Folia Oeconomica Stetinensia
Volume 21 (2021) Issue 2
DOI: 10.2478/foli-2021-0020 | 132–147
ISSN (print): 1730-4237 | ISSN (online): 1898-0198
www.wnus.edu.pl/fos

THE RELATIONSHIP BETWEEN ECONOMIC GROWTH, ENERGY CONSUMPTION AND CO_2 EMISSION IN THE MIDDLE EAST AND NORTH AFRICA (MENA)

Prof. Mohammed Touitou

Faculty of Economics and Business
University of Algiers 3, Algiers. Algeria
e-mail: touitoutouitou@yahoo.fr; touitou.mohammed@univ-alger3.dz
ORCID: 0000-0002-4442-7888

Received 20 February 2021, Accepted 20 October 2021

Abstract

Research background: CO_2 emissions are considered to be the main reason for global warming, and for this reason, their regulation is a very important issue for governments. Due to the increasing use of energy, carbon dioxide emissions have increased dramatically over the past century, with a direct link to economic growth and development. The relationship between CO_2 emissions, growth and energy consumption is therefore at the heart of current economic issues.
Purpose: This study aimed at examining the relationship among economic growth, carbon dioxide (CO_2) emissions and energy consumption in selected MENA countries, in the period 1995–2017.
Research methodology: To prove these relations, a stationary data panel methodology is used supported by unitary root and cointegration tests.
Results: The results indicated that there is a long-term relationship between CO_2 emissions, energy consumption and GDP. In addition, it is found that the elasticity of CO_2 emissions with respect to energy consumption is less than one (inelastic), and the elasticity of CO_2 emissions with respect to GDP suggests the existence of an Environmental Kuznets Curve. An important finding is that energy consumption has a positive but relatively low effect on CO_2 emissions. To reduce CO_2 emissions, the countries of the MENA region are being called upon to increase significantly the use of renewable energies and the establishment of a more efficient energy policy.

Keywords: Energy consumption, Economic growth, CO_2 emissions, cointegration panel, EKC, MENA

JEL classification: O10, O47, Q50, Q53

Introduction

Environmental issues are the subject of a great deal of scientific research and are of constant concern to governments at the highest level around the world (Alkhathlan, Javid, 2013; Wang, Zhou, Wang, 2011). Indeed, the destruction of the ozone layer by the release into the atmosphere of greenhouse gases, including carbon dioxide (CO_2), constitutes the main threat to humanity. According to Stern (2007), it could cost the entire world economy up to $ 550 billion if real action is not taken. Due to the increasing use of energy, carbon dioxide emissions have increased dramatically over the past century, with a direct link to economic growth and development (Lau, Tan, Lee, Mohamed, 2009; Sotyas, Sari, 2009; Soytas, Sari, Ewing, 2007). The relationship between CO_2 emissions, growth and energy consumption is therefore at the heart of current economic issues.

CO_2 emissions are considered to be the main reason for global warming, and for this reason, their regulation is a very important issue for governments. For example, the Kyoto protocol in 1997 set the goal of reducing greenhouse gases. As MENA countries is a group of countries that have recently experienced rapid economic growth, it is important to study the effect that GDP has on CO_2 emissions. Additionally, the extensive study of the relationship between energy consumption and GDP indicates that energy consumption patterns also have a positive impact on CO_2 emissions. In this sense, if the relationship is positive, mechanisms should be proposed for the conservation and efficient use of energy.

Economic literature refers to economic growth as the accumulation of factors of production, such as physical capital, labour, human capital and technical progress (Solow, 1956; Romer, 1986; Lucas, 1988). However, many economists, specialists in the economics of energy, support the idea that these factors of production can only be productive in the presence of energy, then the latter is considered to be the engine of economic growth (Asafu-Adjaye, 2000; Yang, 2000; Stern, 2000; Ghali, Khalifa, El-Sakka, 2004). Therefore, the causes of environmental degradation are not reduced to just one factor, namely economic growth, but other factors are also involved such as energy consumption. Indeed, the most widely used energy sources in the MENA countries are fossil fuels. The latter are the most polluting, because the use of gas or oil in economic activity, for example the production of electricity, emits CO2 in the air and contributes to the greenhouse effect. This air pollution is causing climate change. According to a World Bank report published in 2011, countries in the region will be hit hard by climate change. Because the average rate of warming will be higher than the world average, there is also the phenomenon of drought and water stress.

It should be noted that statistics from the World Bank (WDI, 2017) show that CO_2 emissions in MENA countries were 3.6 metric tons per capita in 1990 and 6.2 metric tons per capita in 2014, an increase of 172% in the space of just two decades. While the global emission averages for the same periods (1990 and 2014) are only 4.2 metric tons per capita and 5 metric tons per capita. The upward trend in emissions will be a real problem that the countries of the MENA region will have to face, since their international commitments vis-à-vis climate change (Paris Agreement of 2016) will oblige them to work to reduce emissions from greenhouse gas. This requires, of course, a reduction in the consumption of fossil fuels, bearing in mind that clean, so-called renewable energies are not sufficiently developed to make the energy transition a success, which risks jeopardizing the economic development of the countries in question.

The objective of this work is to study the relationship between energy consumption, GDP and CO_2 emissions. Through a non-stationary macroeconomic panel data model, the long-term elasticity's of CO_2 emissions to energy consumption and GDP are estimated. The above, in order to provide empirical evidence about the relationship between CO_2 emissions and some of its determinants, in this particular case, energy consumption and GDP. In addition, evidence is presented on the hypothesis of the existence of an Environmental Kuznets Curve (EKC) for the MENA group of countries.

Likewise, the contribution of this work to the existing literature lies in the use of non-stationary panel data methodologies, with unit root tests for panel data and panel cointegration tests, and empirical evidence is presented for a group of countries (economic region) little studied as in the case of the MENA.

Households and firms determine the growth of economies, in part, since through the production of goods and services by firms, the consumption of goods and services are provided so that households, can satisfy their needs. Now, if household consumption increases, firms will increase their production to meet household demand, and the problem here is that the said increase in production will generate possible negative and positive externalities added to possible excesses compared to the use of environmental resources, through increases in energy consumption and income. Referring to this context, the construction of economic policies, in most cases, does not link the factors of pollution and degradation of the environment, to try to reduce the negative impact of these on the economy or considerably limit the use of these resources. Here, then, is the importance of knowing the effects that increases in energy consumption and GDP have on the CO_2 emissions of an economy.

This paper is divided into five sections, including an introduction, and it is organized as follows. The first section presents a brief review of international empirical literature on

the relationship between CO_2 emissions, energy consumption, and GDP. In the second, the methodology and data are exposed. In the third section, the results of the unit root and panel cointegration tests are presented, in addition to the estimates. Finally, the fourth and last section presents the conclusions.

1. Literature review

Numerous researchers have studied the relationship between energy consumption and GDP over the last thirty years, 1990–2020; however, it is necessary to include CO_2 emissions in this relationship, given the growing environmental concern, due to the problem of climate change that is occurring worldwide. Some of the most relevant works on this topic, during the first decade of the 21st century, are reviewed below.

Since the study by (Panayotou, 1993), empirical work on the question of the relationship between economic growth and the environment continues to abound. Indeed, (Panayotou, 1993) had attempted, through both theoretical and empirical analysis, to verify the hypothesis of the Kuznets environmental curve (EKC). This assumption assumes that the economic growth-environment relationship takes the form of an inverted "U". Indeed, the empirical study consisted of highlighting the relationship between the effects of economic development on deforestation and air pollution, for a sample comprising developed and developing countries. The results obtained confirm the EKC hypothesis. According to the author, the confirmation of the EKC involves important political consequences. Because during the development period, environmental degradation is inevitable. However, when the economy reaches an advanced level of growth, the environmental framework begins to improve significantly.

In contrast, much empirical work confirms the hypothesis that the relationship between environmental degradation and economic development is in the form of an inverted "U"(Apergis, Payne, 2009; Pao, Tsai, 2010; Jalil, Feridun, 2011; Shahbaz, Khraief, Uddin, Ozturk, 2014; Osabuohien, Efobi, Gitau, 2014; Cüneyt, Feyza, 2018). Indeed, the methodology adopted by (Shahbaz, Khraief, Uddin, Ozturk, 2014) is the ARDL model to test a possible cointegrating relationship between CO_2 emissions and GDP, GDP squared, energy consumption and trade openness. These variables were studied over the period from 1971 to 2010 and for the case of Tunisia. The results then confirm the presence of a cointegration relationship between the variables studied and the CEK hypothesis was confirmed. This finding is corroborated by other studies(Plassmann, Khanna, 2006; Soytas, Sari, Ewing, 2007; Al-Mulali, Saboori, Ozturk, 2015; Chng, 2019; Işık, Ongan, Özdemir, 2019; Arifur, Woahid, 2020). (Raggad, 2018) investigated

the determinants of pollutant emissions. He found the positive effects of income and energy use on the CO_2 emissions. This result is shared by other authors, such as the study of (Ang, 2007b; Soytas, Sari, Ewing, 2007; Sotyas, Sari, 2009; Bhat, 2018; Muhammad, Khan, Rehan, 2020; Cihan, Emrah, 2021; Gessesse, He 2020; Zhang, Jihuan, 2021).

2. Methodology

This section describes the methodology used to determine the effects that GDP and energy consumption have on CO_2 emissions. In addition, graphs of the data with which this methodology is applied are presented.

2.1. Panel data

During the last two decades, 2010–2020, panel data have been used as an analysis tool by researchers from various areas to study the relationships between different variables. The main reason is that this methodology combines a time dimension (time series) with a cross-sectional one (cross section).

When working with macroeconomic panel data, which contemplate a time series greater than the number of individuals, the existence of a long-term relationship between the variables that are analyzed for the group of individuals must be taken into account. In other words, it must be ensured that a cointegration relationship exists to avoid the problem of obtaining spurious results as argued by (Engle, Granger, 1987; Entorf, 1997; Kao, 1999; Phillips, Moon, 1999), who introduced the term of spurious relationships in the use of panel data, when the time observations are greater than the number of individuals in a panel. For this, it is necessary to apply unit root tests that allow determining the order of integration of the time series, and cointegration tests to determine whether or not the time series of each country are cointegrated, and thus avoiding spurious results.

The implementation of this panel data methodology links the fact that individuals, firms, banks or countries, as in this case (the MENA) are heterogeneous. Cross-sectional and time series analyzes do not attempt to control for this heterogeneity at the risk of biased results. An additional advantage is that they allow a better study of the dynamics of the adjustment processes of the data taken for the MENA countries.

According to the international literature on energy economics, the following equation can be formulated in order to determine the long-term relationship between CO_2 emissions,

energy consumption and GDP. Other authors such as (Pao, Tsai, 2010; Apergis, Payne, 2009; Halicioglu, 2009) have used this functional form:

$$LCO2_{it} = \beta_0 + \beta_1 LEC_{it} + \beta_2 LGDPP_{it} + \beta_3 LGDPP_{it}^2 + \varepsilon_{it} \quad (1)$$

where: $LCO2_{it}$ – is the logarithm of the CO_2 emissions of each country (i) in the period (t), LEC_{it} – is the logarithm of the Energy consumption of each country (i) in the period (t), $LGDPP_{it}$ – is the logarithm of the GDP of each country (i) in period (t).The variable $LGDPP_{it}^2$ – is used for the purpose of testing the hypothesis of the existence of an Environmental Kuznets Curve; therefore, if such a curve exists, the sign of the coefficient that accompanies the variable ($LGDPP_{it}$) is expected to be positive, while the sign of the coefficient that accompanies the variable $LGDPP_{it}^2$) will be negative. On the other hand, the coefficient that accompanies the variable (LEC_{it}) is expected to have a positive sign.

2.2. Unit root tests for the panel

The order of integration of the series of CO_2 emissions, energy consumption and GDP, expressed in per capita terms, is considered first. The tests for panel data developed by (Im, Pesaran, Shin, 2003) known as the IPS test, (Levin, Lin, Chu, 2002; Breitung, 2000; Maddala, Wu, 1999) (Fisher type ADF) and Choi are used (2001) (Fisher type PP). The tests of (Maddala, Wu, 1999; Im et al., 2003) allow for heterogeneity between individuals in the panel data. The panel unit root tests are based on the tests developed for the time series, but have an advantage over the latter, and that is that when combining time series and cross-section data, more degrees of freedom are obtained, which improves the properties of the estimators, and correct for unobserved heterogeneity.

2.3. Cointegration test for the panel

After verifying that the series are integrated of order one, that is, that they contain a unit root in the panel, the cointegration test is continued, in order to find evidence of the existence of a relationship between the variables in the long term, and thus avoiding the presence of spurious relationships. The foregoing is proven through the well-known heterogeneous panel cointegration test of Pedroni (2000, 2004). This test is based on seven statistics divided into two groups; the first is based on the (Phillips, Ouliaris, 1990) statistic, which is defined as:

$$\tilde{Z}_p = \sum_{i=1}^{N} \frac{\sum_{i=1}^{T} \left(\hat{\varepsilon}_{it-1} \Delta \hat{\varepsilon}_{it} - \hat{\lambda}_t \right)}{\left(\sum_{i=1}^{T} \hat{\varepsilon}_{it-1}^2 \right)} \quad (2)$$

where: $\hat{\varepsilon}_{it}$ is estimated from equation (1), $\left[\lambda_i = \frac{1}{2}\left(\hat{\delta}_i^2 - \hat{s}_i^2\right)\right]$, for which $\hat{\delta}_i^2$ is the long-term variance of $\hat{\varepsilon}_{it}$ and $\hat{s}_i^2$ is the contemporary variance. The second group of statistics are based on the variance ratio, defined from the matrix of long-term variances and covariance. The estimation method is Fully Modified Ordinary Least Squares (FMOLS), since this estimator corrects for endogeneity and heterogeneity problems that are present in cointegration tests based on model errors and estimated by OLS. A further description of this can be found in (Pedroni, 2000).

2.4. Data

Below we can see the variables that were used in this paper. GDP per capita measured (in dollars at constant prices 2010), energy consumption (kWh per capita), CO_2 emissions (metric tons per capita).

All series were obtained from the World Bank. Figures 1 to 3 show the behaviour of each of the series of the selected MENA countries.

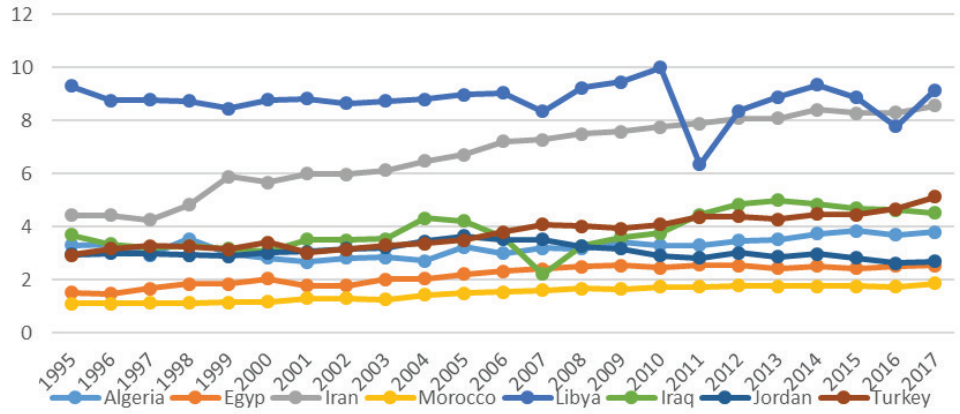


Figure 1. CO_2 emissions (tons of carbon dioxide per capita), 1995–2017

Source: prepared by the authors based on information from the World Bank.

Figures 1 and 2 show that Libya is the country with the most CO_2 emissions and energy consumption per capita, compared to the other MENA countries. This is due primarily to the high level of primary energy consumption per capita (more than 3 tons/capita). In the case of Algeria, can be observed that its behaviour is within the range of the other countries of the group, and that Egypt and Morocco are the most homogeneous countries with a low share of CO_2 emissions per person.

The energy consumption of the MENA is reflected in Figure 2 where the energy consumption of Turkey stands out in contrast to the other countries of the group, which present homogeneous behaviour, which may be due to consumption habits, such as the minimal use of fossil fuels or the high rate of economic growth during the last decade.

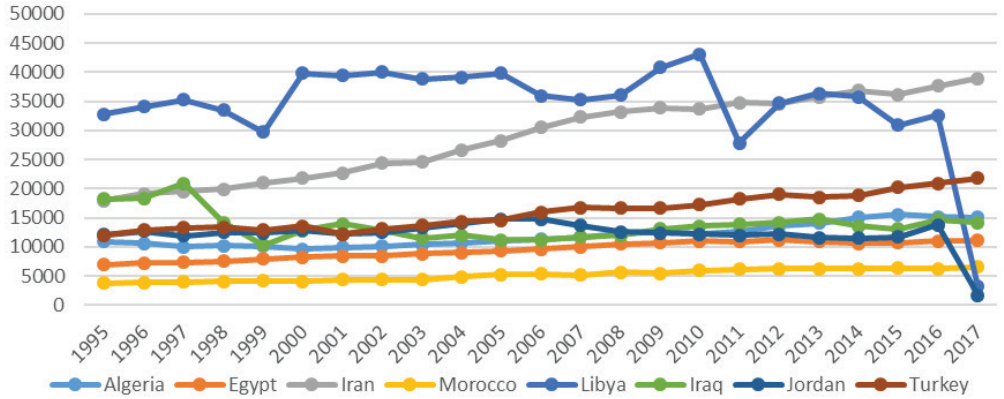


Figure 2. Energy consumption per capita, 1995–2017

Source: prepared by the authors based on information from the World Bank.

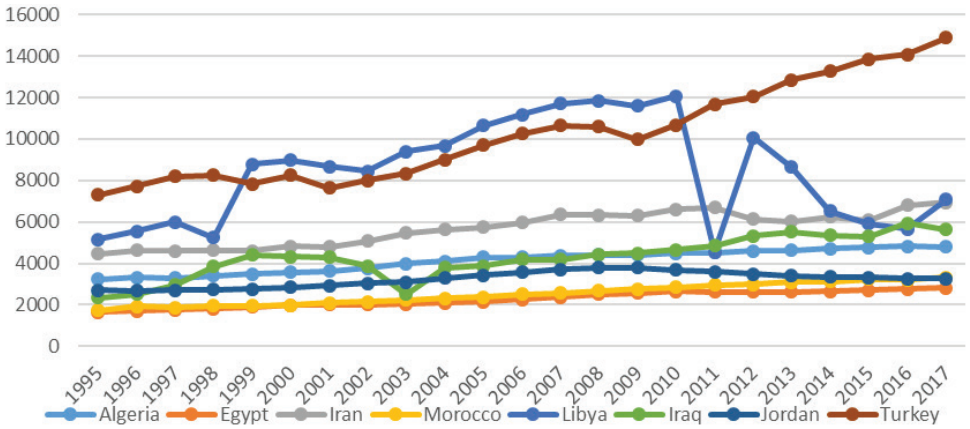


Figure 3. Real GDP per capita, 1995–2017

Source: prepared by the authors based on information from the World Bank.

Figure 3 allows us to infer that Turkey is the country that has presented the highest economic growth per capita throughout the series, with an average increase of 2.40%. The economy of Libya depends primarily on revenues from the petroleum sector, which represents over 95%

of export earnings and 60% of GDP. These oil revenues and a small population have given Libya one of the highest per capita GDP in Africa. Libya after 2000, recorded favourable growth rates with an estimated 10.6% growth of GDP in 2010. This development was interrupted by the Libyan Civil War, which resulted in the contraction of the economy by 62.1% in 2011. After the war, the economy rebounded by 104.5% in 2012, but then crashed again following the Second Libyan Civil War as of 2017, Libya's per capita GDP stands at 60% of its pre-war levels.

3. Results and discussion

This section presents the results of the unit root and cointegration tests in the panel data. Table 1 shows the results of the five-unit root tests presented in the previous section, and is indicated for each of the variables in levels, the statistics and the probability. It can be seen that for none of the tests the null hypothesis of unit root can be rejected, with which it is concluded that the series are not stationary in the levels.

Table 1. Unit root for variables in levels

Test	CO_2 emissions		Energy consumption		GDP	
	statistic	probability	statistic	probability	statistic	probability
Im, Pesaran and Shin (W statistic)	0.33	0.61	0.55	0.63	1.42	0.89
ADF – Fisher (Chi squared)	4.84	0.75	2.01	0.68	5.98	0.85
PP – Fisher (Chi squared)	5.29	0.69	3.45	0.43	11.35	0.44
Levin, Lin and Chu (t)	–0.60	0.23	–0.81	0.18	1.38	0.81
Breitung (t-statistic)	0.71	0.73	2.05	0.96	3.42	1.00

Source: elaborated on by the authors and based on the results of the estimates.

The results of the unit root tests applied to the series in the first differences are presented below, in order to rule out the presence of more than one unit root. Table 2 shows these results for each variable, and the statistic and probability corresponding. It can be concluded that the series in differences are stationary, which can be rejected by the null hypothesis that there is a unit root.

The result of the Pedroni (2000, 2004) cointegration test for the MENA countries is presented in Table 3. It can be seen that five of the seven statistics of this test allow rejecting the null hypothesis of non-cointegration at 5% significance; therefore, there this is strong statistical evidence in favour of a cointegration relationship between the variables CO_2 emissions per capita, energy consumption per capita, and GDP per capita.

Table 2. Unit root for variables in the first difference

Test	Δ (CO_2 emissions)		Δ (Energy consumption)		Δ (GDP)	
	statistic	probability	statistic	probability	statistic	probability
Im, Pesaran and Shin (W statistic)	–4.79	0.00***	–2.61	0.000***	–2.16	0.00**
ADF – Fisher (Chi squared)	41.68	0.00***	25.73	0.000***	21.02	0.04**
PP – Fisher (Chi squared)	87.30	0.00***	57.37	0.000***	38.12	0.00***
Levin, Lin and Chu (t)	–4.81	0.00***	–1.28	0.085	–3.85	0.00***
Breitung (t-statistic)	–4.63	0.00***	–2.54	0.000***	–2.09	0.01**

*** Indicates the rejection of the null hypothesis at 1% significance.
** Indicates the rejection of the null hypothesis at 5% significance.

Source: elaborated on by the authors and based on the results of the estimates.

Table 3. Cointegration tests

Test	Statistic	Probability
Within – dimension		
Panel v-Statistic	1.97	0.01**
Panel rho-Statistic	–0.68	0.19
Panel PP-Statistic	–2.58	0.00**
Panel ADF-Statistic	–2.11	0.01**
Between – dimension		
Group rho-Statistic	0.82	0.23
Group PP-Statistic	–1.74	0.03**
Group ADF-Statistic	–2.81	0.00*

** Indicates the rejection of the null hypothesis at 5% significance.
* Indicates the rejection of the null hypothesis at 10% significance.

Source: elaborated on by the authors and based on the results of the estimates.

Table 4 shows the results of the estimation of the long-term relationship based on the cointegration test of Pedroni (1999, 2004), for equation (1), and can be observed that all the coefficients are statistically significant at 1%, and also have the expected a-priori sign.

Table 4. Long-term relationship, cointegration equation

Variable	Coefficient	T statistic	Probability
Constante	–7.84	–3.72	0.00
LEC	0.39	5.85	0.00
LGDP	1.71	2.81	0.02
(LGDP)A2	–0.11	–2.94	0.00

Source: elaborated on by the authors and based on the results of the estimates.

In summary form, the cointegration equation can be expressed as follows (standard errors)

$$LCO2_{it} = \underset{(2.17)}{7,84} + \underset{(0.06)}{0,39}LEC_{it} + \underset{(0.51)}{1,71}LGDPP_{it} - \underset{(0.02)}{0,11}LGDPP_{it}^2 \quad (3)$$

The above results show that CO_2 emissions are inelastic (less than one) to changes in energy consumption, that is, a 1% increase in energy consumption generates in the long term an increase of 0.39% in energy consumption seen by the CO_2 emissions from the MENA data panel. On the other hand, the panel elasticity of CO_2 emissions with respect to GDP in the long term can be formulated as follows:

$$1,71\ LGDPP_{it} - 0,09\ LGDPP_{it}^2$$

$$\frac{\partial LCO2_{it}}{\partial LGDPP_{it}} = 1,71 - (2 \times 0,11) LGDPP_{it} = 0$$

$$\frac{\partial LCO2_{it}}{\partial LGDPP_{it}} = 1,1 - 0,226 LGDPP_{it} = 0$$

$$LGDPP_{it} = \frac{1,71}{0,22} = 7,77$$

This implies that the inflection point is found when GDP reaches a level of 7.77 in logarithms (or 2,368.47 in million dollars of 2010 per capita). These results reinforce the hypothesis of the existence of an EKC, since the level of CO_2 emissions first increases with GDP, and then it stabilizes and finally decreases. The elasticity of GDP over CO_2 emissions will be greater than 1, when GDP per capita is less than (1.71 – 1)/0.22 = 3.23 (in logarithms). In summary, in the long term, CO_2 emissions are inelastic to energy consumption and elastic to GDP if it is less than 3.23, while they are inelastic if GDP is greater than 3.23.

In summary, the results suggest a considerable response of CO_2 emissions to changes in GDP, and a relatively low response of CO_2 emissions to increases in energy consumption. Similar results were found by (Apergis, Payne, 2009; Pao, Tsai, 2011), for a different group of countries.

Conclusions

During the decade 2010–2020, regions and countries in the world have become aware of the negative effect that energy consumption patterns and GDP growth could have, among

other things, on the environment. In other words, they have realized that the most important thing, even above economic growth, was the negative impact that global consumption patterns can have on the environment.

This paper presents a first approach at studying the determinants of CO_2 emissions for the eight MENA countries for the period 1995–2017. Using the panel data, the relationship of CO_2 emissions, real GDP, and energy consumption is estimated, in order to know the coefficients of this relationship in the long term and to be able to analyze the impact, in addition to contributing to the fulfilment of the hypothesis of the existence of an EKC.

The results presented in this paper indicate that there is a long-term relationship between CO_2 emissions, energy consumption and GDP. In addition, it has been found that the elasticity of CO_2 emissions with respect to energy consumption is less than one (inelastic), and the elasticity of CO_2 emissions with respect to GDP suggests the existence of an Environmental Kuznets Curve, which is U-shaped inverted with a point of inflection at the level of GDP per capita of 7.77 (in logarithms).

Similarly, the results suggest that there is a causal relationship between GDP and CO_2 emissions, and energy consumption with CO_2 emissions, which means that in the long-term economic growth, is one of the determinants of climate change through CO_2 emissions, at least for the studied countries, known as the MENA. Specifically, at equilibrium, a 1% increase in energy consumption generates in the long term an increase of 0.39% in CO_2 emissions from the MENA data panel. On the other hand, CO_2 emissions are elastic to GDP if it is less than 3.23 (in logarithms), while they are inelastic if GDP is greater than 3.23 (in logarithms).

An important finding is that energy consumption has a positive effect on CO_2 emissions, but relatively low, as mentioned above, indicating that policies aimed at promoting efficient use and conservation of energy reduce CO_2 emissions, hence, these could contribute to reducing global warming. On the other hand, the evidence found in favour of the Environmental Kuznets Curve indicates that although economic growth increases the level of CO_2 emissions, this increase stabilizes and then introduces a decrease in emissions. This reduction demonstrates that countries are becoming more efficient at production, with better production processes and less polluting.

To reduce CO_2 emissions, considering that the MENA countries are the most affected and vulnerable in the world because of environmental degradation and climate change, accordingly, the countries of the MENA region are called upon to significantly increase the use of renewable energies and to develop the establishment of a more efficient energy policy. Solar energy is among the most important renewable energy resources available in the MENA region, as it

possesses the largest desert in the world, which makes it have sunlight throughout the whole year.

However, several aspects to study remain on the research agenda, such as what is the effect that the financial deepening or capital flows of this region of the MENA have on CO_2 emissions, since as (Frankel, Romer, 1999) argue, that financial deepening and development can attract foreign direct investment and increased investment in research and development, which accelerates the economic growth of economies and affects the dynamics of environmental performance.

References

Alkhathlan, K., Javid, M. (2013). Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. *Energy Policy*, *62*, 1525–1532. DOI: 10.1016/j.enpol.2013.07.068.

Al-Mulali, U., Saboori, B., Ozturk, I. (2015). Investigating the environmental Kuznets curve hypothesis in Vietnam. *Energy Policy*, *76*, 123–131. DOI: https://doi.org/10.1016/j.enpol.2014.11.019.

Ang, J. (2007b). CO_2 emissions, energy consumption, and output in France. *Energy Policy*, *35* (10), 4772–4778. October.

Apergis, N., Payne, J. (2009). CO_2 emissions, energy usage, and output in Central America. *Energy Policy*, *37* (8), 3282–3286. DOI: http://doi.org/10.1016/j.enpol.2009.03.048.

Arifur, R., Woahid, S.M., Ahmed, F., Wang, X . (2020). Evaluating the EKC Hypothesis for the BCIM-EC Member Countries under the Belt and Road Initiative. *Sustainability*, *12* (4), 1478. DOI: 10.3390/su12041478.

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices, and economic growth: time series evidence from Asian developing countries. *Energy Econ.*, *22*, 615–625.

Bhat, J. (2018). Renewable and non-renewable energy consumption – impact on economic growth and CO_2 emissions in five emerging market economies. *Environ Sci Pollut Res*, *25* (35), 35515–35530. DOI: 10.1007/s11356-018-3523-8.

Breitung, J. (2000). The local power of some unit root tests for panel data. *Advances in Econometrics*, *15*, 161–177. DOI: https://doi.org/10.1016/S0731-9053(00)15006-6.

Chng, Z. (2019). Environmental Degradation and Economics Growth: Testing the Environmental Kuznets Curve Hypothesis (EKC) in Six ASEAN Countries. *Journal of Undergraduate Research at Minnesota State University, Mankato*, *19* (1).

Cihan, Ö., Emrah, B. (2021). Environmental Kuznets Curve (EKC) in Australia: Evidence from Nonlinear ARDL Model with a Structural Break. *Pol. J. Environ. Stud*., *30* (3), 2245–2254. DOI: https://doi.org/10.15244/pjoes/127555.

Cüneyt, K., Feyza, B. (2018). Is There an Environmental Kuznets Inverted-U Shaped Curve? *PANOECONOMICUS*, *65* (1), 79–94. DOI: http://dx.doi.org/10.2298/PAN150215006K.

Engle, R., Granger, C. (1987). Co-integration and Error-Correction: Representation, estimation and testing. *Econometrica*, *55* (2). 251–276. DOI: https://doi.org/10.2307/1913236.

Entorf, H. (1997). Random walks with drifts: Nonsense regression and spurious fixed-effect estimation. *Journal of Econometrics*, *80* (2), 287–296. DOI: https://doi.org/10.1016/S0304-4076(97)00041-9.

Frankel, J.A., Romer, D.H. (1999). Does trade cause growth? *American Economic Review*, *89* (3), 379–399. DOI: 10.1257/aer.89.3.379.

Gessesse, A.T., He, G. (2020). Analysis of carbon dioxide emissions, energy consumption, and economic growth in China. *Agric. Econ. – Czech*, *66*, 183–192.

Ghali, K.H., El-Sakka, M. (2004). Energy use and output growth in Canada: a multivariate cointegration analysis. *Energy Economics*, *26* (2), 225–238. DOI: 10.1016/S0140-9883(03)00056-2.

Halicioglu, F. (2009). An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey. *Energy Policy*, *37* (3), 1156–1164. DOI: https://doi.org/10.1016/j.enpol.2008.11.012.

Im, K., Pesaran, M., Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115* (1), 53–74. DOI: https://doi.org/10.1016/S0304-4076(03)00092-7.

Işık, C., Ongan, S., Özdemir, D. (2019). Testing the EKC hypothesis for ten US states: an application of heterogeneous panel estimation method. *Environmental Science and Pollution Research*, *26* (11), 10846–10853. DOI: 10.1007/s11356-019-04514-6.

Jalil, A., Feridun, M. (2011). The impact of growth, energy and financial development on the environment in China: a cointegration analysis. *Energy Econ.*, *33* (2), 284–291. DOI: https://doi.org/10.1016/j.eneco.2010.10.003.

Kao, C. (1999). Spurious regression and residual-based test for cointegration in panel data. *Journal of Econometrics*, *90* (1), 1–44. DOI: https://doi.org/10.1016/S0304-4076(98)00023-2.

Lau, L., Tan, K., Lee, K., Mohamed, A. (2009). A comparative study on the energy policies in Japan and Malaysia in fulfilling their nations' obligations towards the Kyoto Protocol. *Energy Policy*, *37* (11), 4771–4778.

Levin, A., Lin, C., Chu, J. (2002). Unit root in panel data: Asymptotic and finite simple Properties. *Journal of Econometrics*, *108* (1), 1–24. DOI: https://doi.org/10.1016/S0304-4076(01)00098-7.

Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22* (1), 3–42. DOI: https://doi.org/10.1016/0304-3932(88)90168-7.

Maddala, G., Wu, S. (1999). A comparative study of unit root test with panel data and a new simple test. *Oxford Bulletin of Economics y Statistics*, *61*(1), 631–652. DOI: https://doi.org/10.1111/1468-0084.0610s1631.

Muhammad, K.K., Khan, M.I., Rehan, M. (2020). The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan. *Financial Innovation*, *6*, 1. DOI: https://doi.org/10.1186/s40854-019-0162-0.

Osabuohien, E., Efobi, U., Gitau, C. (2014). Beyond the environmental Kuznets curve in Africa: evidence from panel cointegration. *J. Environ. Policy Plan*, *16*, 517–538.

Panayotou, T. (1993). Empirical tests and policy analysis of environmental degradation at different stages of economic development. Working Paper WP238, Technology and Employment Programme. International Labour Office, Geneva.

Pao, H., Tsai, C. (2011). Multivariate Granger causality between CO_2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product): Evidence from a panel of BRIC (Brazil, Russian Federation, India, and China) countries. *Energy*, *36* (1), 685–693. DOI: https://doi.org/10.1016/j.energy.2010.09.041.

Pao, H., Tsai, C. (2010). CO_2 emissions, energy consumption and economic growth in BRIC countries. *Energy Policy*, *38* (12), 7850–7860. DOI: https://doi.org/10.1016/j.enpol.2010.08.045.

Pedroni, P. (2000). Fully modified OLS for heterogeneous cointegrated panels. DOI: https://doi.org/10.1016/S0731-9053(00)15004-2.

Pedroni, P. (1999). Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors. *Oxford Bulletin of Economics and Statistics*, *61* (1), 653–670. DOI: https://doi.org/10.1111/1468-0084.0610s1653.

Pedroni, P. (2004). Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the Ppp Hypothesis. *Econometric Theory*, *20*, 597–625. DOI: https://doi.org/10.1017/S0266466604203073.

Phillips, P.C.B., Ouliaris, S. (1990). Asymptotic Properties of Residual Based Test for Cointegration. *Econometrica*, *58* (1), 165–193. DOI: https://doi.org/10.2307/2938339.

Phillips, P.C.B., Moon, H. (1999). Linear regression limits theory for nonstationary panel data. *Econometrica*, *67* (5), 1057–1111. Retrieved from: https://www.jstor.org/stable/2999513.

Plassmann, F., Khanna, K. (2006). Household income and pollution implications for the de bate about the environmental Kuznets curve hypothesis. *J. Environ. Dev.*, *15* (1), 22–41. DOI: https://doi.org/10.1177/1070496505285466.

Raggad, B. (2018). Carbon dioxide emissions, economic growth, energy use, and urbanisation in Saudi Arabia: evidence from the ARDL approach and impulse saturation break tests. *Environ Sci Pollut Res*, *25* (15), 14882–14898. DOI: 10.1007/s11356-018-1698-7.

Romer, P. (1986). Increasing returns and long-run growth. *Journal of Political Economy*, *94* (5), 1002–1037.

Shahbaz, M., Khraief, N., Uddin, G., Ozturk, I. (2014). Environmental Kuznets curve in anopen economy: a bounds testing and causality analysis for Tunisia. *Renew. Sustain. Energy Rev.*, *34* (C), 325–336. DOI: 10.1016/j.rser.2014.03.022.

Solow, R.M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, *70* (1), 65–94. DOI: https://doi.org/10.2307/1884513.

Sotyas, U., Sari, R. (2009). Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member. *Ecological Economics*, *68*, 1667–1675.

Soytas, U., Sari, R., Ewing, T. (2007). Energy consumption, income and carbon emissions in the United States. *Ecological Economics*, *62* (3), 482–489. DOI: https://doi.org/10.1016/j.ecolecon.2006.07.009.

Stern, D. (2000). A multivariate cointegration analysis of the role of energy in the US macroeconomy. *Energy Economics*, *22* (2), 267–283. DOI: https://doi.org/10.1016/S0140-9883(99)00028-6.

Wang, S.S, Zhou, P., Wang, W. (2011). CO_2 emissions, energy consumption and economic growth in China: a panel data analysis. *Energy Policy*, *39*, 4870–4875.

World Development Indicators (*WDI*, 2017). Retrieved from: http://databank.worldbank.org/data/reports.aspx?source=worlddevelopment-indicators.

Yang, H. (2000). A note on the causal relationship between energy and GDP in Taiwan. *Energy Econ.*, *22* (3), 309–317. DOI: https://doi.org/10.1016/S0140-9883(99)00044-4.

Zhang, J. (2021). Environmental Kuznets Curve Hypothesis on CO– Emissions: Evidence for China. *Journal of Risk and Financial Management*, *14*, 93. DOI: https://doi.org/10.3390/jrfm14030093.

Citation

Touitou, M. (2021). The relationship between Economic Growth, Energy Consumption and CO_2 Emission in the Middle East and North Africa (MENA). *Folia Oeconomica Stetinensia*, *21* (2), 132–147. DOI: 10.2478/foli-2021-0020.