-term correlation among the number of tourist arrivals, energy consumption, FDI, population growth and CO_2 emissions.

Furthermore, the Pedroni residual cointegration test was extended to investigate the short-term causal relationship between variables, as detailed below.

Table 5. *Panel ARDL estimation.*

D (LCO_2)					
Long Run			**Short Run**		
Variable	**Coefficient**	**Prob.**	**Variable**	**Coefficient**	**Prob.**
LAT	0.856***	0.000	ECT	-0.049*	0.06

D (LCO_2)					
Long Run			**Short Run**		
Variable	**Coefficient**	**Prob.**	**Variable**	**Coefficient**	**Prob.**
LEN	0.996***	0.008	D (LAT)	-0.027	0.286
LGDP	-1.807**	0.018	D (LEN)	0.527***	0.000
LHE	-0.130	0.159	D (LGDP)	0.049	0.779
LFDI	-0.004	0.899	D (LHE)	0.018	0.626
LPOP	-0.603**	0.014	D (LFDI)	0.003	0.44
			D (LPOP)	-0.016	0.554

Note: ***, **, and* denote significance respectively at the 1%, 5%, and 10%.
Source: Author`s estimates

The analysis of the table unveils a series of distinct findings. The first note concerns the ECT value, which is negative, establishing a prerequisite for achieving long-term equilibrium. Secondly, the identification of short-term impacts based on the significance of the coefficient linked to the first difference lagged variable D(LEN). However, the P-values associated with the rest of variables exceed the 5% threshold, suggesting a lack of significant influence on CO_2 emissions from tourism, economic growth, government health expenditure, FDI, and population growth.

Significantly, energy use in the sampled countries contributes to a short-term increase in CO_2 emissions. To address this, implementing additional awareness efforts targeting policymakers to achieve a long-run effect is recommended.

In the long term, statistically significant model variables encompass the tourism sector, economic growth, energy use, and population growth. In the MENA region, tourist arrivals and energy consumption positively impact CO_2 emissions at the 1% significance level, leading to an increase. Conversely, economic growth and population contribute to CO_2 reduction in the MENA region at the 5% significance level. Regrettably, neither FDI nor government health expenditure demonstrates a statistically significant impact on the dependent variable, both in the short run and the long run.

The outcomes of Dumitrescu Hurlin estimated are presents in appendix.

Table 6. *Dumitrescu Hurlin outcomes.*

Variable	Algeria	Bahrain	Egypt	Iran	Israel	Jordan	Kuwait	Lebanon	Morocco	Tunisia
ECT	-0.2***	0.01***	-0.058***	0.014***	0.006***	0.006**	0.013***	0.006***	-0.29***	0.01***
D (LTA)	-0.116***	0.054***	-0.067***	0.046***	-0.007***	0.04***	0.045	0.004	-0.197***	-0.045***
D (LGDP)	-0.118	-0.41	-0.93***	0.09***	0.141	0.306	0.38**	-0.26**	0.105**	1.194***
D (LEN)	0.227***	0.32***	0.89**	0.56***	1.08***	0.34***	0.64***	0.8***	0.3***	0.107***
D (LHE)	-0.01***	0.067***	0.065***	-0.016***	0.32***	-0.14***	0.004	-0.17***	-0.03***	-0.057***
D (FDI)	-0.028***	-0.007***	0.019***	0.000***	0.001**	0.016***	-0.009***	0.003***	0.004***	0.02***
D (PG)	-0.09***	-0.014***	-0.197	0.019***	-0.09***	-0.000	0.014***	0.009***	0.08***	0.103***

Source: Author`s estimates
Note: ***, **, and* denote significance respectively at the 1%, 5%, and 10%.

The first observation is that the ECT value is both negative and statistically significant in some MENA countries, specifically Algeria, Egypt, and Morocco, at a 1% significance level. This negative ECT value suggests that long-term equilibrium of causality has been achieved in these countries.

However, the short-term cross-sectional results, as presented in the Pedroni table, reveal a contrasting scenario to the panel level. The tourism sector exerts a significant impact on CO_2 emissions in all MENA countries except Kuwait and Lebanon. Notably, these effects are heterogeneous. In Algeria, Egypt, Israel, Tunisia, and Morocco, the sector acts as a reduction factor for CO_2 emissions, with Morocco exhibiting the most significant impact. Conversely, it contributes to an increase in CO_2 emissions for Bahrain, Iran, and Jordan.

Examining the influence of GDP, the short-term dynamics reveal distinctive patterns across several MENA countries. Economic growth exhibits a statistically significant and negative impact on CO_2 emissions in Egypt and Lebanon, with Egypt experiencing the highest impact. Conversely, in Iran, Kuwait, Morocco, and Tunisia, economic growth demonstrates a statistically significant and positive influence on CO_2 emissions. No significant impact is observed for Algeria, Bahrain, Israel, and Jordan.

The short-term impact of energy consumption is found to be statistically significant at a 1% risk level and positive. However, the magnitude of this impact varies across countries. Specifically, Israel exhibits the highest impact with a value of 1.08, while Tunisia experiences the lowest impact at 0.107.

In examining the influence of government health expenditure, it is notable that Kuwait does not exhibit a meaningful effect. Moving to specific countries, Algeria, Iran, Jordan, Lebanon, Morocco, and Tunisia show a statistically significant and negative impact on CO_2 emissions in response to government health expenditure. Conversely, Bahrain, Egypt, and Israel experience a positive impact in the short term. It is worth mentioning that Lebanon and Jordan demonstrate the highest and similar impacts among the countries studied.

Analyzing the impact of the globalization, across the entire sample of countries, it is observed to be statistically significant at a 1% risk level. However, its effects are heterogeneous. Specifically, FDI is associated with a decrease in CO_2 emissions in Algeria, Bahrain, and Kuwait, while the rest of the countries in the sample experience an increase.

The results of the influence of population growth indicate that it contributes to a reduction in CO_2 emissions only in Algeria, Bahrain, and Israel. Conversely, in Iran, Kuwait, Morocco, Lebanon, and Tunisia, population growth leads to an increase in CO_2 emissions. No significant impact is observed for Egypt and Israel.

4.3. Causality Between Variables

In our panel data analysis, the Dumitrescu and Hurlin test was employed. The summary of pairwise causality results is presented in the Table 7. To streamline interpretation, only statistically significant relationships are discussed due to the large number of established relationships. The table delineates the causality direction between variables using symbols.

Table 7. *Panel findings Dumitrescu Hurlin tests between all model variables.*

Null Hypothesis:	W-Stat.	Causality direction
LTA ⇏ LCO_2	4.13**	LTA → LCO_2
LCO_2 ⇏ LGDP	3.65*	LCO_2 → LGDP
LCO_2 ⇏ LEN	4.52***	LCO_2 → LEN
LCO_2 ⇏ LFDI	4.63***	LCO_2 → LFDI
LTA ⇏ LEN	5.12***	LTA→LEN
LTA ⇏ LHE	3.96**	LTA →LHE
LPG ⇏ LAT	4.13**	LPG→LTA
LGDP ⇏ LEN	4.82***	LGDP→LEN
LHE ⇏LGDP	3.88**	LHE→LGDP
LFDI ⇏ LGDP	5.002***	LFDI→LGDP
LPG ⇏ LGDP	4.09**	LPG→LGDP
LEN ⇏ LHE	4.9***	LEN→LHE
LFDI ⇏ LEN	3.77**	LFDI↔LEN
LEN ⇏ LFDI	4.05**	
LPG ⇏ LFDI	3.71*	LPG →LFDI

Note: ***, **, and* denote significance respectively at the 1%, 5%, and 10%.
Source: Author`s compilation

A total of 42 tests were conducted. From this refined table, conclusions can be drawn. Specifically, there are 15 statistically significant causal links identified. Among these, 6 are significant at the 1% level, 7 at the 5% risk level, and 2 at the 90% confidence level.

The analysis of causal relationships among variables reveals distinct patterns. Unidirectional causality is identified for these variable pairs, including: (LTA, LCO_2); (LCO_2, LGDP); (LCO_2, LEN); (LCO_2, LFDI); (LTA, LEN); (LTA, LHE); (LPG, LTA); (LGDP, LEN); (LHE, LGDP); (LFDI, LGDP); (LPG, LGDP); (LEN, LHE). However, a bidirectional causality is observed between LFDI and LEN.

Within these causal relationships, a singular unidirectional connection emerges between the tourism sector and CO_2 emissions. This aligns with the findings expounded by Balli [46] in the context of Mediterranean countries. The validity of these outcomes is substantiated by antecedent studies. Upon examination of part 2 in the literature review, numerous investigations have concurred with similar conclusions, as demonstrated by Aydin [41], Tinoco [54], Gyamerah and Gil-Alana [60], and Chirilus and Costea [59]. Notably, Fan et al [10] contributed to this discourse by illustrating the existence of an asymmetric relationship between variables.

The environmental degradation, linked to economic growth, is found to be unidirectional, contrasting with bidirectional findings in prior research by Bunnag [57], Donkor et al. [7], and Alkasasbeh, et al [38]. A unidirectional causality from CO_2 to energy use aligns with the validation of this hypothesis by Chirilus and Costea [59]. Similarly, the causality relationship between the dependent variable and FDI confirms Bunnag's [57] findings.

Additional interconnections emerge, such as from the tourism sector to energy use and health capital. Bidirectional relationships signify interconnection between variables such as economic growth and the tourism sector.

Given the acquired results, it is worth noting that classifying countries based on (GDP) could enhance the comprehension of the interplay among the tourism sector, GDP, CO_2 emissions, and energy consumption. Such stratification, characterized by homogeneity, holds the potential to furnish nuanced insights into the strength, directionality, and temporal aspects of the relationships among the investigated variables providing a more comprehensive understanding of their short- and long-term dynamics.

Concluding this analysis, the Dumitrescu Hurlin causality test reveals a substantial long-term causal association originating from the tourism sector and extending to CO_2 carbon dioxide emissions. Notably, in the MENA countries, CO_2 emissions have demonstrably influenced economic growth, energy consumption, and FDI. In the short term, our estimations emphasize that only energy consumption significantly contributes to the dynamics of CO_2 carbon dioxide emissions.

5. Discussion

The significant variables in our model are: tourism sector, energy use, economic growth and population growth. Consequently, FDI and health expenditures can not be considered as a significant drivers of the quality degradation in the selected countries MENA, for the period 1995-2019, neither in the short nor the long term.

In reference to literature review part 1 and through a comparison of our findings, disparities with other studies become evident. Notably, in the case of energy use, our results diverge from Ullah [13] and Basuki, Stioningrum [22], where the effect is negative. Conversely, are similar to Javed Al [8], Aydin [41], Shushu, Li et al [71], and Teng et al.[72]. However, our results are in line with those obtained by Usman et al. [50], Anser et al [73], Haseeb and Azam [68]: positive impact of CO_2, but they differ from the findings of Khan et al. [33]. Furthermore, our findings indicate that a 1% increase in energy consumption results in environmental degradation of about 1% in the study countries. This aligns with the results of Khan et al [33] and is consistent with previous studies indicating that various countries heavily reliant on energy sources experience increased CO_2 emissions and environmental degradation, as shown by Ahmed et al. [40] for China, India, and the USA, and Jabeen et al. [74]. The significance of the energy use in the short and log term is similar to Tukhtamurodov [9].

Regarding the impact of economic growth, this is similar to Voumik et al [32], Naz and Tariq [17], Bu and Ali [34]. But the majority of studies underlined a positive impact: Javed Al [8], Khan et al. [33]. Our finding is partially similar to Tukhtamurodov [9], in terms of insignificance of the variable in the court term.

Similar observations extend to the tourism sector. Our results align with previous studies, such as Dogan et al. [75], Raza et al. [45], Hu [28], Tang et al. [27], Raihan and Tuspekova [29], and Alaganthiran et al [30]. Conversely, contradictory results are reported by Naz and Tariq [17]. The positive impact of population growth confirmed results of Naz and Tariq [17], Voumik [32] and Martial [35]. But another result was found by Ahmed [16] demonstrating a negative impact.

Regrading the non significance of the government health expenditures in our study, it is similar to Ullah [13], but contradictory to Ganda [14]. Khan et al. [33] discovered that the increasing effect of government health expenditures leads to a rise in CO_2 emissions in the MENA region. The non-significance of the FDI variable aligns with the results of Aydin [41] indicating that this variable has a significant impact on CO_2 emissions in only a few countries. Our result is similar to Apergis [24], and partially similar to Belloumi et Alshehry [15], regarding the non significance in the short term, and opposite for the long term which had a positive impact. However, conflicting results exist, with some authors, such as Farhan et al [76] and Khan et al [19], suggesting a positive impact, while others, including Tahir [26] and Basuki and Stioningrum [22], demonstrating a negative effect.

Concerning the causality between carbon dioxide emissions and its drivers. Globally, there is no significant relationship, principally from variables to our interest variable. Our findings are similar to Bunnags [57] and Chirilus [59]. Moreover, concerning the causality between tourism sector and CO_2, the results align to Sharif [44], Balli [46]. It's opposite to findings of Raza [45], they showed a unidirectional relationship from energy use to CO_2. For his part Adedoyin, al [77] showed a bidirectional relationship between these variables.

6. Conclusion

Climate change has been a pressing issue for the past few decades. In fact, environmental degradation is a serious problem that decision makers need to address in order to avoid serious adverse consequences for the population at micro and macroeconomic levels. For MENA countries, the challenge lies in balancing economic development with environmental quality due to the complex system of relationships between the variables.

The current paper assesses the relationship between CO_2 emissions and socio-economic factors in MENA countries. Within this framework, the ARDL model is used to identify the long and short - term relationships between the variables.

In the estimation, a panel data for 10 MENA countries for the period from 1995 to 2020 is utilized.

The explanatory variables are: tourism sector, energy consumption, economic growth, government health expenditures, FDI and population growth. Stationarity tests are applied. The results according to Pedroni analysis indicate that in the long run, there is a relationship between the dependent variable and some explanatory variables. On the one hand, the tourism sector and energy consumption have a positive impact on CO_2 emissions; on the other hand, the economic growth and population growth have a negative impact. However, only the economic growth is statistically significant in the short term.

This research confirms that in MENA countries, the rising influx of international tourist arrivals contributes to heightened CO_2 emissions.

This empirical finding confirms that an increase in economic growth is associated with an improvement in environmental quality in the long- run. Therefore, it is possible to reduce carbon dioxide emissions and grow the economy at the same time.

The impact analysis of the dependent and explanatory variables by country indicates that these outcomes are cross-country. To tackle carbon dioxide emissions in the MENA region, decision-makers need to examine the impact of each variable, one by one, and take into account the timing of each impact. For some countries the variables may be a source of pollution reduction, while for others it may be a driver of pollution.

The empirical results reveal that out of all the causality tests which were carried out on the model variables; only 9 were found to be statistically significant. Among them, there is only one unidirectional causality relationship between tourism and carbon dioxide emissions.

It is worth mentioning some of the shortcomings of this study, such as the heterogeneity of the countries in terms of wealth, and the fact that not all MENA countries were included in the sample due to a lack of available data.

Other limitations include the short period in which this study was carried out. Additionally, climate change, health capital and globalization can be measured using indicators other than those used in this study.

Abbreviations

ARDL: Autoregressive Distributed Lag
MENA: Middle East North Africa
CO_2: Carbon dioxide emission
FDI: Foreign Direct Investment
GDP: Gross Domestic Product
WDI: World Development Indicator
CD: Cross Dependence
LM: Lagrange Multiplier

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Jihene Khalifa: Conceptualization, Data curation, Formal Analysis, Resources, Software, Visualization, Writing – original draft

Conflicts of Interest

The authors declare no conflicts of interest.

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