



# Does globalization and financial sector development affect environmental quality? A panel data investigation for the Middle East and North African countries

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## Abstract

The broad purpose of this study is to empirically explore the impact of globalization and financial development on environmental pollution by carbon (CO<sub>2</sub>) emissions in the six Middle East and North Africa (MENA) countries using balanced panel data from 1971 to 2015. We also aimed to test the legitimacy of the environmental Kuznets curve (EKC) hypothesis for this region. The fixed-effects approach preferred by the Hausman specification test is used to estimate the empirical model, and the feasible generalized least squares (F.G.L.S.) estimator is employed to cope with any issue of heteroscedasticity and serial correlation. This study found that globalization and financial development have adverse and significant effects on environmental degradation and affirm the legitimacy of the EKC hypothesis for these countries. The finding of this study suggests that the governments of MENA countries should design and implement appropriate policies for strengthening the renewable sources of energy like wind, solar, bio-fuel, and thermal to decrease CO<sub>2</sub> emissions and boost sustainable economic development. The policymakers should focus on the efficiency of institutions and enhancement of energy-saving projects in this region.

**Keywords** Globalization · Financial sector development · Carbon emissions · MENA-6

**JEL codes** F6 · G1 · N2

## Introduction

The temperature and environmental changes have been growing across the world in the past several decades. This issue has now got priority to think both politically and economically. In 1997, the Kyoto convention featured the issue of diminishing greenhouse gases (GHG) that answerable for atmosphere

harms. Presently, several factors can be observed that can make environmental pollutants and can be the reason for climate change, but carbon dioxide (CO<sub>2</sub>), which is the highest level in history nowadays, is the most prominent reason for global warming (Rogelj and Schleussner 2019). Sustainable economic development is the prime goal of every country. Azam (2016: 175) noted that “sustainable economic growth needs to be the primary objective of every government, including developing Asian countries, for improving the social welfare of people. Therefore, to achieve the desired level of sustainable economic growth, environmental degradation must be controlled without lowering real growth and the well-being of society.”

Globalization is the multifaceted process because it requires swift social alteration that is happening simultaneously diagonally in the different dimensions in the world economy, in culture, in the physical environment, in communication, and in politics transformation with each other. So, it is too difficult process to hold in it's completely (Tomlinson 1999). This concept has been developed since the 1970s, which has promoted trade growth, has increased capital innovation, and has extended the exchange of culture, social, and

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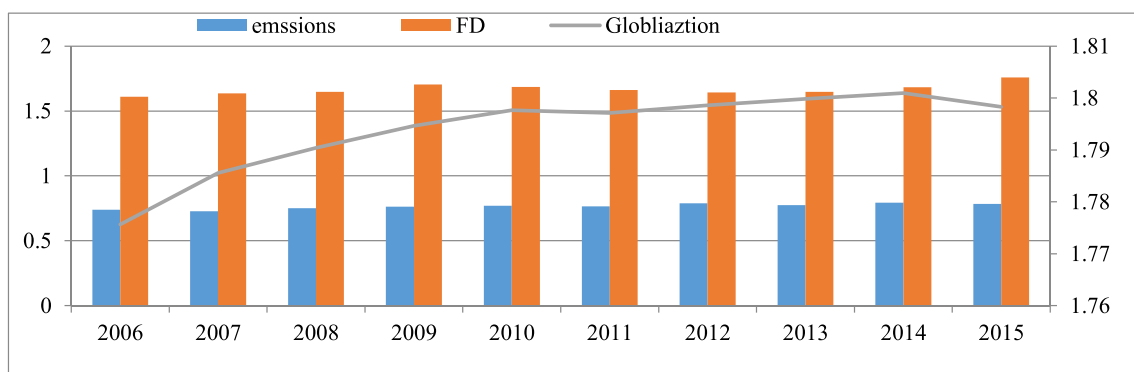
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political values (Shahbaz et al. 2017). Globalization not only causes the economic, communal, and cultural phase of a nation collectively but also hit the environmental worth globally. The globalization has so impressed the new era that air quality has been concerned about raising business activities like trade and investment (Latif et al. 2018). Similarly, financial development is the other important factor that can cause environmental quality. Though Mishkin (2009) has noted that globalization makes the way to financial development and hardly suggested that financial development could be significant as it makes the venture process solid and that innovation is embraced to decrease the ecological discharge (Zafar et al. 2019). For this reason, the current study has included the financial development variable in the model and has analyzed its impact on environmental degradation. Figure 1 depicts CO<sub>2</sub> emissions, financial development, and globalization in the Middle East and North Africa (MENA) region.

According to Simon Kuznets (1955), income disparity first rises and afterward falls as economic development continues. As per Stern (2004), ecological Kuznets curve is a theorized connection between the different indications of environmental deprivation and income per capita. At the initial phase of economic growth, both degradation and pollution rise. However, with time, growth in income leads the economy to grow, which prompts environmental improvement. The ecological Kuznets curve confronts the contention very regularly that increments in income lead unavoidably to more contamination because more income suggests more energy consumption, which thusly infers more contamination. Theoretically, an ecological Kuznets curve concedes the likelihood that there might be factors having the contrary impact of diminishing, as opposed to expanding, contamination. The blend of the two impacts can lead to contamination first expanding and afterward diminishing with increments in income (Carson et al. 1997). The study of Grossman and Krueger (1991) on the environmental impacts of North American Free Trade Agreement (NAFTA) advanced a hypothesis about the environmental Kuznets curve (EKC). Shafik and Bandyopadhyay (1992) were the first to complete a significant report to approve the EKC speculation.

This study aims to examine the influence of globalization and financial development along with some other explanatory variables, namely economic growth, inward FDI, energy consumption, and population growth on CO<sub>2</sub> emissions. Grossman and Krueger (1991) examined the association between economic growth, and ecological discharge was sure at the beginning times of development; yet, after arriving at a specific point, it transforms into negative. So, the economic growth protects the environment when the per capita income reached to the required level. Many studies were conducted to examine the relationship between CO<sub>2</sub> emissions and energy consumption like Ang (2007) and Azam (2019) found that carbon emissions and energy consumption have a strong relation. Irfan et al. (2020a, 2020b) concluded that energy is the main cause of environmental pollution. Energy usage is indeed the source to get economic development by improving productivity, but, more use of energy leads to higher toxin gases. Irfan et al. (2019a, 2019b) energy inefficiency affects the life of people as well as impeding the financial improvement of the nation. Foreign direct investment (FDI) inflows have instantly extended during the past few decades in basically every locale of the world. As a general rule, it is additionally apparent that FDI inflows play a vital role in diminished carbon emanations (Omri et al. 2014). Lastly, population growth is also to be examined in this study. Population size is a complex issue for development, but more human means more skills, and that skill can be efficiently utilized to mitigate the emissions through inventing new technologies.

Globalization and financial development with carbon dioxide emissions is an important issue and required more discussion. After the review literature, a very small amount of studies had been carried out on this issue, especially in MENA countries (Ang 2007). Therefore, this study was conducted to investigate the effect of globalization and financial sector development on environmental quality in the MENA region. There are many reasons to select MENA region because countries have more than 40% of natural gas, whereas 57% of oil reserves all over the world. Almost 85% of greenhouse gases discharge in this region through the usage and production of



**Fig. 1** Carbon emissions (emissions), financial development (FD), and globalization in the MENA region. The primary Y-axis shows the data of CO<sub>2</sub> and FD, both in per capita (WDI, 2020) and the secondary Y-axis shows globalization data in average numbers (Dreher 2006)

oil and gases and the environment is too polluted in these countries (Audi and Ali 2018). Secondly, these nations have an extreme issue of natural degradation in the feeling of carbon discharges. The release of CO<sub>2</sub> emissions for most of the MENA countries is higher than in other regions (Charfeddine and Mrabet 2017). The forgoing studies exhibits that it is needed to conduct research on the connection between globalization and carbon emissions right now, including the job of financial development, and it is a significant issue to be talked about. The existing literature reveals that both globalization and financial development indicators have been overlooked so far to find their impact on CO<sub>2</sub> emissions within the framework of EKC hypothesis in these selected MENA countries. Therefore, this study plans to identify and verify the effect of globalization and financial development on CO<sub>2</sub> emissions and tests the EKC hypothesis, by taking the panel data from six MENA countries in which Israel and Saudi Arabia are the high-income nations, Jordan and Iran are upper-income nations, and Egypt and Tunisia are the middle-income nations from 1971 to 2015.

The contributions of this study to the literature on environment-globalization nexus are three-fold. First, this study is most recent study to exploring empirically the relationship between globalization and the financial development sector together with environmental degradation in six selected countries of the MENA region for 1971–2015 within the framework of EKC hypothesis. Second, we used the KOF index of overall globalization (economic, social, and political) by commissioning the fixed-effect model to get unbiased estimates and true causal effects of an entity. Third, this study also implanted that most appropriate analytical techniques namely feasible generalized least squares (FGLS) to tackle the issues of heteroskedasticity and autocorrelation in the data.

The arrangement of the study is that in the “[Literature review](#)” section, focused on the review of the literature and the “[Data and empirical methodology](#)” section deals with data and methodology. The “[Results and discussions](#)” section presents results and discussion and “[Concluding remarks](#)” section contains conclusion and policy recommendations.

## Literature review

### Carbon emissions and globalization

Bu et al. (2016) used the panel data from 1990 to 2016 for 166 countries to examined globalization and carbon emission relationship, and suggests that the role of globalization in natural debasement is crucial for Organization for Economic Cooperation and Development (OECD) and non-OECD nations. Audi and Ali (2018) examined the elements of environmental deprivation by considering the globalization if there should be an occurrence of chose MENA countries from 1980 to 2013. The

panel autoregressive distributed lag (ARDL) technique was utilized to estimate the model. The globalization, energy utilization, and financial development have both noteworthy and positive relationship with the ecological quality in the selected MENA region. Haseeb et al. (2018) used the panel data of Brazil, Russia, India, China, and South Africa (BRICS) region from 1995 to 2015 and used the variables of energy use, financial development, CO<sub>2</sub> emissions, urbanization, and globalization. They used the dynamic unrelated regression technique to estimate the data. Their results showed the negative relationship between globalization and carbon emissions for the BRICS and in the case of Russia and India globalization significantly contributed to rising CO<sub>2</sub> emissions while in Brazil, China, and India helped to improve environmental quality significantly. Destek (2019) studied the impact of the political social and economic globalization on CO<sub>2</sub> emissions explaining the time frame of 1995–2015 for the area of central and European countries by using the augmented mean group (AMG) technique for the long-run relationship. He concluded that political globalization reduced CO<sub>2</sub> emissions while social and economic globalization was responsible for raising the CO<sub>2</sub> level. Salahuddin et al. (2019) explored globalization, environmental quality, and urbanization relationship for sub-Saharan African countries. They showed an insignificant impact of globalization and ecological quality; anyhow, urbanization is the cause to slow down globalization in those countries.

### Carbon emissions and financial development

Shahbaz et al. (2016) conducted a study on the nexus between CO<sub>2</sub> emissions and financial development with two additional variables namely GDP and energy consumption in the context of Pakistan. The authors developed an index of financial development that consisted of the banking sector and stock market indicators. They concluded that as the index raised the CO<sub>2</sub> emissions also accelerated. Pata (2018) found that carbon emissions are directly related to financial development and EKC was valid for Turkey. The empirical findings of Azam (2019) showed that financial development and environmental pollution by CO<sub>2</sub> emissions had close linkages by using the panel data four BRICS countries from 1981 to 2015. Charfeddin and Kahia (2019) investigated 24 MENA countries through the Panel VAR technique and concluded that CO<sub>2</sub> emissions accelerated with an increase in financial development.

### Economic growth and carbon emissions

EKC is widely used in literature to shows the relationship between national income and CO<sub>2</sub> emissions. Grossman and Krueger (1995) proposed an inverted U-shaped EKC for a long-run relationship between an increase in per capita income and environmental quality, and hence are considered as pioneers. They were of the view that with the increase in

economic growth the environment goes through degradation at first, but after a certain growth limit, any further improvement in growth will cause the quality of the environment to improve. Farhani and Rajeb (2012) investigated the link among economic growth, CO<sub>2</sub> emissions, and consumption of energy by using the panel data of 15 MENA countries. They found that there was a long run, a unidirectional causality from CO<sub>2</sub> emissions and growth to energy-burning up; while, in the short run, there were no relationship between carbon emissions and the consumption of energy and also between growth and energy consumption. Al-Rawashdeh et al. (2014) used time-series data for 22 MENA countries and performed a country-level analysis to examine EKC between gross domestic product (GDP) and environmental degradation. Environmental degradation was measured by pollution indicators, i.e., SO<sub>2</sub> and CO<sub>2</sub>. For the panel, EKC was not valid in this region, whereas for country-wise, it gives mixed results for EKC. Azam and Khan (2016) found that EKC was valid in low, middle, upper middle, and high-income countries over 1975–2014. The studies of Ali et al. (2016, 2017) confirmed the validity of the EKC hypothesis for Malaysia between 1985–2012 and 1971–2012 using a different set of regressors. Zafeiriou and Azam (2017) corroborated the EKC hypothesis covering the agriculture sector for three Mediterranean countries namely France, Portugal, and Spain from 1992 to 2014. The Bah et al. (2020) study vindicated the existence of EKC hypothesis of ten sub-Saharan African countries from 1971 to 2012.

### Carbon emission and energy usage

Omri (2013) examined CO<sub>2</sub> emissions, energy use, and financial development in the MENA area and discovered unidirectional connection from energy utilization to emanation while bi-directional among CO<sub>2</sub> emissions and economic development. Magazzino (2017) found that the relation of energy use with emissions was the cause to increase in the income in Asia-Pacific Economic Cooperation (APEC) countries. Sinha and Sengupta (2019) studied the role of NO<sub>2</sub> emissions and found that there was an *N*-shaped relation of income and emissions in APEC countries. Irfan et al. (2020a, 2020b) conducted the study on major cities of Pakistan based on primary data. They used structural equation modeling and found that environment and renewable energy cost had not any significant relationship in major cities of Pakistan.

### Carbon emissions, FDI, and population size

Al-Mulali et al. (2013) contemplated the connection between energy utilization, urbanization, and CO<sub>2</sub> discharge in the MENA locale for the time of 1980–2009. The dynamic ordinary least squares (OLS) results found that there was a bi-directionally positive connection among the factors, whereas

the level of income and development had long-run relationships among all the variables. Dong et al. (2018) explored the nexus of CO<sub>2</sub>, population growth, and economic growth for 128 nations from 1990 to 2014. They utilized common correlated effects mean group estimator to locate that, both, population and economic growth, had a fundamentally positive connection with carbon discharges at worldwide just as at the provincial level. Shahbaz et al. (2019) examined FDI and carbon emanations in the region of the MENA for 1990–2015. They utilized generalized methods of moments (GMM) to demonstrate the presence of the pollution haven hypothesis (PHH) and found an *N*-shaped connection among CO<sub>2</sub> emissions and FDI in the MENA region. Table 1 shows prior empirical studies on globalization, financial development, and some other variable's impacts on CO<sub>2</sub> emissions. Figure 2 describes the graphical relationship of all the independent variables with the dependent variable (carbon emissions) in this study.

The aforementioned studies indicate that carbon emissions, globalization, and financial development are still to be explored for MENA countries. Only a few studies considered the MENA region, whereas advanced economies have been studied these issues several times (Dreher 2006), though these variables are studied by other researchers for a different part of economies like Zafar et al. (2019) for OECD countries and Bu et al. (2016) for OECD and non-OECD countries (Fig. 3). The issue of economic growth, energy usage, and ecological debasement has been talked about by the number of studies; yet, at the same time, there is a need to contemplate globalization and financial development with the EKC hypothesis together in the MENA district. So, this study will certainly reduce this gap by contemplating the effect of globalization and financial development on CO<sub>2</sub> emissions by together with GDP, energy consumption, foreign direct investment, and population size.

## Data and empirical methodology

### Data of the study

We utilized selected variables namely globalization, financial development, CO<sub>2</sub> emissions, FDI inflows, population, and economic growth by GDP, while the extensive goal of this study is to verify the legitimacy of EKC theory. We included high-income countries (Israel and Saudi Arabia), upper-income countries (Iran and Jordan), and lower income countries (Egypt and Tunisia) countries from the MENA region over the period of 1971–2015. Sample data is limited to these countries due to the confinements on the accessibility of data, especially on CO<sub>2</sub> emissions. We used annual/yearly data (45 years) from 1971 to 2015. Though we intend to use longer and updated data, consistent balanced data on CO<sub>2</sub> emissions were only available up to 2015. Besides, low-income nations from

**Table 1** Prior studies on the links between globalization, financial development and CO<sub>2</sub> emissions

| Authors                       | Time, countries and method  | Dependent variable  | Independent variables  | Findings   |
|-------------------------------|---|---|--|--|
| Khan et al. (2020)            | 1965–2015<br>Pakistan, ARDL   | CO <sub>2</sub> emissions   | Economic growth, coal use, oil use, and gas use  | Energy use has a positive impact on CO <sub>2</sub> emissions  |
| Bah et al. (2020)             | 1971–2012<br>SSA countries<br>Pedroni cointegration, DOLS           | GHG emissions   | GDP per capita, fossil fuel consumption, and urbanization rate   | Long-run relationships found between GHG emissions and all the regressors. EKC hypothesis existed for the selected region for the study  |
| Salahuddin et al. (2019)      | 1984–2006<br>44 SSA countries<br>Westerlund cointegration           | CO <sub>2</sub> emissions   | Real GDP, urbanization, globalization, and energy poverty  | Globalization is negative and insignificant and all other regressors are positive and significant relationship with emissions  |
| Haseeb et al. (2018)          | 1995–2014<br>BRICS countries FMOLS                                  | CO <sub>2</sub> emissions   | Energy use, financial development, economic growth, globalization, and urbanization                                      | Energy consumption and financial development (+ive), globalization, and urbanization (-ive)  |
| Audi and Ali (2018)           | 1980–2013<br>MENA countries<br>Panel ARDL                           | CO <sub>2</sub> emissions   | Energy consumption, per capita income, globalization, and population density   | All the independent variables have a positive and significant relationship with CO <sub>2</sub> emissions  |
| Charfeddine and Mrabet (2017) | 1975–2007<br>15 MENA countries<br>Pedroni cointegration FMOLS, DOLS | Ecological footprint variable (a proxy for environment)                               | Real GDP, energy use and urbanization  | GDP and urbanization had an inverse relationship with the dependent variable. U-shaped behavior in all non-oil-exporting countries   |
| Shaari et al. (2017)          | 1971–2013<br>Malaysia ARDL  | CO <sub>2</sub> emissions   | GDP, energy use  | Electricity and economic growth have a significant impact on the environment in the long run   |
| Bu et al. (2016)              | 1990–2009<br>166 countries<br>2SLS, fixed effect                    | GHG, CO <sub>2</sub> , and CO <sub>2</sub> from manufacturing and construction sector | KOF globalization, per capita GDP and manufacturing value added to GDP   | Expanded carbon discharges move to pair with more significant levels of globalization. CO <sub>2</sub> from man., and construction sector is negatively related to globalization |
| Saidi and Hammami (2015)      | 1990–2012<br>58 Countries<br>GMM                                    | Energy use per Capita   | GDP, CO <sub>2</sub> , capital stock, population, labor force, and financial development                                 | GDP (+), CO <sub>2</sub> (+), financial development (+)  |
| Munir and Khan (2014)         | 1980–2010<br>Pakistan<br>VEC  | CO <sub>2</sub> emissions and Fossil fuel energy use                                  | Real GDP, financial development, trade openness, and industrial value-added population, investment, exports, and imports | Energy use negatively affects CO <sub>2</sub> , industrial value added, and trade positively affect CO <sub>2</sub> , imports negatively affect energy use                       |
| Al-Mulali et al. (2013)       | 1980–2009<br>MENA countries<br>cointegration, DOLS                  | Total primary energy use  | Urban population and total carbon dioxide emission   | Long-run bi-directional positive relationship between the variables  |
| Silva et al. (2012)           | 1960–2004<br>Spain, Denmark, Portugal, and USA<br>SVAR              | Renewable energy  | Economic growth and CO <sub>2</sub>  | Renewable energy is harmful to GDP except for the USA but it reduces CO <sub>2</sub>   |
| Jaunsky (2011)                | 1980–2005<br>36 high-income countries<br>GMM                        | CO <sub>2</sub> emissions   | GDP  | Unidirectional causality from GDP to CO <sub>2</sub> emissions is found in both long run and short run   |

Table 1 (continued)

| Authors                     | Time, countries and method  | Dependent variable        | Independent variables  | Findings  |
|-----------------------------|---|---------------------------|--|---|
| Choi et al. (2010)          | 1971–2006<br>China, Korea, and Japan<br>VECM                        | CO <sub>2</sub> emissions | Trade openness, GDP, renewable energy, fossil consumption                        | China and Japan had N-shaped EKC. Korea and China had a positive relationship among GDP and CO <sub>2</sub> emissions   |
| Lean and Smyth (2009)       | 1980–2006<br>ASEAN,<br>Panel VECM                                   | CO <sub>2</sub> emissions | GDP and electricity use  | The long-run link is positive among emissions and electricity use and a nonlinear link between CO <sub>2</sub> emissions and GDP                                    |
| Jalil and Mahmud (2009)     | 1975–2005<br>China<br>ARDL  | CO <sub>2</sub> emissions | Commercial energy, real income, and foreign trade                                | CO <sub>2</sub> and income had a quadratic relationship. EKC hypothesis found. One-way causality from income to CO <sub>2</sub> emissions                           |
| Hatzigeorgiou et al. (2008) | 1990–2002<br>Greece<br>AMDJ and LMDI                                | CO <sub>2</sub> emissions | Income effect, energy intensity effect, fuel share effect, and population effect | Income effect contributed more to produce CO <sub>2</sub> and energy intensity effect contributed to control CO <sub>2</sub> in Greece in the selected time series. |
| Maddison and Rehdanz (2008) | 1990–2005<br>134 countries<br>Kao and Pedroni cointegration test    | CO <sub>2</sub> emissions | GDP per capita   | A bi-directional relationship was found. The results showed that heterogeneous non-causality can be rejected in Asia.   |
| Ang (2007)                  | 1960–2000<br>France<br>Johansen cointegration and multivariate VECM | CO <sub>2</sub> emissions | Commercial energy and per capita real GDP  | Emissions and output had a quadratic relationship in the long run and energy usage created air pollution in France  |

Source: authors compilation

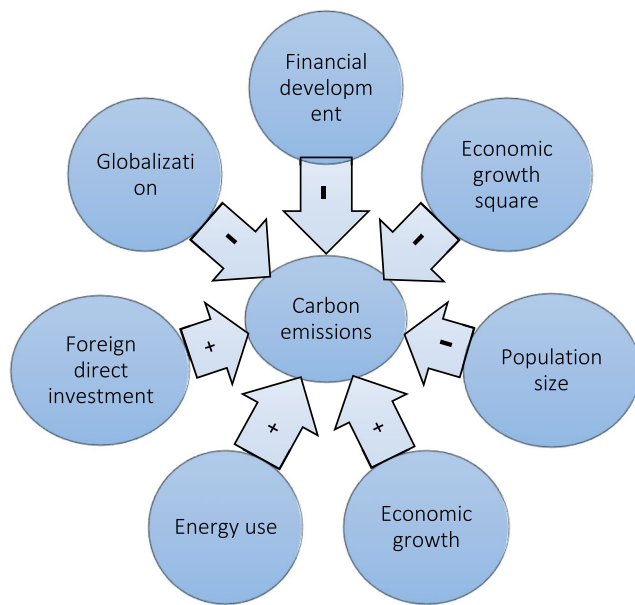


Fig. 2 Conceptual framework. Source: authors constructed

this locale have almost no commitment to the world economy, so those nations are prohibited and there is an issue for adjusted information for low-income nations. The data have been taken from the World Development Indicators (WDI) (2020), the World Bank, while data on globalization has been from KOF index, in light of the Dreher (2006), who presented the idea of globalization list dependent on economic, political, and social globalization. Details of the data are given in Table 2.

**Empirical model**

The concept of globalization discussed in different studies is an old tradition like Grossman and Krueger (1991) discussed the Northern America Free Trade Agreement and debated on the effects of globalization. When production increases through foreign trade and investments, it is called a scale effect of globalization. Two other effects are the technique and the composition scale of globalization.

Dreher (2006) explicated that due to the scale effect of globalization; structural changes took place whereas the composition effect might be a reason for environmental damage as the production sector might increase the investment. When economic growth becomes constant, along with scale effect than new concepts of the technology are considered and new patterns of production methods are introduced, and this is called a technique effect of globalization. This consequence reduces CO<sub>2</sub> emissions because of pollution-free trade and investment.

Financial development is another variable to check the relationship with carbon emissions. Financial development can play a vital role in CO<sub>2</sub> emissions in any

society. For example, Sadorsky (2011) explored that monetary improvements cover the customer’s approach to the strength and consistency of the products which increased energy usage and environmental emissions. Financial development provides the opportunity for the business community to increase the capital to expand the production activities. Charfeddine and Khediri (2016) expounded that domestic credit to the private sector scaled by real GDP proxy to measure the financial development notwithstanding economic growth and energy utilization as globalization impact and financial development can’t be estimated without these referenced factors appropriately. The conversation concerning the association of CO<sub>2</sub> emissions and economic growth has been concentrated broadly through EKC. for instance, Zaidi et al. (2019) for APEC nations, Azam and Khan (2016) for low, lower center, upper center, and high-income nations from various pieces of the world. After Zaidi et al. (2019), this study will pursue the following function to estimate carbon emissions.

$$CO_2 = f (GLOB, FD, GDP, GDP^2, EUSE, FDI, PS) \quad (1)$$

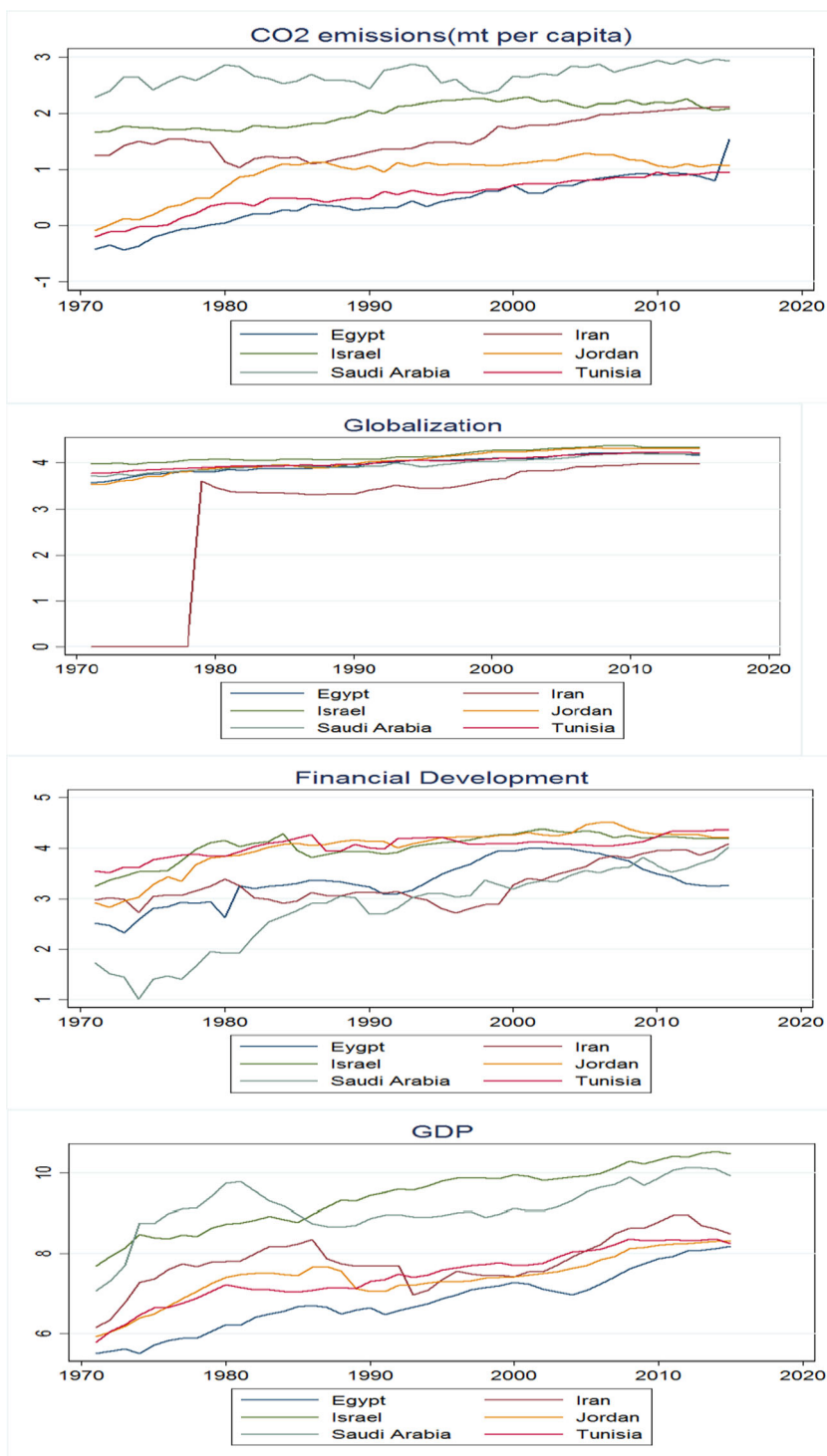
In Equation (1), CO<sub>2</sub> refers to carbon emissions extended in metric tons. The use of coal, oil, gas, and other fuels is the source of CO<sub>2</sub> emissions. FD refers to financial development, which is the % of GDP and is extended through the proxy “domestic credit issued to the Private sector.” GDP is per capita gross domestic product, current US dollars, used as a proxy of economic growth. GDP square is the square term of per capita GDP, current US dollars to measure the EKC, EUSE is energy usage, kilograms of oil equivalent per capita energy use from all sources, FDI is the foreign direct investment of inflows measured in percentage of GDP, and PS is a total population of midyear estimates.

Swiss Institute for Economic Research developed the globalization index which is named as KOF index. It consists of three sub-indexes called economic, social, and political indexes. All the factors are included in the KOF globalization index. KOF index is scaled from 0 to a maximum of 100. In the above model, the GLOB variable is a globalization index that has been taken from the KOF globalization index.

All the used variables in this model are transformed into log form to stay away from sharpness in the data. The log transformation method is the most adopted technique as it transforms the data to confirm normality (Changyong et al. 2014).

$$LCO_{2it} = \beta_0 + \beta_{1i}LGLOB_{it} + \beta_{2i}LFD_{it} + \beta_{3i}LGDP_{it} + \beta_{4i}LGDP^2_{it} + \beta_{5i}LEUSE_{it} + \beta_{6i}LFDI_{it} + \beta_{7i}LPS_{it} + \varepsilon_{it} \quad (2)$$

**Fig. 3.** Trends of variables in selected countries of the MENA region. Data of globalization is taken from Dreher (2006) and source of other series, is WDI (2020)



whereas  $i$  represent the number of countries;  $t$  shows the quantity of time;  $\varepsilon$  is the error term; and  $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6,$  and  $\beta_7$  are the coefficient of globalization, financial development, economic growth, economic growth square, energy use, foreign direct investment inflows, population growth, and error term respectively.

**Estimation procedure**

The issue of cross-sectional dependence in panel data has seen in a large portion of the investigations. This issue emerges due to numerous components like nearer outskirts, same exchange designs, or nearly the equivalent financial exercises and



**Table 2** Data and its sources

| Series                   | Definition                              | Supporting references   | Sources   |
|--------------------------|---|-------------------------|-----------|
| Carbon emissions         | Metric tons per capita                  | Omri (2013)             | WDI, 2020 |
| Globalization            | Index                                   | Zafar et al. (2019)     | KOF index |
| Financial development    | % of GDP                                | Al-Mulali et al. (2013) | WDI, 2020 |
| Per capita GDP           | Current USD                             | Bilgili et al. (2016)   | WDI, 2020 |
| Square of per capita GDP | Current USD                             | Bilgili et al. (2016)   |           |
| Energy use               | A kilogram of oil equivalent per capita | Zaidi et al. (2019)     | WDI, 2020 |
| FDI inflows              | % of GDP                                | Shahbaz et al. (2019)   | WDI, 2020 |
| Population size          | Total population                        | Dong et al. (2018)      | WDI, 2020 |

patterns. So, by overlooking the issue of cross-sectional dependence results might be out of line (Paramati et al. 2017). This investigation utilized the cross-sectional dependence (CD) test, Pesaran (2004), and the Breusch-Pagan-LM (1980) test.

The first-generation unit root tests cannot be executed as the problem of cross-section dependence exists in the data (Zafar et al. 2019). Accordingly, this study will utilize the second-generation unit root test of cross-sectional augmented Dickey-Fuller (CADF), proposed by Pesaran (2007). This test has command over the cross-sectional dependence issue when data is inspected for the unit root test and the selection of the right unit root test intensifies the consistency of the outcomes (Paramati et al. 2017). The null hypothesis shows that data is non-stationary. In the wake of testing the 2nd-generation unit root of the panel data, it is required to check the 2nd-generation panel cointegration test among the variables (Menegaki 2019). So, this study employs the Westerlund (2005) test for panel cointegration. Westerlund (2005) test inferred a couple of variance ratio (VR) test statistics for the null hypothesis of no cointegration. The default test utilizes a model wherein the autoregressive (AR) parameter is board explicit and for which the alternative hypothesis is that the series in a portion of the panels are cointegrated. Determining the “all panels” choice creates the outcomes for a test where the alternative hypothesis is that the series in all the panels are cointegrated, and this test utilizes a model wherein the AR parameter is the equivalent over the panels.

In case when panel data does not find any cointegration between the variables then polling is the best technique to check the relationship between the variables and the option between fixed effect and random effect can be picked through the Hausman test (Menegaki 2019). Panel data modeling investigates the time and group effect to compact with individual effect and heterogeneity effect and these effects are fixed effect or random effect (Park 2011).

The Hausman (1978) test is exercised to decide between the fixed-effect (FE) model and the random effect (RE) model. It is used to determine which of the two models is appropriate. The Hausman test calculates that the residuals are correlated

with the explanatory variables. The fixed and random effects are better than other techniques of estimation as the result of the following:

- 1) The RE model assists in providing estimates for time-constant covariates.
- 2) The FE model is used to derive unbiased estimates.
- 3) The FE is a better measure of identifying the true causal effect of an entity.
- 4) The FE and the RE models help to analyze the panel data which constitutes of time-series data and cross-sectional data (Oshin and Ogundipe 2014).

To check the cross-sectional independency, this study will use Breusch and Pagan’s (1980) test since this test is pertinent for cross-sectional independence under the fixed-effect regression model (Greene 2000). Wooldridge (2002) test for autocorrelation in this study is used. For panel data, a major issue to be faced is the autocorrelation problem (Driscoll and Kraay 1998). This issue emerges because regularly utilized panel data estimators have insufficient ability to deal with autocorrelation. Parks’ feasible generalized least squares (FGLS) estimator Parks (1967) can be a dependable source to handle autocorrelation problems. Notwithstanding, it must be executed when the volume of the cross-segment is not exactly or equivalent to the volume of time (Reed and Ye 2011).

To check the group-wise heteroskedasticity in the model of fixed-fixed regression, an adjusted Wald test will be executed (Baum 2001). If group-wise heteroskedasticity is found in the fixed-effect model, at that point the FGLS are tried to expel the issue of heteroskedasticity (Reed and Ye 2011). So, we also implement the FGLS approach.

## Results and discussions

Table 3 shows a summary of descriptive statistics and correlation matrix. CO<sub>2</sub> emissions in the selected MENA nations have been 1.3528 metric tons on normal from 1971 through 2015. The most reduced GDP, speaking to economic growth,

**Table 3** Summary of descriptive statistics, and correlation matrix

| Variables           | Mean               | Min.                | Max.              | Std. dev.          |                     |                    |                   |  |
|---------------------|--------------------|---------------------|-------------------|--------------------|---------------------|--------------------|-------------------|--|
| LCO <sub>2it</sub>  | 1.352821           | – .438635           | 2.967367          | .8760321           |                     |                    |                   |  |
| LGLOB <sub>it</sub> | 3.865844           | 3.318839            | 4.386682          | .7174191           |                     |                    |                   |  |
| LFD <sub>it</sub>   | 3.588851           | 1.011817            | 4.505349          | .6629812           |                     |                    |                   |  |
| LGDP <sub>it</sub>  | 8.009402           | 5.496376            | 10.53685          | 1.168841           |                     |                    |                   |  |
| LEUSE <sub>it</sub> | 7.115166           | 5.380083            | 8.840111          | .8265699           |                     |                    |                   |  |
| LFDI <sub>it</sub>  | .4147791           | – 1.29133           | 1.394486          | .4413644           |                     |                    |                   |  |
| LPS <sub>it</sub>   | 7.153587           | 6.257482            | 7.965872          | .4861979           |                     |                    |                   |  |
| Variables           | LCO <sub>2it</sub> | LGLOB <sub>it</sub> | LFD <sub>it</sub> | LGDP <sub>it</sub> | LEUSE <sub>it</sub> | LFDI <sub>it</sub> | LPS <sub>it</sub> |  |
| LCO <sub>2it</sub>  | 1.0000             |                     |                   |                    |                     |                    |                   |  |
| LGLOB <sub>it</sub> | 0.0566             | 1.0000              |                   |                    |                     |                    |                   |  |
| LFD <sub>it</sub>   | – 0.1594           | 0.3514              | 1.0000            |                    |                     |                    |                   |  |
| LGDP <sub>it</sub>  | 0.8604             | 0.2762              | 0.1722            | 1.0000             |                     |                    |                   |  |
| LEUSE <sub>it</sub> | 0.9545             | 0.1886              | 0.0190            | 0.7481             | 1.0000              |                    |                   |  |
| LFDI <sub>it</sub>  | 0.3019             | 0.1335              | – 0.1697          | 0.1152             | 0.2688              | 1.0000             |                   |  |
| LPS <sub>it</sub>   | – 0.0070           | – 0.2015            | – 0.2897          | – 0.1352           | 0.0384              | 0.1574             | 1.0000            |  |

was 5.49% though; the most elevated GDP rate was 10.53%. The globalization was 3.86 on standard and financial development was 3.58%. The least and most elevated paces of energy usage were 5.38 kg and 8.84 kg, individually, while, inflows of FDI were 0.414% in selected MENA countries.

Table 3 shows a positive connection between globalization and CO<sub>2</sub> emissions, between CO<sub>2</sub> emissions and GDP, CO<sub>2</sub> emissions, and energy use, among CO<sub>2</sub> emissions and inward FDI. There exists additionally a positive relationship among globalization and financial development, financial development, and energy use; FDI has likewise a positive connection with population size. A negative relationship between financial development and CO<sub>2</sub> emissions, among CO<sub>2</sub> emissions and population size, and among globalization and population size can be seen.

Table 4 describes the results of cross-section dependence in data. This study considers the outcomes of the Pesaran CD test

**Table 4** Cross-sectional dependence results

| Series                          | Breusch-Pagan LM | Pesaran Scaled | Pesaran CD  |
|---------------------------------|------------------|----------------|-------------|
| LCO <sub>2it</sub>              | 314.3932***      | 54.66147***    | 17.05994*** |
| LGLOB <sub>it</sub>             | 549.8039***      | 97.64138***    | 23.31242*** |
| LFD <sub>it</sub>               | 348.4735***      | 60.88365***    | 18.07397*** |
| LGDP <sub>it</sub>              | 472.8036***      | 83.58312***    | 21.58188*** |
| LGDP <sup>2</sup> <sub>it</sub> | 473.0353***      | 83.62542***    | 21.59257*** |
| LEUSE <sub>it</sub>             | 515.8459***      | 91.44153***    | 22.60216*** |
| LFDI <sub>it</sub>              | 69.71900***      | 9.990276***    | 6.440047*** |
| LPS <sub>it</sub>               | 656.9363***      | 117.2010***    | 25.62944*** |

\*\*\*Show significance at the 1% levels, respectively. The results are described on the source of Breusch-Pagan (1980) LM test

and the Breusch-Pagan LM test. All the variables are at 1% of a significant level so we reject the null hypothesis of no cross-section dependence.

After the cross-sectional dependence results, the next step is to check the unit root of the selected variables. We used the second-generation unit root test of cross-sectional augmented Dickey-Fuller (CADF), proposed by Pesaran (2007) due to the issue of cross-sectional dependence and results of CADF unit root test are given in Table 5. The results indicate that there is mix order of integration, i.e., *I*(0) and *I*(1). Inward FDI and population size are stationary at a level while all other variables have unit root but become stationary at the first difference at 1% significant level.

**Table 5** Results of CADF unit root tests

| Variables                       | CADF        |                  |
|---------------------------------|-------------|------------------|
|                                 | Level       | First difference |
| LCO <sub>2it</sub>              | – 2.417     | – 4.525***       |
| LGLOB <sub>it</sub>             | – 1.635     | – 3.460***       |
| LFD <sub>it</sub>               | – 2.161     | – 4.576***       |
| LGDP <sub>it</sub>              | – 2.708     | – 4.275***       |
| LGDP <sup>2</sup> <sub>it</sub> | – 2.736     | – 4.217 ***      |
| LEUSE <sub>it</sub>             | – 2.575     | – 4.605 ***      |
| LFDI <sub>it</sub>              | – 3.378***  | ----             |
| LPS <sub>it</sub>               | – 4.237 *** | ----             |

\*\*\*Shows the significance at the 1% level respectively. Deterministic chosen are constant and trend. Critical values for CADF – 2.730 at 10%, – 2.840 at 5%, and – 3.060 at 1% significance levels. The results are reported at lag = 1. \*\*\* denotes rejection of the null hypothesis

The results of the Westerlund cointegration test are shown in Table 6. The null hypothesis of the test describes that there is no cointegration and some panels are cointegrated is an alternative hypothesis so our study accepts the null hypothesis as variance ratio is insignificant and is greater than 5% if significant level.

Table 6 shows that the *P* value is profoundly unimportant that implies there is no panel cointegration then this study executed the pooling technique as discussed in the estimation procedure.

Under the panel data estimation technique, the fixed-effect and the random effect estimators were used and the Hausman test was used to ascertain the most efficient and consistent model. The fixed-effect estimator accounts for the time-invariant characteristics, that is, unique traits or characteristics which are found in individual countries. Those characteristics are unique to just that particular country or entity, e.g., culture. Therefore, when carrying out the FE test, we assume that something within the entity may lead to the bias of our explanatory variables; therefore, we need to control for this. The hypothesis of the Hausman test is specified as follows:

$H_0$ : Random effect model is suitable.

$H_1$ : Random effect model is not suitable.

The null hypothesis suggests that the random effect estimator is best to employ, whereas alternative suggests that the fixed-effect estimator is more reliable to check the relations among the variables.

Table 7 shows the results of the fixed-effect model, which indicated that the Hausman test rejects the null hypothesis and concluded that the fixed-effect estimator is more suitable. But before going to interpret the fixed-effect model results, some diagnostic tests to be executed like group-wise Heteroskedasticity, serial correlation, and cross-sectional independence test whether the results of fixed-effect model is reliable or not. The diagnostic tests results are given in Table 8, which shows the result of the Breusch-Pagan LM test of cross-sectional independence was significant at 1% level of significant; therefore, this study reject the null hypothesis that the cross-sectional independent. The modified Wald test for group-wise heteroskedasticity result was also found significant at 1% level of significant and reject the null hypothesis that heteroskedasticity in the data. The Wooldridge test for autocorrelation results found significant; therefore, reject the null hypothesis that there are first order correlation in the data.

**Table 6** Westerlund test for panel cointegration

|                | Statistic | <i>P</i> value |
|----------------|-----------|----------------|
| Variance ratio | - 1.5146  | 0.0649         |

\*\*, \*The rejection of null hypothesis of no cointegration is statistically significant at 5% and 1% levels, respectively

**Table 7** Fixed-effect estimation

| Variables                       | Coefficient | <i>P</i> values |
|---------------------------------|-------------|-----------------|
| LGLOB <sub>it</sub>             | - 0.0937*** | 0.000           |
| LFD <sub>it</sub>               | - 0.1149*** | 0.004           |
| LGDP <sub>it</sub>              | 0.9038***   | 0.000           |
| LGDP <sup>2</sup> <sub>it</sub> | - 0.0451*** | 0.000           |
| LEUSE <sub>it</sub>             | 0.5106***   | 0.000           |
| LFDI <sub>it</sub>              | 0.0957***   | 0.007           |
| LPS <sub>it</sub>               | 0.0524      | 0.703           |
| adj. R <sup>2</sup>             | 0.94        |                 |
| Hausman test                    | 27.52***    | 0.000           |

\*\*\*Shows significance at the 1% level. Dependant variable: LCO<sub>2</sub> emissions

The results of the diagnostic tests show that the fixed-effect model results were not reliable. Therefore, this study used cross-sectional time-series FGLS regression to get ride from the heteroskedasticity and autocorrelation problems. Table 9 presents the FGLS regression results, which shows the negative and significant relationship between globalization and CO<sub>2</sub> emissions. The coefficient of this variable indicates that a 1% increase in globalization will lead to reducing the emission by 0.1255% in the selected MENA countries. Our results are parallel to the results of Haseeb et al. (2018) and Zaidi et al. (2019). Carbon emissions and financial development has also a significant and negative relationship. Environmental conditions are improved by 0.2644% when financial development is decreases by 1%. The similar results were found by Zafar et al. (2019) and Zaidi et al. (2019).

The estimated coefficient values of GDP and GDP square explain the concept of EKC. Economic growth by GDP has a positive relationship with carbon emissions, which means that if GDP improves by 1% then carbon emissions will make the environment polluted by 0.6248%. On the other hand,

**Table 8** Cross-sectional independence test under the fixed-effect estimator, group-wise heteroskedasticity test, and results of autocorrelation test

| Cross-sectional independence test under the fixed-effect estimator |                      |                     |
|--|----------------------|---------------------|
| Ho: cross-sectional Independence                                   |                      |                     |
| Breusch-Pagan LM test: chi2(15)                                    |                      | 74.370, Pr = 0.0000 |
| Group-wise heteroskedasticity test                                 |                      |                     |
| Modified Wald test   | chi <sup>2</sup> (6) | <i>P</i> value      |
|  | 477.95               | 0.0000              |
| Results of autocorrelation test                                    |                      |                     |
| $H_0$ : no first-order autocorrelation                             |                      |                     |
| Wooldridge test  | <i>F</i> (1,5)       | Probability         |
|  | 11.255               | 0.0202              |

**Table 9** Results of cross-sectional time-series FGLS

| Coefficients                    | Generalized least squares |                 |
|---------------------------------|---------------------------|-----------------|
| Panels                          | Homoskedastic             |                 |
| Correlation                     | No autocorrelation        |                 |
| Variables                       | Coefficients              | <i>P</i> values |
| LGLOB <sub>it</sub>             | − 0.1255***               | 0.000           |
| LFD <sub>it</sub>               | − 0.2644***               | 0.000           |
| LGPD <sub>it</sub>              | 0.6248***                 | 0.000           |
| LGDP <sup>2</sup> <sub>it</sub> | − 0.0286***               | 0.000           |
| LEUSE <sub>it</sub>             | 0.8216***                 | 0.000           |
| LFDI <sub>it</sub>              | 0.0985***                 | 0.000           |
| LPS <sub>it</sub>               | − 0.1728***               | 0.000           |
| Wald chi <sup>2</sup> (7)       | 8464.41                   | 0.000           |

\*\*\*Show significance at the 1% level. Dependent variable: LCO<sub>2</sub> emissions

emission can be eliminated by 0.0286 percent due to an increase in GDP squares by one percent, which means that carbon emission is inversely related to GDP squares. These results interpret that in earlier stages when economic growth raises carbon emissions also increase but over time and after reaching a threshold point when economic growth develops, CO<sub>2</sub> emissions start declining. Azam et al. (2016) and Dogan and Turkekul (2016) have also obtained similar results for the EKC hypothesis in their respective studies. The CO<sub>2</sub> emissions and energy consumption has also significant but positive relations. If 1% increase in energy consumption in the selected MENA region will increase the carbon emission by 0.8216%. These results are the same as by the study of Haseeb and Azam (2015) and Shaari et al. (2017) and Azam and Ozturk (2020). The most reliable way of producing energy like wind energy which have no harmful emissions (Irfan et al. 2019a, 2019b). The after effects of FDI inflows demonstrate that the relationship is certain and profoundly critical with carbon emanations. A 1% increase in incoming FDI can cause environmental pollution by 0.0985% in selected MENA regions during the mentioned period. Our empirical results are the same as the findings of Omri et al. (2014) and Shahbaz et al. (2019). The population size and carbon emissions have a significant and negative relationship. It is obvious from the results that CO<sub>2</sub> emissions decreased by 0.1728 when population size is increased by 1%. The same results were given by Azam (2016) and Charfeddine and Mrabet (2017).

## Concluding remarks

This study aims to investigate the impact of globalization and financial development on CO<sub>2</sub> emissions in six countries of the MENA region which are a high-income (Israel, Saudi Arabia), upper center income (Jordan, and Iran), and lower

center income (Egypt and Tunisia) from 1971 to 2015. The second-generation unit root test indicated that there were mixed level of stationery of the variables. The Westerlund test of cointegration is additionally employed to check the long-run relationship. The Hausman test recommend to use the fixed-effect model, but the results of fixed-effect model results were not reliable due to autocorrelation and heteroskedasticity problem in the data. To overcome these problems, the study used feasible generalized least square (FGLS) techniques to estimate the data. This study found that globalization, financial development, and population size reduces CO<sub>2</sub> emissions, whereas energy usage and foreign direct investment are the cause to make the environment more polluted. The results reveal a positive linear connection and a negative relationship in quadratic structures between CO<sub>2</sub> emissions and economic growth. This association suggests that in the beginning periods, growing economic growth in selected MENA nations additionally inspire CO<sub>2</sub> discharges to a defining point yet after that point outflows begin to diminish as economic growth increments further.

This study recommended for MENA countries that environmental issues can be eliminated by introducing the trade openness to the economy and developing relations with trade partners. High-quality reform in institutions can be a cause to increase the globalization index. Furthermore, improvement in the efficiency of the banking system, reduction in corruption, betterment in legal systems, control on the misuse of property rights acts, and reduction in unemployment rates can also improve the globalization in the selected MENA countries. The private sector is always a strong element to reduce emissions. Governments should pay attention to the private sector so that commercialization and investment can reduce poverty rates in selected in MENA countries. Environmental projects should be launched through private sectors as they are directly involved in financial development and has an important role to make the surroundings free of pollution. The MENA countries should be worried about energy use and its role to make the environment more polluted. Wind energy and solar energy could be the best option to reduce air pollution; so, policies should be designed and implemented to renewable sources of energy like wind, solar, bio-fuel, and thermal to decrease CO<sub>2</sub> emissions. Energy consumption should be a decline in the selected MENA countries. Energy efficiency can be gain by introducing energy-saving projects and energy conservation policies in selected MENA countries.

The incoming FDI needs to be utilized efficiently, where environmental pollution shall be regulated to mitigate emissions. Otherwise, FDI inflows will create problems in these selected countries, so the policymakers should focus and give attention to the “environmental standard” of FDI inflows to escape “pollution haven” frauds, by promoting organized know-how and safe technology transfers with foreign investors. The relationship between absolute population figures and emissions cannot be overlooked in these selected countries.

As population size has a very complex impact on carbon emissions so the only way, to reduce emissions, is not by regulating population size. The government and policymakers should follow the fundamental laws of population size. Along with that, it is comprehensively required to highlight the problems of emissions and population.

The restriction of the current study is the deficiency of data. Currently, the study exercises the overall index of globalization. The future individual indexes of globalization (economic, political, and social) can be more beneficial for further studies for selected MENA countries.

## References

- Ali W, Abdullah A, Azam M (2016) The dynamic linkage between technological innovation and CO<sub>2</sub> emissions in Malaysia: an autoregressive distributed lagged bound approach. *Int J Energy Econ Policy* 6(3):389–400
- Ali W, Abdullah A, Azam M (2017) The dynamic relationship between structural change and CO<sub>2</sub> emissions in Malaysia: a cointegrating approach. *Environ Sci Pollut Res* 24(14):12723–12739
- Al-Mulali U, Fereidouni HG, Lee JY, Sab CNBC (2013) Exploring the relationship between urbanization, energy consumption, and CO<sub>2</sub> emission in MENA countries. *Renew Sust Energy Rev* 23:107–112
- Al-Rawashdeh R, Jaradat AQ, Al-Shboul M (2014) Air pollution and economic growth in MENA countries: testing EKC hypothesis. *Environ Res Eng Manag* 70(4):54–65
- Ang JB (2007) CO<sub>2</sub> emissions, energy consumption, and output in France. *Energy Policy* 35(10):4772–4778
- Audi, M. & Ali, A. (2018). Determinants of environmental degradation under the perspective of globalization: a panel analysis of selected MENA nations. MPRA Paper 85776, University Library of Munich, Germany, 18, 149, 166.
- Azam M (2016) Does environmental degradation shackle economic growth? A panel data investigation on 11 Asian countries. *Renew Sustain Energy Rev* 65(2016):175–182
- Azam M (2019) Relationship between energy, investment, human capital, environment and economic growth in BRICS-4. *Environ Sci Pollut Res* 26(33):34388–34400
- Azam M, Khan AQ (2016) Testing the Environmental Kuznets Curve hypothesis: a comparative empirical study for low, lower middle, upper middle- and high-income countries. *Renew Sust Energy Rev* 63:556–567
- Azam MK, Ozturk I (2020) Examining foreign direct investment and environmental pollution linkage in Asia. *Environ Sci Pollut Res* 27(7):7244–7255
- Azam M, Khan AQ, Abdullah H, Qureshi IM (2016) The impact of CO<sub>2</sub> emissions on economic growth: evidence from selected higher CO<sub>2</sub> emissions economies. *Environ Sci Pollut Res* 23(7):6376–6389
- Bah MM, Abdulwakil MM, Azam M (2020) Income heterogeneity and the Environmental Kuznets Curve hypothesis in Sub-Saharan African countries. *Geo J* 85:617–628
- Baum CF (2001) Residual diagnostics for cross-section time series regression models. *Stata J* 1(1):101–104
- Bilgili F, Koçak E, Bulut Ü (2016) The dynamic impact of renewable energy consumption on CO<sub>2</sub> emissions: a revisited Environmental Kuznets Curve approach. *Renew Sust Energy Rev* 54:838–845
- Breusch TS, Pagan AR (1980) The Lagrange multiplier test and its applications to model specification in econometrics. *Rev Econ Stud* 47:239–253
- Bu M, Lin CT, Zhang B (2016) Globalization and climate change: new empirical panel data evidence. *J Econ Surv* 30(3):577–595
- Carson RT, Jeon Y, McCubbin DR (1997) The relationship between air pollution emissions and income: US data. *Environ Dev Econ* 2(4):433–450
- Changyong FENG, Hongyue WANG, Najji LU, Tian CHEN, Hua HE, Ying LU (2014) Log-transformation and its implications for data analysis. *Shanghai Arch Psychiatry* 26(2):105–109
- Charfeddine L, Khediri KB (2016) Financial development and environmental quality in UAE: cointegration with structural breaks. *Renew Sust Energy Rev* 55:1322–1335
- Charfeddine L, Mrabet Z (2017) The impact of economic development and social-political factors on ecological footprint: a panel data analysis for 15 MENA countries. *Renew Sust Energy Rev* 76:138–154
- Choi, E., Heshmati, A., & Cho, Y. (2010). An empirical study of the relationships between CO<sub>2</sub> emissions, economic growth and openness.
- Destek, M. A. (2019). Investigation on the role of economic, social, and political globalization on environment: evidence from CEECs. *Environ Sci Pollut Res*, 1-14.
- Dogan E, Turkekel B (2016) CO<sub>2</sub> emissions, real output, energy consumption, trade, urbanization and financial development: testing the EKC hypothesis for the USA. *Environ Sci Pollut Res* 23(2):1203–1213
- Dong K, Hochman G, Zhang Y, Sun R, Li H, Liao H (2018) CO<sub>2</sub> emissions, economic and population growth, and renewable energy: empirical evidence across regions. *Energy Econ* 75:180–192
- Dreher A (2006) Does globalization affect growth? Evidence from a new index of globalization. *Appl Econ* 38(10):1091–1110
- Driscoll JC, Kraay AC (1998) Consistent covariance matrix estimation with spatially dependent panel data. *Rev Econ Stat* 80(4):549–560
- Farhani S, Rejeb J (2012) Energy consumption, economic growth and CO<sub>2</sub> emissions: evidence from panel data for MENA region. *Int J Energy Econ Policy* 2(2):71–81
- Greene, W. H. (2000). *Econometric analysis* 4th edition. International edition, New Jersey: Prentice Hall, 201-215.
- Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement (No. w3914). National Bureau of Economic Research.
- Grossman GM, Krueger AB (1995) Economic growth and the environment. *Q J Econ* 110(2):353–377
- Haseeb M, Azam M (2015) The energy consumption, economic growth and CO<sub>2</sub> emission nexus: evidence from Pakistan. *Asian J Appl Sci* 8(1):27–36
- Haseeb A, Xia E, Baloch MA, Abbas K (2018) Financial development, globalization, and CO<sub>2</sub> emission in the presence of EKC: evidence from BRICS countries. *Environ Sci Pollut Res* 25(31):31283–31296
- Hatzigeorgiou E, Polatidis H, Haralambopoulos D (2008) CO<sub>2</sub> emissions in Greece for 1990–2002: a decomposition analysis and comparison of results using the Arithmetic Mean Divisia Index and Logarithmic Mean Divisia Index techniques. *Energy* 33(3):492–499
- Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica*, 1251-1271.
- Irfan M, Zhao ZY, Ahmad M, Mukeshimana MC (2019a) Critical factors influencing wind power industry: a diamond model-based study of India. *Energy Rep* 5:1222–1235
- Irfan M, Zhao ZY, Ahmad M, Mukeshimana MC (2019b) Solar energy development in Pakistan: barriers and policy recommendations. *Sustainability* 11(4):1206
- Irfan M, Zhao ZY, Li H, Rehman A (2020a) The influence of consumers' intention factors on willingness to pay for renewable energy: a structural equation modeling approach. *Environ Sci Pollut Res*:1–15
- Irfan M, Zhao ZY, Panjwani MK, Mangi FH, Li H, Jan A, Ahmad M, Rehman A (2020b) Assessing the energy dynamics of Pakistan: prospects of biomass energy. *Energy Rep* 6:80–93

- Jalil A, Mahmud SF (2009) Environment Kuznets curve for CO<sub>2</sub> emissions: a cointegration analysis for China. *Energy Policy* 37(12):5167–5172
- Jaunky VC (2011) The CO<sub>2</sub> emissions-income nexus: evidence from rich countries. *Energy Policy* 39(3):1228–1240
- Khan MK, Khan MI, Rehan M (2020) The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan. *Financ Innov* 6(1):1–13
- Kuznets S (1955) Economic growth and income inequality. *Am Econ Rev* 45(1):1–28
- Latif Z, Latif S, Ximei L, Pathan ZH, Salam S, Jianqiu Z (2018) The dynamics of ICT, foreign direct investment, globalization and economic growth: panel estimation robust to heterogeneity and cross-sectional dependence. *Telematics Inform* 35(2):318–328
- Lean H, H., & Smyth, R. (2009). CO<sub>2</sub> emissions, electricity consumption and output in ASEAN. *Development Research Unit. (Discussion Paper DEVBP, 09-13)*.
- Maddison, D., &Rehdanz, K. (2008). *Carbon emissions and economic growth: homogeneous causality in heterogeneous panels* (No. 1437). Kiel working paper.
- Magazzino C (2017) The relationship among economic growth, CO<sub>2</sub> emissions, and energy use in the APEC countries: a panel VAR approach. *Environ Syst Decis* 37(3):353–366
- Menegaki AN (2019) The ARDL method in the energy-growth nexus field; best implementation strategies. *Economies* 7(4):105
- Mishkin FS (2009) Globalization and financial development. *J Dev Econ* 89(2):164–169
- Munir S, Khan A (2014) Impact of fossil fuel energy consumption on CO<sub>2</sub> emissions: evidence from Pakistan (1980–2010). *Pak Dev Rev* 53(4):327–346
- Omri A (2013) CO<sub>2</sub> emissions, energy consumption and economic growth Nexus in MENA countries: evidence from simultaneous equations models. *Energy Econ* 40:657–664
- Omri A, Nguyen DK, Rault C (2014) Causal interactions between CO<sub>2</sub> emissions, FDI, and economic growth: evidence from dynamic simultaneous-equation models. *Econ Model* 42:382–389
- Oshin S, Ogundipe A (2014) An empirical examination of environmental Kuznets curve (EKC) in West Africa. *Euro-Asia J Econ Financ* 3(1):1–16
- Paramati SR, Mo D, Gupta R (2017) The effects of stock market growth and renewable energy use on CO<sub>2</sub> emissions: evidence from G20 countries. *Energy Econ* 66:360–371
- Park, H. M. (2011). Practical guides to panel data modeling: a step-by-step analysis using Stata. Public Management and Policy Analysis Program, Graduate School of International Relations, International University of Japan, 1-52.
- Parks R (1967) Efficient estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated. *J Am Stat Assoc* 62:500–509
- Pata UK (2018) Renewable energy consumption, urbanization, financial development, income and CO<sub>2</sub> emissions in Turkey: testing EKC hypothesis with structural breaks. *J Clean Prod* 187:770–779
- Pesaran MH (2004) General diagnostic tests for cross section dependence in panels general diagnostic tests for cross section dependence in panels. Univ Cambridge, Cambridge
- Pesaran MH (2007) A simple panel unit root test in the presence of cross section dependence. *J Appl Econ* 22:265–312
- Reed WR, Ye H (2011) Which panel data estimator should I use? *Appl Econ* 43:985–1000
- Rogelj J, Schlessner CF (2019) Unintentional unfairness when applying new greenhouse gas emissions metrics at country level. *Environ Res Lett* 14(11):114039
- Sadorsky P (2011) Financial development and energy consumption in Central and Eastern European frontier economies. *Energy Policy* 39(2):999–1006
- Saidi K, Hammami S (2015) The impact of CO<sub>2</sub> emissions and economic growth on energy consumption in 58 countries. *Energy Rep* 1:62–70
- Salahuddin M, Ali MI, Vink N, Gow J (2019) The effects of urbanization and globalization on CO<sub>2</sub> emissions: evidence from the Sub-Saharan Africa (SSA) countries. *Environ Sci Pollut Res* 26(3):2699–2709
- Shaari SM, Abdul Razak AN, Basri HB (2017) The effects of electricity consumption and economic growth on carbon dioxide emission. *Int J Energy Econ Policy* 7(4):287–290
- Shafik, N., & Bandyopadhyay, S. (1992). Economic growth and environmental quality: time-series and cross-country evidence. Policy Research Working Paper Series 904, The World Bank. Retrieved from <https://ideas.repec.org/p/wbk/wbrwps/904.html>
- Shahbaz M, Shahzad SJH, Ahmad N, Alam S (2016) Financial development and environmental quality: the way forward. *Energy Policy* 98:353–364
- Shahbaz M, Khan S, Ali A, Bhattacharya M (2017) The impact of globalization on CO<sub>2</sub> emissions in China. *Singapore Econ Rev* 62(04):929–957
- Shahbaz M, Balsalobre-Lorente D, Sinha A (2019) Foreign direct investment–CO<sub>2</sub> emissions nexus in Middle East and North African countries: importance of biomass energy consumption. *J Clean Prod* 217:603–614
- Silva S, Soares I, Pinho C (2012) The impact of renewable energy sources on economic growth and CO<sub>2</sub> emissions—a SVAR approach. *Eur Res Stud XV*:133–144
- Sinha A, Sengupta T (2019) Impact of energy mix on nitrous oxide emissions: an environmental Kuznets curve approach for APEC countries. *Environ Sci Pollut Res* 26(3):2613–2622
- Stern DI (2004) The rise and fall of the environmental Kuznets curve. *World Dev* 32(8):1419–1439
- Tomlinson J (1999) Globalization and culture. University of Chicago Press, Chicago
- Westerlund J (2005) New simple tests for panel cointegration. *Econ Rev* 24(3):297–316
- Wooldridge JM (2002) *Econometric analysis of cross section and panel data*. MIT Press, Cambridge
- World Development Indicators (2020), World Bank, (2020). URL: <http://www.wdi.org/>. accessed 01.24.2020.
- Zafar MW, Saud S, Hou F (2019) The impact of globalization and financial development on environmental quality: evidence from selected countries in the Organization for Economic Co-operation and Development (OECD). *Environ Sci Pollut Res* 26(13):13246–13262
- Zafeiriou E, Azam M (2017) CO<sub>2</sub> emissions and economic performance in EU agriculture: some evidence from Mediterranean countries. *Ecol Indic* 8:104–114
- Zaidi SAH, Zafar MW, Shahbaz M, Hou F (2019) Dynamic linkages between globalization, financial development and carbon emissions: evidence from Asia Pacific Economic Cooperation countries. *J Clean Prod* 228:533–543

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