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CO_2 emissions, export and foreign direct investment: Empirical evidence from Middle East and North Africa Region

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ABSTRACT

This study aimed to investigate the relationship among CO_2 emissions, exports of goods and services, and foreign direct investment (FDI) inflows in countries in the MENA region over the period 2002–2014. To that end, spatial panel simultaneous equations model based on the adjacency-based and distance-based weight matrices was used. The findings indicated that the results of spatial panel simultaneous equations with distance-based weight matrix were more fitting than those with adjacency-based weight matrix. The empirical findings approved a two-way linkage between CO_2 emissions and exports and a one-way linkage between CO_2 emissions and FDI inflows and also, between FDI inflows and exports. Furthermore, the existence of the spatial correlations among the CO_2 emissions, exports and FDI inflows across countries was confirmed. It was further indicated that fossil fuel energy consumption was the main determinant of CO_2 emissions, and accession to the WTO played a major role in enhancing exports and FDI inflows. The present study can provide new insights for policymakers and planners to not only consider the economic benefits of exporting goods and services and FDI inflows, but also attend their environmental impacts on local and neighboring countries.

KEYWORDS CO_2 emissions; exports of goods and services; foreign direct investment; MENA region; spatial panel simultaneous equations; distance-based weight matrices

JEL CLASSIFICATIONS C23, F18, F21, Q53

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1. Introduction

The Middle East and North Africa (MENA) are composed of developing countries. According to the Energy Information Administration (EIA), CO_2 emissions as the primary source of greenhouse gas (GHG) emissions have reached a critical level in this region through increasing by more than 200 percent over the last two decades (Al-mulali 2012). The MENA region has also witnessed a rapid growth in exports of goods and services and FDI inflows. Based on the World Development Indicators (WDI), FDI inflows and aggregated exports in the MENA countries steadily raised from \$10.66 and \$356.27

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billion in 2002 to $54.46 and $1624.44 billion in 2014, respectively. This rapid increase in exports and FDI inflows can be the reason behind the rapid rise in CO_2 emissions in recent years. In other words, there may be a relationship among CO_2 emissions, exports, and FDI inflows. The literature has shown a relationship among these variables in different countries and regions (Mahmood et al. 2019; Koçak and Şarkgüneşi 2018; Kahouli and Omri 2017; Zhang 2015; Al-mulali and Sheau-Ting 2014), but the demonstrated relations are ambiguous and not so clear. Current studies have displayed contradictory results, some indicating two-way relationships between CO_2 emissions, trade, and FDI inflows (Mahmood et al. 2019; Kahouli and Omri 2017; Zhang 2015) and some suggesting a one-way linkage among them (Ssali et al. 2019; Kahouli and Omri 2017). Moreover, these variables may be spatially correlated among countries (Mahmood, Alkhateeb, and Furqan 2020; Saghaian et al. 2020). The inconsistent findings of the mentioned studies reveal the need for further study on spatial correlations across the MENA countries.

Exports of goods and services may lead to the emissions of CO_2 in various ways. One of the crucial ways of CO_2 emissions is the use of carbon-rich products in both developed and developing countries. Strict environmental regulations in developed countries have caused the polluting industries to move to developing countries, resulting in an increased production of carbon-rich products in countries with lax regulations (Xu et al. 2011; Levinson and Taylor 2008) and thus, making the developing countries the leading producers and exporters of carbon-rich products. Another cause of CO_2 emissions is the vast expansion of the transportation sector that has a powerful impact on international exports and CO_2 emissions (Hulshof and Mulder 2020). FDI inflows are also argued as another reason for environmental degradation (Baek 2016). Although FDI inflows provide capital financing and access to new technology and improve production, management and labor skills, employment opportunities, new market accessibility, export incentive and impetus to economic growth (Mert and Bölük 2016; Lee 2013), they can act as a double-edged knife. They can raise the level of environmental pollution through moving polluting industries towards the developing countries with weak environmental regulations and low standards (Seker, Ertugrul, and Cetin 2015) to avoid paying high environmental taxes (Zhang and Zhou 2016). Furthermore, FDI inflows can transfer environment-friendly technologies or develop pollution-free technology through encouraging technology investments in developing countries (Jalil and Feridun 2011).

Table 1 presents the average value of goods and services exports, FDI inflows and CO_2 emissions (i.e. $61.1 and $3.3 billion and 114.8 million metric tons, respectively) in the MENA countries over the period 2002–2014. As shown in the table, the average CO_2 emissions have increased in the MENA region over time. From 2002 to 2014, the average CO_2 emissions among 18 MENA countries had been 114.8 million metric tons in the range of 18.7 in Lebanon to 531.1 million metric tons in Iran. In the MENA region, Iran and Saudi Arabia as major oil producers and exporters contributed to the CO_2 emissions in all sub-periods and the period 2002–2014. In terms of exports, Saudi Arabia, United Arab Emirates and Iran had been the largest exporting countries that contributed over 50 percent of MENA region exports. According to the data, the average FDI also dropped from $2.1 billion between 2002 and 2006 to $3.3 billion between 2011 and 2014. Saudi Arabia has always attracted more FDI.

According to the Tobler's (1970) first law of geography and Anselin's (1988) spatial econometrics, no region is isolated and the regions which are closer geographically are more interrelated than the distant ones. Therefore, spatial correlation can be observed

Table 1. Average of exports, FDI, and CO_2 emissions.

	2002–2006			2007–2010			2011–2014			2002–2014		
Country	Exp.	FDI	CO_2	Exp.	FDI	CO_2	Exp.	FDI	CO_2	Exp.	FDI	CO_2
Algeria	37.2	1.1	95.7	64.0	2.3	115.0	72.2	1.8	132.8	56.2	1.7	113.0
Bahrain	10.9	1.1	17.5	18.0	1.0	28.5	31.5	0.9	29.5	19.4	1.0	24.6
Egypt	23.2	3.5	154.4	46.8	8.5	199.3	46.7	2.9	212.4	37.7	4.9	186.0
Iran	53.1	2.9	449.1	105.4	2.7	547.1	130.1	3.5	617.5	92.9	3.0	531.1
Iraq	24.4	0.4	101.0	51.4	1.5	93.0	92.4	3.8	155.3	53.6	1.8	115.2
Israel	51.5	5.6	60.2	76.6	7.4	66.2	95.9	9.1	69.1	72.9	7.2	64.8
Jordan	6.1	1.5	19.2	11.1	2.4	21.6	11.1	1.7	24.2	9.1	1.8	21.5
Kuwait	38.8	0.1	65.4	77.8	0.6	83.7	119.4	2.0	96.8	75.6	0.8	80.7
Lebanon	6.0	2.3	16.3	11.6	4.2	17.9	14.4	3.1	22.4	10.3	3.1	18.7
Libya	23.2	0.7	50.5	49.7	3.0	56.5	36.4	1.0	51.4	35.4	1.5	52.6
Morocco	17.0	1.4	42.5	29.1	2.1	52.9	35.7	3.1	59.8	26.5	2.1	51.0
Oman	14.5	0.7	31.1	30.6	2.3	43.7	52.9	1.5	58.9	31.3	1.4	43.5
Qatar	22.8	1.7	48.0	61.7	5.3	67.5	137.4	0.6	91.9	70.0	2.5	67.5
Saudi Arabia	144.3	6.1	376.0	259.0	32.4	451.4	379.5	11.3	551.7	251.9	15.8	453.2
Syria	10.1	0.3	49.7	15.6	1.7	64.5	15.6	2.1	42.2	13.5	1.3	52.0
Tunisia	12.8	1.2	22.0	21.6	1.7	25.3	21.8	1.0	27.4	18.2	1.3	24.7
United Arab Emirates	98.5	7.6	109.0	215.7	7.3	155.4	370.7	9.1	181.0	218.3	8.0	145.4
Yemen	5.6	0.3	18.7	8.6	0.7	22.8	9.3	0.0	21.6	7.6	0.3	20.9
MENA region	33.3	2.1	95.9	64.1	4.8	117.4	92.9	3.3	135.9	61.1	3.3	114.8

Notes: Exp., FDI and CO_2 show exports of goods and services (billion US$), foreign direct investment inflows (billion US$), and CO_2 emissions (million metric tons), respectively.
Source: World Bank Database (2019).

in different subjects such as environmental issues among neighboring regions (Wang and Ye 2017). For example, CO_2 emissions are not static and can be shifted from one region or country to another through various ways such as wind and trade of goods and services (Huang, Chen, and Zhang 2018). Empirical research also confirmed that the CO_2 emissions are spatially correlated across countries (Mahmood, Alkhateeb, and Furqan 2020; You and Lv 2018). Spatial dependence is important in economy, because the economies of countries are interdependent as a result of FDI flows, trade, and other forms of global interaction (Tanious 2019). In fact, financial and trade decisions of one country have effect on other countries. Companies in neighboring countries can work together in the form of joint cooperation, meaning that their performance and export decisions have spillover effect (Koenig, Mayneris, and Poncet 2010). Moreover, developing countries, through imposing weak environmental standards, attempt to attract foreign investment. In fact, there exists severe competition among neighboring developing countries to increase investment with the developed countries, indicating that FDI inflows have spatial spillovers (Mahmood, Alkhateeb, and Furqan 2020). Therefore, it is important to consider the spatial dependence when we are analyzing the relation among CO_2 emissions, exports, and FDI inflows. Ignoring the spatial dependence would cause biased estimation results and hence, wrong policy implications.

To the best of our knowledge, previous studies have not investigated the relationship among CO_2 emission, exports, and FDI in the MENA countries considering spatial interaction effect. Given the importance of creating real conditions for analyzing data and providing comprehensive findings and useful policy implications, this study tries to explore the relationship among CO_2 emissions, exports, and FDI inflow in the MENA countries using spatial panel simultaneous equations model over the period from 2002 to 2014. Our study attempts to make contributions to the existing knowledge in three ways.

First, this study examines the simultaneous three-way relationship among CO_2 emissions, exports, and FDI inflows for the MENA countries. Second, to consider the spatial correlations of these three variables among countries, it made use of spatial panel simultaneous which is more efficient and provides consistent evidence in regional analysis. Third, it focused on the MENA countries as a set of countries suffering from increased CO_2 emissions.

The remainder of this study is organized as follows: Part 2 surveys existing literature. Part 3 explains the model's structure and the required data. Part 4 presents empirical results and discussion. Part 5 provides some policy suggestions.

2. Literature review

Theoretical and empirical studies on environmental economics indicate that FDI inflows and export (trade) are the important drivers of CO_2 emissions (Kahia, Jebli, and Belloumi 2019; Shahbaz, Balsalobre-Lorente, and Sinha 2019; Abdouli and Hammami 2017). Literature also reveals that CO_2 emissions influence these two variables (Koçak and Şarkgüneşi 2018; Kahouli and Omri 2017). In other words, a relationship among CO_2 emissions, FDI inflows and export has been confirmed, but the relationship is ambiguous. Some studies showed a positive two-way relationship between CO_2 emissions and trade, CO_2 emissions and FDI inflows, and trade and FDI inflows (Mahmood et al. 2019; Kahouli and Omri 2017; Zhang 2015). Some other found a negative two-way linkage (Mahmood et al. 2019; Emmanuel, Oyelade, and Adegboyega 2018; Omri et al. 2015) and some indicated a positive or negative one-way linkage between them (Ssali et al. 2019; Kahouli and Omri 2017). These contradictory findings may be associated with differences in the region of study, research methods and so on. These studies employed different econometric methods such as panel data model, GMM method, and panel Vector Autoregressive model. However, the spatial dependence of the three variables among countries and their simultaneous influence on each other have not been considered in previous studies, leading to incorrect estimation and hence, wrong analysis. Therefore, the present study focused on the relationship among export, FDI inflows, and CO_2 emissions as well as the spatial correlation of these variables through investigating seven hypotheses described in the following sections.

2.1. Exports and CO_2 emissions

Previous studies have found that exports positively affect CO_2 emissions. Al-mulali and Sheau-Ting (2014), as an example, indicated a bidirectional positive linkage between trade variables (trade, imports, and exports) in the long run and CO_2 emissions in 75 percent of the countries in six study regions. They also showed a bidirectional positive relationship between trade and CO_2 emissions in most MENA countries. Zhang (2015) demonstrated that exports of intermediate and final goods have a significant positive effect on CO_2 emissions in 11 Eastern Asia countries. Similar results were found by Guan et al. (2008), Hossain (2011), Jayanthakumaran, Verma, and Liu (2012), and Ozatac, Gokmenoglu, and Taspinar (2017) for different countries. Based on several studies, furthermore, CO_2 emissions play an effective role in rising trade variables (e.g. Ren et al. 2014; Levinson and Taylor 2008). On the contrary, few studies revealed the negative impact of CO_2 emissions on trade components (e.g. Kahouli and Omri 2017; Omri et al. 2015). Hence, following hypotheses were proposed here in this study:

Hypothesis 1: Exports of goods and services increase CO_2 emissions.

Hypothesis 2: CO_2 emissions increase the exports of goods and services.

2.2. CO_2 emissions and FDI inflows

Previous studies have revealed that FDI inflows had a significant positive effect on emissions of CO_2 in Ghana (Solarin et al. 2017), China (Sun, Zhang, and Xu 2017), Turkey (Kaya et al. 2017), and Pakistan (Naz et al. 2019). However, in Pakistan (Mahmood et al. 2019), FDI inflows negatively influence the emissions of CO_2 in a short run, but this effect was positive in the long run. Other studies such as Gökmenoğlu and Taspinar (2016) indicated a two-way relationship between CO_2 emissions and FDI inflows in Turkey, demonstrating that both variables were jointly determined and affected at the same time in a way that FDI inflows increased CO_2 emissions and vice versa. Koçak and Şarkgüneşi (2018) also found that CO_2 emissions and FDI had a simultaneous positive effect on each other. Ssali et al. (2019) found a significant positive and unidirectional relationship from CO_2 to FDI in the long-run. Kahouli and Omri (2017) also showed an insignificant negative effect of the environmental damage on FDI. Therefore, following hypotheses where proposed based on these findings:

Hypothesis 3: FDI inflows increase CO_2 emissions.

Hypothesis 4: CO_2 emissions increase FDI inflows.

2.3. Exports and FDI inflows

Considering the effect of exports and FDI inflows on CO_2 emissions, FDI inflows and trade variables were shown to have a two-way relationship (Kahouli and Omri 2017; Sakyi and Egyir 2017; Omri et al. 2015; Simionescu 2014). Proximity–concentration trade-off theory states that there is a negative and substitute relationship between FDI and exports. However, according to the spillover effects of multinational corporations on productivity of firms, there can be a positive and complementarity relationship between FDI and exports (Boubacar 2016; Jensen 2002). The empirical studies revealed controversial findings on relationships between FDI and exports. Boubacar (2016), based on the spatial simultaneous equations model, found that there is a positive and significant relationship between FDI and exports in OECD countries, indicating that FDI and exports are complementary. Similar results were found by Clausing (2000), who revealed that U.S. FDI has a positive and significant effect on exports to OECD countries. Simionescu (2014) indicated that, in short run, a causality association can be observed between FDI and exports in G7 countries. Kahouli and Omri (2017), based on the simultaneous-equation system, represented a one-way relationship from trade to FDI, indicating that an increase in trade, particularly in exports, encourages the investors to participate in investment. Therefore, the following hypotheses were presented:

Hypothesis 5: Exports of goods and services increase FDI inflows.

Hypothesis 6: FDI inflows increase exports of goods and services.

Summary of the existing studies on the relationship between CO_2 emissions, trade, and FDI inflows are presented in Table 2. According to the literature, a three-way relationship is possible among CO_2 emissions, exports, and FDI inflows.

Table 2. Relationship among CO_2 emissions, trade and FDI inflows.

No	Author	Sample	Conclusions
CO_2 emissions – Trade/Export/Import studies:			
Dependent Variable: Trade/Export/Import, Independent Variable: CO_2 emissions			
1	Kahouli and Omri (2017)	14 home countries and 39 host countries	Positive and insignificant, Negative and significant
2	Omri et al. (2015)	12 MENA countries	Negative and significant, Negative and insignificant
3	Al-mulali and Sheau-Ting (2014)	189 countries	Positive and significant, Negative and significant
Dependent Variable: CO_2 emissions, Independent Variable: Trade/Export/Import			
4	Zhang (2015)	11 countries	Positive and significant
5	Al-mulali and Sheau-Ting (2014)	189 countries	Positive and significant, Negative and significant
6	Ren et al. (2014)	China	Positive and insignificant, Negative and insignificant
7	Jayanthakumaran, Verma, and Liu (2012)	China and India	Positive and significant
8	Hossain (2011)	Newly industrialized countries	Positive and significant
9	Jalil and Mahmud (2009)	China	Positive and significant
10	Guan et al. (2008)	China	Positive and significant
CO_2 emissions – FDI inflows studies:			
Dependent Variable: CO_2 emissions, Independent Variable: FDI inflows			
11	Mahmood et al. (2019)	Pakistan	Negative and significant in the short run; Positive and significant in the long run
12	Emmanuel, Oyelade, and Adegboyega (2018)	Nigeria	Negative and significant
13	Koçak and Şarkgüneşi (2018)	Turkey	Positive and significant
14	Naz et al. (2018)	Pakistan	Positive and significant
15	Ozatac, Gokmenoglu, and Taspinar (2017)	Turkey	Positive and significant
16	Solarin et al. (2017)	Ghana	Positive and significant
17	Sun, Zhang, and Xu (2017)	China	Positive and significant
18	Kaya et al. (2017)	Turkey	Positive and significant
19	Gökmenoğlu and Taspinar (2016)	Turkey	Positive and significant
Dependent Variable: FDI inflows, Independent Variable: CO_2 emissions			
20	Koçak and Şarkgüneşi (2018)	Turkey	Positive and significant
21	Gökmenoğlu and Taspinar (2016)	Turkey	Positive and significant
22	Omri, Nguyen, and Rault (2014)	Latin America, Caribbean, Middle East, North Africa and sub-Sahara	Negative and significant
FDI inflows – Trade/Export/Import studies:			
Dependent Variable: FDI inflows, Independent Variable: Trade/Export/Import			
23	Kahouli and Omri (2017)	14 home countries 39 host countries	Positive and significant
24	Mahmoodi and Mahmoodi (2016)	Eight European developing countries	Positive and significant
25	Boubacar (2016)	OECD countries	Positive and significant
26	Simionescu (2014)	G7 Countries	Positive and significant
Dependent Variable: Trade/Export/Import, Independent Variable: FDI inflows			
27	Kahouli and Omri (2017)	14 home countries 39 host countries	Positive and insignificant
28	Boubacar (2016)	OECD countries	Positive and significant

(*continued*)

Table 2. Continued.

No	Author	Sample	Conclusions
29	Omri et al. (2015)	Algeria, Jordan, Morocco, Qatar, Saudi Arabia, Tunisia	Positive and significant
30	Simionescu (2014)	G7 Countries	Positive and significant
31	Clausing (2000)	OECD countries	Positive and significant

2.4. Spatial correlation among CO_2 emissions, exports, and FDI inflows

The importance of spatial analysis for economic, social and environmental issues has been confirmed by empirical regional studies. The CO_2 emissions, international trade and FDI inflows depend not only on performance of local country, but also on the characteristics of neighboring countries. You and Lv (2018) applied spatial panel data approach to analyze CO_2 emissions and indicated the spatial correlations of countries in CO_2 emissions, which was later verified by other studies (Zhao, Burnett, and Fletcher 2014; Kang, Zhao, and Yang 2016; Mahmood, Alkhateeb, and Furqan 2020).

Moreover, Boubacar (2016) emphasized the importance of considering the spatial dependence to investigate the determinants of international trade and FDI inflows. In this regard, studies such as Yang, Liu, and Mai (2017), Saghaian et al. (2020), and Yin, Wang, and Gan (2020) suggested that trade in one country affects both local and surrounding countries. The need for considering spatial dependence in studies on FDI inflows have also been highlighted by other researchers (Ledyaeva 2009; Escobar Gamboa 2013; Hoang and Goujon 2019). Therefore, hypothesis 7 was presented as follows:

> Hypothesis 7: There exists a spatial correlation among CO_2 emissions, exports, and FDI inflows across MENA countries.

3. Materials and methods

In order to investigate the relationship among CO_2 emissions, exports, and FDI inflows and also, the spatial correlation of these variables, spatial panel data simultaneous equations model was employed due to the nature of the dataset and several advantages of the panel data models (Baltagi 2009).

3.1. Spatial panel data models

The spatial dependence and spatial econometrics were initially tested by Anselin (1988) in regression models. Since common econometric methods like OLS are incompatible with geographical data because of their spatial characteristics (spatial dependence or autocorrelation), spatial models have been employed for this purpose (Anselin 2001). Several models like the spatial autoregressive model (SAR), spatial error model (SEM), and spatial autoregressive model with autoregressive disturbances (SARAR) have been used in spatial econometrics. From among these models, SAR model was applied here because of its prevalent application in environmental analysis (Cheng 2016). The spatial autoregressive model (SAR) refers to situations where the dependent variable in a location depends on the level of neighboring dependent variables (Qu and Lee 2015). This model (Anselin, Le Gallo, and Jayet 2008) has the following format:

$$Y_{it} = \beta X_{it} + \rho \sum_{j=1}^{N} W_{ij} Y_{jt} + \mu_i + \eta_t + \varepsilon_{it} \tag{1}$$

where Y_{it} represents the dependent variable, i stands for the cross-section dimension, t symbolizes time, ρ is autoregressive spatial coefficient, $W_{ij}Y_{it}$ indicates the spatial variable, and X_{it} is independent variable. The symbols μ_i and η_t reflect the individual effect of the spatial unit and time-period, respectively and ε_{it} demonstrates an error vector.

From among different forms of spatial weights matrix available in the literature, adjacency-based weight matrix and distance-based weight matrix are the positive and symmetric weight matrices most commonly-used in spatial econometrics. The adjacency-based weight matrix relies on the common border between the two countries. Therefore, when two countries have common borders and vertices (first-order contiguity), the weight matrix elements (w_{ij}) are equivalent to one; Otherwise, they will be zero. Also, as countries can't be neighbors of themselves, the oblique elements of this matrix are zero. The weight matrix is defined as follows (Duncan, White, and Mengersen 2017):

$$W = \begin{bmatrix} 0 & w_{12} & . & w_{1N} \\ w_{21} & 0 & . & w_{2N} \\ . & . & 0 & . \\ w_{N1} & w_{N2} & . & 0 \end{bmatrix} \tag{2}$$

The distance-based weight matrix is based on the distance between countries. So, the elements of the weight matrix (d_{ij}) are made of geographical distance among countries. A general definition for distance-based weights is the following inverse distance function (Getis and Aldstadt 2008; Earnest et al. 2007):

$$w_{ij} = \left(\frac{1}{d_{ij}}\right)^k \tag{3}$$

Where k is usually one. The bigger k increases the impact of closer countries compared with far ones. These weight matrices are generally in row standardized form. Estimation methods of SAR model which are well-known in the literature are the instrumental variable (IV), the maximum likelihood estimation (MLE), the quasi-maximum likelihood (QML), methods, and the generalized method of moments (GMM) (Lin and Lee 2010).

3.2. Spatial panel simultaneous-equations model

Spatial econometrics has reduced regression problems such as spatial heteroskedasticity and spatial dependence in geographical data and individual equation framework (Gebremariam et al. 2007). Steinnes and Fisher (1974) incorporated spatial dependence between data in a simultaneous-equations frame to consider the correlation between the error terms of individual equations and individual effects across equations. The terms are unobserved and indicate endogeneity issues (Adeline and Moussa 2020). Kelejian and Prucha (2004), then, proposed the simultaneous equations spatial autoregressive model and suggested methods such as full information three-stage least squares (3SLS) estimators and limited information two-stage least squares (2SLS). The methodology presented by Kelejian and Prucha (2004) in the content of social interplay models was adopted by Liu (2014). The two-equation frame with spatial lags was extended by Baltagi and Deng (2015). Based on the methodology of Kelejian and Prucha (2004) and through extending the methods presented by Kang, Zhao, and Yang (2016) and Rossi, Santos, and Campos (2016) and introducing various explanatory variables obtained from empirical and theoretical studies, a spatial autoregressive simultaneous equations model was proposed for CO2 emissions, exports, and FDI inflows as follows:

$$LnCO_{2it} = \beta_1 LnEX_{it} + \beta_2 LnFC_{it} + \beta_3 LnGDP_{it} + \beta_4 LnFDI_{it} + \beta_5 LnPOP_{it} + \beta_6 LnT_{it} + \beta_7 WTO_{it} + \rho WLnCO_{2it} + u_{it} \quad (4)$$

$$LnEX_{it} = \beta_1 LnCO_{2it} + \beta_2 LnWGDP_{it} + \beta_3 lnPOP_{it} + \beta_4 LnFDI_{it} + \beta_5 lnRER_{it} + \beta_6 LnT_{it} + \beta_7 WTO_{it} + \rho WLnEX_{it} + u_{it} \quad (5)$$

$$LnFDI_{it} = \beta_1 LnEX_{it} + \beta_2 LnCO_{2it} + \beta_3 LnGDP_{it} + \beta_4 LnRER_{it} + \beta_5 LnFD_{it} + \beta_6 LnPOP_{it} + \beta_7 WTO_{it} + \rho WLnFDI_{2it} + u_{it} \quad (6)$$

Where, equations (4), (5) and (6) demonstrate CO_2 emissions, the export supply, and FDI inflows equations, respectively. $LnCO_{2it}$ indicates the amount of CO_2 emissions in log form, $LnEX_{it}$ is the value of exports of goods and services in log form at current prices, $LnFC_{it}$ stands for fossil fuel energy consumption in log form, $LnGDP_{it}$ denotes the gross domestic product in log form, $LnIFDI_{it}$ is FDI inflows in log form, $LnPOP_{it}$ represents total population in country in log form. LnT_{it} is technology level in log form, WTO_{it} denotes accession to the World Trade Organization, $LnWGDP_{it}$ represents the real-world income in log form at current prices, $lnRER_{it}$ is the real exchange rate in log form, $LnFD_{it}$ stands for the level of financial development in log form, and $WLnCO_{2it}$, $WLnEXPORT_{it}$ and $WLnFDI_{2it}$ are the spatial lag variables.

3.3. Relevant tests and estimation methods

To investigate the existence of spatial correlations in a simultaneous equations framework, this paper firstly ran non-spatial simultaneous panel data model by means of 2SLS. Then, it examined, by several tests like Geary's GC (Geary 1954), Getis-Ords GO (Getis and Ord 1992) and Moran's I (Moran 1950), whether there exist any spatial correlations among CO_2 emissions, exports and FDI inflows. The null hypothesis in these tests was the presence of spatial independence in the model. The Moran's I value ranges between −1 and 1. The negative value reflects the presence of negative spatial autocorrelation, and positive value implies positive spatial autocorrelation (Tu and Xia 2008). Geary's C statistic varies from 0 to 2, with values close to 0 implying positive spatial autocorrelation and those close to 2 indicating negative spatial autocorrelation. Values 0 and 2 represent perfect positive and negative spatial autocorrelation, respectively (Nole, Lasaponara, and Murgante 2013). However, Getis and Ord's G statistic values demonstrate only positive spatial autocorrelation, not the spatial integration intensity in regions (Getis 2010).

If the non-spatial models are not accepted by using the above tests, the equations (4) to (6) would be executed in a simultaneous spatial panel data model framework employing the generalized spatial two-stage least squares (GS2SLS) estimation method and STATA 13. This method was developed by Kelejian and Prucha (2010, 1999, 1998) and modified by others like Arraiz et al. (2010) and Drukker, Egger, and Prucha (2013). The GS2SLS is one of the estimation methods used in spatial panel data models with specified variables in single equations. This method is based on instrumental variables which are the same with explanatory variables in the study. In order to model estimation, the identification of each equation should be tested. So, the quantity of dependent variables in any equation should be fewer than/or equal to the number of predestinated variables in the model (Kelejian and Prucha 2004). In this study, simultaneous spatial panel data models were estimated according to the adjacency-based weight matrix and distance-based weight matrix. Then, a suitable model was adopted based on the results obtained from two matrices.

Besides the above tests, the cross-sectional dependence and stationary of all variables should be tested in the panel data model. To evaluate the cross-sectional dependence, the test presented by Pesaran (2004) was used due to its application in panel data model with the large cross dimension, which has made it possible to test the null hypothesis of cross-sectional independence in the model. In addition, to test panel unit root or stationary in panel datasets, Levin, Lin, and Chu (2002) and Im, Pesaran, and Shin (2003) tests were employed in this study because they have been widely used by the previous studies. Both tests consider the basic ADF specification. The null hypothesis in these tests assumes that the variables are non-stationary.

3.4. Data description

This study used balanced panel dataset covering 18 MENA countries over the period 2002–2014. The data were obtained from the World Development Indicators (WDI) of the World Bank and World Trade Organization. All variables were in a logarithmic form that their descriptions and sources of data collection are shown in Table 3.

4. Results

The statistical description of the variables studied is presented in Table 4. As seen in the table, the value of exports, for example, varies from \$3083.25 to \$399,570 million in the study period. The minimum and maximum values of FDI inflows are \$1 and \$39.40 billion, respectively. The highest and lowest amount of CO_2 are 13,461.56 and 649,480.71 kilo ton, respectively. The values indicate that the variables are different among the MENA countries.

Before estimating the study models, the cross-sectional dependence for the three panel equations was checked using the tests proposed by Pesaran (2004). This test investigates the null hypothesis of cross-sectional independence in panel equations. The test results which are presented in Table 5 shows the acceptance of the cross-sectional independence in three equations.

After the confirmation of cross-sectional independence in three equations, we used the unit root tests including Levin, Lin, and Chu (2002) and Im, Pesaran, and Shin (2003) to test the panel unit root or stationary in panel datasets. The empirical results of these tests are displayed in Table 6. Accordingly, all variables are stationary and therefore, the null hypothesis that the variables are non-stationary is rejected at 5 percent level of significance.

Table 3. Variables description and data sources.

Variable	Description	Units	Source
Export (EX)	The value of exports of goods and services	Current prices (current US$)	WDI
Fossil fuel energy consumption (FC)	Percentage of fossil fuel energy consumption in the total energy consumption	Percent	WDI
Gross domestic product (GDP)	The value of gross domestic product	Current US$	WDI
Foreign direct investment (FDI)	Foreign direct investment inflows	Current US$	WDI
Population (POP)	Population size	Number	WDI
Technology level (T)	Carbon emission intensity	Kg per kg of oil equivalent energy use	WDI
WTO (WTO)	Accession to the World Trade Organization = 1, otherwise = 0		World Trade Organization
CO_2 emissions (CO_2)	Energy-related CO_2 emissions	Kg tons	WDI
Real world income (WGDP)	Real gross domestic product of the world that is used as a proxy for the real world income	Current US$	WDI
Real exchange rate (RER)	$nominal\ exchange\ rate * \frac{US\ CPI}{domestic\ CPI}$		Authors calculation
Financial Development (FD)	Percentage of total credit of the private sector to GDP	Percent	WDI

Table 4. Descriptive statistics for the variables.

Variable	Mean	Min	Max	S.D.
EX (in million US$)	61,144.42	3083.25	399,570	79,210.17
FC (in percent)	97.33	81.49	100	4.04
GDP (in billion US$)	128.41	9.58	756.35	144.33
FDI (in billion US$)	3.31	1.00	39.40	5.09
POP (in thousands)	20.89	0.64	95.69	23.45
T (in kg per kg of oil equivalent energy use)	2.89	1.69	4.37	0.35
WTO	0.55	0.00	1.00	0.49
CO_2 (kt)	114,802.10	13,461.56	649,480.71	144,994.40
WGDP (in billion US$)	59,060	34,636	79,049.20	14,372.50
RER (in thousand)	0.91	0.00	18.53	3.05
FD (in percent)	43.14	1.27	98.76	25.48

Table 5. The result of cross-sectional dependence test.

Equation	Pesaran (CD)	*P*-Value
CO_2 emissions equation	0.81	0.42
Export supply equation	1.16	0.27
FDI inflows equation	0.73	0.46

Source: Study findings.

4.1. Results of non-spatial panel simultaneous equations model

The relationship among CO_2 emissions, exports, and FDI inflows were estimated by the non-spatial panel simultaneous equations model (Table 7). Concerning the identification problem, the rank and order conditions indicated that equations (4)–(6)

Table 6. Results of panel unit root tests.

Variable	Levin-Lin-Chu	*P*-Value	Im-Pesaran-Shin	*P*-Value
LnEX	−12.23	0.00	−2.09	0.00
LnFC	−2.66	0.00	−2.40	0.00
LnGDP	−7.02	0.00	−2.16	0.01
LnFDI	−2.41	0.00	−3.89	0.00
LnPOP	−1.96	0.00	−2.00	0.02
LnT	−5.93	0.00	−3.99	0.00
LnCO_2	−5.53	0.00	−2.41	0.00
LnWGDP	−9.56	0.00	−2.49	0.00
LnRER	−3.95	0.00	−4.55	0.00
LnFD	−3.16	0.00	−1.90	0.04

Source: Study findings.

Table 7. Estimation results of non-spatial panel simultaneous equations model.

	CO_2 Emissions		Export Supply		FDI inflows	
Variables	FE	RE	FE	RE	FE	RE
LnEX	0.02	0.05			4.88***	4.95***
LnFC	4.07***	4.94***				
LnGDP	0.19***	0.20***			−2.66*	−4.23***
LnFDI	0.01***	0.01*	0.01***	0.01**		
LnPOP	0.43***	0.34***	0.62***	0.06	−7.56***	−0.18
LnT	0.38***	0.38***	0.70***	−0.82***		
WTO	−0.11	−0.07	−0.04	0.04	12.73***	6.38***
LnCO_2			0.48***	0.78***	1.81	−0.64
LnWGDP			1.08***	1.17***		
LnRER			−0.01	−0.03	2.66***	1.44***
LnFD					2.99***	1.65***
Constant	−14.39***	−19.20***	−16.09***	−21.05***	−30.69***	0.85
Wald test	2,550,000***	607.62***	3,790,000***	1264.07***	6095.10***	48.50***
Chow test	133.75***		47.93***		45.44***	
Hausman	34.20***		43.86***		43.35***	

Source: Study findings. ***,**,* are statistically significant at the 1%, 5%, 10%, respectively.

are identified. According to the Chow and Hausman tests, for all three equations of CO_2 emissions, and exports and FDI inflows, panel data model with fixed effects is the best among the non-spatial models. Table 7 shows that, given the significance of the Wald test in three equations, the whole panel data model is significant, and exogenous variables explain variations in the endogenous variables.

As for the CO_2 emissions model with a fixed effect (Table 7), the findings indicate that the coefficient of fossil fuel energy consumption (FC) has the expected positive and highly significant impact on the emissions of CO_2. Therefore, a 1 percent rise in fossil fuel energy consumption causes a 4.07 percent increase in emissions of CO_2, suggesting that higher consumption of fossil fuel energy leads to higher emissions of carbon dioxide and environmental pollution. This finding is consistent with the findings of Rafindadi et al. (2014) and Mensah et al. (2019).

The coefficient of Gross Domestic Product (GDP) is statistically significant and positive. Therefore, a 1 percent rise in GDP induces a 0.19 percent increase in CO_2 emissions. So, increasing gross domestic product has detrimental impact on the environment through the contribution to CO_2 emissions. This finding confirms the results of Muhammad (2019) and Munir, Lean, and Smyth (2020).

The significantly positive coefficient of FDI inflows indicates that a 1 percent in FDI inflows causes a 0.01 percent rise in CO_2 emissions. In other words, FDI inflows can move polluting industries to the countries without strict environmental regulations and standards and as a result, the increasing FDI inflows rises CO_2 emissions. This finding is consistent with the results of Bakhsh et al. (2017) and Koçak and Şarkgüneşi (2018) results.

The coefficient of population (POP) is found to have a significant positive impact, in a way that a 1 percent increase of population raises CO_2 emissions by 0.43 percent. This finding is in line with the results of Dong et al. (2018) and Yeh and Liao (2017) who confirmed that population growth increases CO_2 emissions due to higher energy consumption. The coefficient of technology level (T) is also significant and positive, so that a 1 percent improvement in the technology level increases CO_2 emissions by 0.38 percent. This suggests that the technology level in terms of the intensity CO_2 emissions is the driver of the increase in CO_2 emissions. Our result is different from Wang, Fang, and Wang (2016), who found that the technology level has a negative effect on CO_2 emissions.

Export supply model with fixed effect (Table 7) demonstrates that FDI inflows (FDI) have a positive effect on exports, that is, a 1 percent rise in FDI inflows induces a 0.01 percent increase in goods and services exports. In other words, FDI inflows can enhance goods and services exports through raising the production capacity of domestic factories. This finding is consistent with Okechukwu, De Vita, and Luo (2018). The results show that population has a positive and significant effect on goods and services exports, meaning that a 1 percent increase of population leads to a 0.62 percent increase in goods and services exports. Population growth means an increase in labor force and consequently, more production, which leads to export growth.

The coefficient of technology level (T) also indicates a positive and significant impact, so that a 1 percent rise in the technology level increases exports by 0.70 percent. This finding is similar to the results of Goldar, Parida, and Sehdev (2017), who revealed that decreasing intensity of carbon emissions reduces the exports of Indian manufacturing firms.

Similarly, the coefficient of CO_2 emissions also shows significant and positive effect, in a way that a 1 percent rise in CO_2 emissions leads to a 0.48 percent increase in goods and services exports, indicating that producing goods in MENA countries increases carbon dioxide due to energy consumption. As a result, the increasing carbon dioxide due to higher production leads to export growth. Al-mulali and Sheau-Ting (2014) also found this relationship between CO_2 emissions and exports for the MENA countries.

The coefficient of real-world income (WGDP) is positive and significant implying that a 1 percent raise in real-world income causes a 1.08 percent in goods and services exports. In other words, higher world income causes greater demand for imports and consequently, increases exports of goods and services. This finding is consistent with the findings of da Silva, da Rocha Ferreira, and Turra (2017) and Aljebrin and Ibrahim (2012).

For the FDI inflows model with fixed effect (Table 7), the estimated coefficient of exports of goods and services is positive and highly significant, indicating that a 1 percent rise in exports leads to a 4.88 percent increase in FDI inflows. In fact, exports lead to an increase in productivity which can attract more foreign investors. This result is similar to what was found by Jayakumar, Kannan, and Anbalagan (2014). The significantly negative coefficient of GDP shows that FDI inflows decrease due to larger GDP. According to

Eregha (2017), the countries that have relatively low GDP cannot provide the platform for attracting FDI. The same results were obtained by Bianco and Loan (2017).

The coefficient of population has a negative and significant impact on the FDI inflows as a 1 percent increse in the population causes a 7.56 percent reduction in the FDI inflows, suggesting that higher population leads to reduction in FDI inflows. In fact, countries with larger population in the MENA region, such as Egypt, Iran, Iraq and Yemen face various problems such as sanctions, war and recession and thus, are not attractive for investment. This finding is contrary to the findings of Peres, Ameer, and Xu (2018).

The estimated coefficient of accession to the World Trade Organization (WTO) is highly significant and positive, indicating that accession to the World Trade Organization causes a 12.73 percent rise in FDI. This finding is similar to the results of Shah (2017), who found that accession to the WTO increases the amount of FDI into East Asian and Pacific developing countries through removing tariffs and other barriers.

The real exchange rate (RER) has a positive and significant impact on FDI inflows, meaning that a 1 percent increase in the real exchange rate will lead to a 2.66 percent raise in FDI inflows. This implies that higher real exchange rate can be a positive sign for foreign investors. Higher rate of the real exchange indicates the depreciation of national money that leads to lower wages and production costs compared to outside the country and consequently, to the attraction of foreign investors. This finding is in line with the results of Omorokunwa and Ikponmwosa (2014) and Khandare (2016). The significant positive coefficient of financial development (FD) demonstrates that FDI inflows increase by 2.99 percent when financial development has a 1 percent raise. This result is consistent with the findings of Nwosa and Emma-Ebere (2017) who stated that financial development contributes to FDI inflows through decreasing information asymmetry problems and enhancing the channelizing of financial resources efficiently.

4.2. Spatial panel simultaneous equations model

In order to test spatial correlation in CO_2 emissions, exports, and FDI inflows equations, Global Moran's I, Getis-Ords GO and Geary's GC tests were used. According to the results (Table 8), although test statistics are significant indicating a need to incorporate spatial autocorrelation in the analysis of three equations (panel data models) with both adjacency-based weight matrix and distance-based weight matrix, the test statistics are statistically weak for three equations with adjacency-based weight matrix compared with distance-based weight matrix.

Besides, according to the results of two spatial weighting models and the coefficients of determination (R^2) shown in Table 9, three equations (the spatial panel data models) with distance-based weight matrix are more fitting than three equations with adjacency-based weight matrix. Therefore, three equations with the distance-based weight matrix were used to investigate the relationship among CO_2 emissions, exports, and FDI inflows.

In order to incorporate spatial autocorrelation in the model, export supply, CO_2 emissions, and FDI inflows equations were estimated simultaneously by incorporating spatial lag into a spatial panel simultaneous equation model. Again, the rank and order conditions approved the identification of all three equations. The results of three equations estimation using G2SLS method and distance-based weight matrix (Table 9) show

Table 8. Results of spatial autocorrelation tests.

		Adjacency-based weight matrices		Distance-based weight matrices	
Equation	Test	Test Statistics	*P*-Value	Test Statistics	*P*-Value
4	Global Moran's I	0.27	0.00	0.65	0.00
	Global Geary's C	0.76	0.00	0.31	0.00
	Global Getis-Ords G	−0.27	0.00	−0.65	0.00
5	Global Moran's I	−0.03	0.09	0.53	0.00
	Global Geary's C	1.03	0.07	−0.47	0.00
	Global Getis-Ords G	0.03	0.09	−0.53	0.00
6	Global Moran's I	−0.10	0.04	0.57	0.00
	Global Geary's C	1.15	0.04	0.39	0.00
	Global Getis-Ords G	0.10	0.04	−0.57	0.00

Source: Study findings.

Table 9. Estimation results of spatial panel simultaneous equations model.

	Adjacency-based weight matrices			Distance-based weight matrices		
Variables	CO_2 Emissions	Export Supply	FDI inflows	CO_2 Emissions	Export Supply	FDI inflows
LnEX	0.28***		4.74***	0.32***		1.37*
LnFC	5.66***			4.83***		
LnGDP	0.24***		−5.26***	0.08*		0.33
LnFDI	0.002	0.001		−0.001	0.002	
LnPOP	0.33***	−0.16***	0.05	0.29***	−0.17***	−1.09***
LnT	0.14	−0.50***		0.05	0.07	
WTO	0.17***	0.21***	5.37***	0.05	0.21***	2.55***
$LnCO_2$		0.99***	0.43		0.82***	1.26***
LnWGDP		0.66***			0.46***	
LnRER		−0.02	1.06***		−0.02*	0.28***
LnFD			1.22**			0.61***
W∗ $LnCO_2$	−0.57***			0.34**		
W* LnEX		0.31***			0.49***	
W* LnFDI			0.26*			1.89***
Constant	−55.05***	−18.07***	2.30	16.80***	20.50***	2.18
Log Likelihood	−1149.72	−623.25	−971.52	−1206.85	−1140.77	−772.35
R^2	0.77	0.81	0.44	0.89	0.92	0.89
Adjusted R^2	0.74	0.79	0.37	0.88	0.91	0.88

Source: Study findings. ***,**,* are statistically significant at the 1%, 5%, 10%, respectively.

that, based on the coefficients of determination (R^2), the models have high explanatory potential.

According to the results (Table 9), the W* $LnCO_2$ that is the spatial variable coefficient, has a positive and highly significant effect on the CO_2 emissions, suggesting that an increase in CO_2 emissions in a country has a positive spillover effect on nearby countries' CO_2 emissions. This means that a country's CO_2 emissions affect not only its own environmental quality but also that of nearby countries. The reason for this effect is that CO_2 emissions move from one country or region to another one and do not disappear. These findings are similar to the findings of Zhao, Burnett, and Fletcher (2014) and Cole et al. (2013). Additionally, the spatial coefficients of W* LnFDI and W* LnEX are positive and statistically significant, together with the coefficient of W* $LnCO_2$ support hypothesis 7. This indicates that FDI inflows and exports in a country have a positive spillover effect on nearby countries' exports and FDI inflows. Accordingly, FDI inflows in a country are positively correlated with FDI inflows in neighboring countries. This can be due to the lack of strict environmental standards and the existence of natural resources such as oil and gas in the MENA countries which create competitive pressure to attract FDI inflows. The impact of countries' exports on neighboring region also means that the export performance of companies in each country can affect the exports of nearby countries in the framework of joint cooperation. Therefore, it can be expected that cooperation between companies is more difficult and costly when the distance between countries increases, which may result in less overflow power. The result related to FDI inflows is in line with the finding of Esiyok and Ugur (2017). However, the spillover effect of exports is different from that of Saghaian et al. (2020) finding.

Our findings show that a two-way relationship exists between CO_2 emissions and exports (unlike to non-spatial simultaneous panel data model). Moreover, results show the existence of a one-way link between CO_2 emissions and FDI inflows (similar to non-spatial simultaneous panel data model) and between FDI inflows and exports (unlike non-spatial simultaneous panel data model).

The empirical results of estimating the CO_2 emissions equation, in support of hypothesis 1, reveal that exports have a positive and highly significant effect on CO_2 emissions. It means that a 1 percent rise in exports increases the emissions of CO_2 by 0.32 percent. Therefore, increasing trade flow harms the environment through the influence of goods production on CO_2 emissions. This finding confirms the results of Ren et al. (2014) and Al-mulali and Sheau-Ting (2014).

The fossil fuel energy consumption as expected has a positive and significant impact on CO_2 emissions, identical to the non-spatial model and a 1 percent rise in fossil fuel energy consumption leads to a 4.83 percent increase in emissions of CO_2. The coefficient of gross domestic production (GDP) is statistically significant and positive, similar to the non-spatial model. It means that a 1 percent rise in the GDP increases the emissions of CO_2 by 0.08 percent. Just like the case with the non-spatial model, the coefficient of population is statistically significant and positive in a way that a 1 percent rise in the population increases the emissions of CO_2 by 0.29 percent.

In the export supply equation, the coefficient of CO_2 emissions has a highly statistically significant and positive impact, unlike the non-spatial model. It indicates that a 1 percent rise in CO_2 emissions increases exports by 0.82 percent, which confirms the hypothesis 2. According to the Environmental Kuznets Curve (EKC), there is a positive relationship between CO_2 emissions and income (trade) level before the EKC threshold and then, a negative relationship beyond the threshold. Our finding confirmed the results of Jayanthakumaran, Verma, and Liu (2012) too.

The significantly negative coefficient of population shows that a 1 percent increase of population level leads to a 0.17 increase in export supply. In short term, population growth appears to increase the demand for goods and this reduces the ability to exports goods. This finding is consistent with Weckström (2013).

The significantly positive coefficient of accession to the WTO reveals the accession to the World Trade Organization causes a 0.21 percent rise in exports. WTO accession increases export opportunities and market access through reducing tariffs and non-tariff barriers. This finding is similar to that of Saghaian et al. (2020).

The coefficient of real-world income (WGDP) is positive and significant. This indicates that a 1 percent rise in the real-world income increases exports by 0.46 percent, similar to the non-spatial model. The significantly small coefficient of the real exchange rate (RER) displays a negative impact of the real exchange rate on exports so that exports decrease by 0.02 percent when the real exchange rate raises by 1 percent. It implies that the production of goods that need foreign inputs decreases due to an increase in the exchange rate and input prices and as a result, the exports of these goods decrease. This result is similar to the findings of Wondemu and Pottsa (2016).

In the FDI equation, the coefficient of goods and services exports reveals the positive and significant effect of exports on FDI inflows, similar to the non-spatial model, indicating that hypothesis 5 is supported. This suggests that a 1 percent rise in goods and services exports increases the FDI inflows by around 1.37 percent. The population has a negative and significant impact on FDI inflows, implying that a 1 percent increase in population leads to a 1.09 percent reduction in FDI inflows. This finding is similar to the non-spatial model results.

The significantly positive coefficient of accession to the WTO demonstrates that accession to the World Trade Organization (WTO) causes a 2.55 percent rise in FDI inflows. This finding is identical to the results of the non-spatial model. The coefficient of CO_2 emissions carries a highly statistically significant and positive effect, supporting hypothesis 4. It reveals that a 1 percent rise in CO_2 emissions increased FDI by 1.26 percent. This means that the countries studied attract FDI inflows due to weak environmental regulations and lower standards. This result is similar to the findings of Ssali et al. (2019) and Gökmenoğlu and Taspinar (2016).

The real exchange rate has a positive and significant impact on FDI inflows, similar to the non-spatial model results. This implies that a 1 percent rise in the real exchange rate results in a 0.28 increase in FDI inflows. Finally, the coefficient of financial development (FD) is positive and significant, identical to the non-spatial model results. Accordingly, a 1 percent rise in the financial development (FD) increases FDI inflows by 0.61 percent.

5. Conclusions

The crisis of CO_2 emissions in the MENA countries along with the increase in exports of goods and services and FDI inflows in recent years suggests a possible link between these variables. This study attempted to explore this relationship and contributed to the research literature in three ways. First, it examines the three-way relationship among CO_2 emissions, exports, and FDI inflows in a simultaneous equations framework. Second, spatial correlation of the variables across countries were investigated by incorporating spatial autocorrelation into the framework. Third, it focused on the MENA countries as a set of countries that suffers from the increase in CO_2 emissions.

A panel simultaneous equations model was employed to incorporate spatial and non-spatial correlation of the variables based on the adjacency-based and distance-based weight matrices and investigate the correlation between the error terms of individual equations. It gives more efficiency and consistency to the regional analysis and also, reduces the regression models limit which has received less attention in previous studies.

The main results of the study are as follows:

First, CO_2 emissions, exports and FDI inflows in a country have positive spillover effects on nearby countries' CO_2 emissions, exports and FDI inflows, respectively. This implies that local CO_2 emissions, exports and FDI inflows of a country have an increasingly impact on the same factors in neighboring countries, respectively. Hence, national decision-makers and policy planners should not just focus on the economic advantages of increasing exports and attracting foreign investment. They must rather consider the environmental effects in local and neighboring countries. Since fossil fuel energy consumption and population are the main determinants of CO_2 emissions in the MENA countries, elimination or reduction of fossil fuel energy subsidies and encouraging the use of alternative energy sources (such as solar energy) can be helpful in decreasing CO_2 emissions.

Second, a two-way relationship was found between CO_2 emissions and exports for spatial estimations, indicating the positive impact of exports on CO_2 emissions and vice versa. Therefore, it is recommended that governments, on the one hand, promote green transportation systems (such as hybrid trains and electric trucks) for sustainable transportation of exports and, on the other hand, expand the non-oil exports through incentive policies, like export subsidies and export bonuses to reduce emissions of CO_2 and protect the environment in the MENA region.

Third, a one-way linkage existed between CO_2 emissions and FDI inflows for both non-spatial and spatial estimations. Forth, a one-way relationship was observed between FDI inflows and exports in the spatial estimation but a two-way in non-spatial estimation. Therefore, the governments are suggested to, instead of imposing weak environmental regulations to attract FDI inflows, adopt other ways such as joining the WTO, stabilizing monetary and fiscal policies (like price stability, interest rate stability, stability in the foreign exchange market), improving business environment (such as revising disruptive business rules and creating a comprehensive market information system), removing export barriers, and supporting export-oriented production. FDI inflows also need to be directed towards restructuring production based on environment-friendly technologies such as solar energy to minimize pollution.

At the present, there are no more comprehensive and up-to-dated data than those used in this study, except for a partially updated data carried out in 2016. To fully develop the method applied in this study, the values of all the considered variables must be available. Therefore, future researches are suggested to repeat this study with the updated data, hoping that the relevant bodies will make available more promptly all the needed data.

Also, future studies can analyze the various effects of different sources of CO_2 emissions on FDI inflows and exports and explore the impact of different policies on them in different countries after considering spatial characteristics.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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