Energy Reports 5 (2019) 1281–1292

Contents lists available at ScienceDirect

Energy Reports

journal homepage: www.elsevier.com/locate/egyr

Research paper

Investigation of energy consumption–Economic growth nexus: A note on MENA sample[☆]

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ARTICLE INFO

Article history:
Received 5 June 2019
Received in revised form 18 August 2019
Accepted 20 August 2019
Available online 13 September 2019

1. Introduction

Energy has gained importance in industrial sector and lately increased its effect on economic growth. The relationship between energy consumption and economic growth has been proven to be highly notable in the determination of energy and economic policies (Pirlogea and Cicea, 2012). Thus, the energy consumption–growth relationship has been discussed intensely in the existing energy literature but provides inconclusive empirical evidence (Shahbaz et al., 2018). It indicates that the causal relationship between energy consumption and economic growth is a considerably complex phenomenon. The relationship between the variables may lead to various probabilities from unilateral or bilateral to neutral causality (Dagher and Yacoubian, 2012). Several hypotheses have been proposed for explaining these probabilities. We can sort these hypotheses into four subtitles as growth, feedback, conservation and neutrality (Hassan et al., 2017). For instance, growth hypothesis reveals that energy appears in every phase of production and plays an active role in economic progress. Thus, a possible non-transitory increase in economic growth will potentially lead to a continuous increase in energy consumption (Ghosh, 2002). Any protective policy implementation for decreasing energy consumption will affect economic growth (Liu, 2018).

Neutrality hypothesis assumes that there is no relationship between energy consumption and economic growth (Chen et al., 2007). This hypothesis regards energy consumption as a small component of economic growth. Thus, energy consumption has very little or no effect on economic growth. So, neither conservative nor expansionary policies towards energy consumption will have effects on economic growth (Omri, 2014). Feedback hypothesis has revealed the presence of a bilateral causal relationship between economic growth and energy consumption (Squalli, 2007). In other words, in feedback hypothesis energy consumption and economic growth affect each other (Al-mulali et al., 2013).

As MENA countries own abundant natural resources, these countries have a great opportunity to reach fast economic growth rates. However, when the economic growth performances of MENA countries are examined, no satisfactory growth performance is observed in parallel with their natural resources abundance and the level of energy consumption. It is a fact that the degree of energy consumption is highly related to the degree of economic growth (Farhani and Ben Rejeb, 2012). So, it is crucial to understand the direction of the relationship between energy consumption and economic growth in determining the wise energy polices of MENA countries which has the most important oil and natural resources in the world. To the best of our knowledge, there are limited researches in the literature on energy consumption–economic growth nexus for MENA countries.

In his study, Al-mulali (2011) investigated the causality nexus between oil consumption, CO_2 emissions and economic growth in MENA countries over the period 1980–2009 by using panel model. The cointegration test results showed that oil consumption has a significant positive effect on the economic growth of the MENA countries and oil consumption has a long run relationship with economic growth. The researcher also found that there

☆ This article is an extended version of the paper presented in ENSCON (International Congress of Energy, Economy and Security) held in Istanbul between 10-11 November 2018.

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https://doi.org/10.1016/j.egyr.2019.08.034

is bidirectional Granger causality between oil consumption and economic growth in both the short term and the long term. In a similar study, Omri (2013) examined the relationship between CO_2 emissions, energy consumption and economic growth of 14 MENA countries for the period 1990–2011 by applying simultaneous equations models. Empirical results revealed that there is a bidirectional causal relationship between energy consumption and economic growth that is known as the feedback hypothesis. Another bidirectional causality nexus was found by Saidi et al. (2018). The researchers investigated the relationship between energy consumption, information technology and communication, foreign direct investment and economic growth using panel data of 13 MENA countries for the period 1990–2012. The test results indicated that there is bidirectional relationship between energy consumption and economic growth

Muhammad (2019) also examined energy consumption, CO_2 emissions and economic growth relationship in 68 countries over the period 2001–2017 by applying seemingly unrelated regression (SUR), and dynamic models estimated through the generalized method of moments (GMM). Among these countries, there were developed, emerging and MENA countries as well. The researcher indicated that as energy consumption increases, economic growth rate increases in developed and developing countries. Contrary, in the MENA countries, energy consumption has a negative and significant effect on the economic growth which indicates that increases in energy consumption decreased the economic growth.

Gorus and Aydin (2019) investigated the causal relationship between energy consumption, economic growth, and CO_2 emission for eight-oil rich MENA countries (Algeria, Egypt, Iran, Oman, Saudi Arabia, Tunisia, and UAE) over the period 1975–2014 by using Granger causality analysis. The researchers concluded that there is causal nexus between energy consumption and economic growth for the selected countries. In the short term, there is a unidirectional causality running from economic growth to energy consumption which confirms the conservations hypothesis in Algeria, Iran, Tunisia, and UAE. There is bidirectional relationship which supports the feedback hypothesis in Saudi Arabia. Besides, in the intermediate run, the authors found a one way causality relationship from economic growth to energy consumption in Iran, Saudi Arabia, Tunisia and UAE.

From this point of view, this paper aims to determine the direction and level of the energy consumption–economic growth relationship to put forth alternative policy suggestions for having a better economic growth performance for these countries. In other words, the empirical investigation of energy consumption–economic growth relationship will guide policy makers to design economic and energy policies to utilize rich energy resources for sustainable economic development. Thus, we used the annual data of 8 MENA countries, namely Algeria, Saudi Arabia, Iraq, Iran, Egypt, Jordan, Lebanon, Tunisia, for the 1990–2014 periods for examining the potential presence of any bilateral relationship between the energy consumption and economic growth variables. The reason behind the preference of 1990–2014 periods for the empirical analysis is that the reliable data could be just found for that period. Actually, the selected period includes the most recent data published by the World Bank. There is no more updated data for the selected group of countries.

In the economic literature, Panel Data Analysis proposes three approaches to analyze causality in a given period of time (Kar et al., 2011). The first approach consists of estimating a panel vector error correction model (VECM) through the generalized method of moments (GM) estimator which estimates a panel model by eliminating fixed effects. However, this approach cannot explain either heterogeneity or cross-sectional dependence (Şen et al., 2015). The second approach proposed by Hurlin (2008) is based on the fixed effects panel data approach. Although this approach explains slope heterogeneity, it does not take into account horizontal cross-sectional dependence. Thus, significant deviations and size distortion can occur in this dataset (Dumitrescu and Hurlin, 2012). Finally, the approach proposed by Kónya (2006) allows us to examine both heterogeneity and horizontal cross-sectional dependence. Due to this advantage, Bootstrap Panel Granger Causality Analysis developed by Kónya (2006) was used for the test. Panel data analysis was used to test the presence and direction of causal relationship between energy consumption and economic growth in multiple country groups.

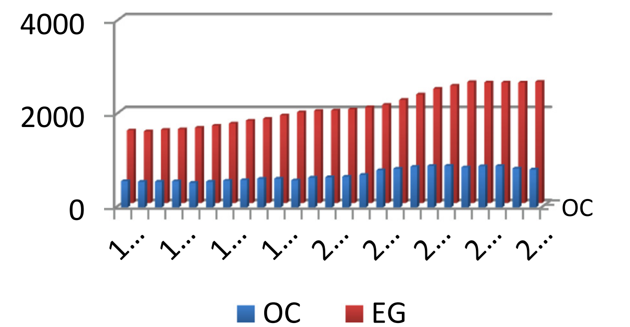

Fig. 1. Egypt's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

2. Energy consumption and economic growth in MENA countries

The MENA region includes Algeria, Egypt, Bahrain, Comoros, Israel, Lebanon, Djibouti, Libya, Iran, Iraq, Jordan, Kuwait, Oman, Mauritania, Qatar, Morocco, Palestine, Saudi Arabia, Sudan, Tunisia, Somalia, Syria, Yemen and United Arab Emirates. The MENA region has a homogeneous formation. The densely populated countries with no natural resources are classified in the lower-middle income group; those with wide workforce and rich natural resources are in the upper-middle income group whereas the energy-rich and labor-importing members of the Gulf Cooperation Council (GCC) are in the high-income group. The MENA region is known for rent-seeking relationships and authoritarian regimes. This region suffers from social tensions stemming from periodical inflation, unemployment and some other chronic problems in the medium-income countries and the inhibitions of organizations and freedom of expression in the high-income countries (Gök et al., 2018).

Figs. 1 to 8 shows the level of oil consumption and economic growth for the 1990–2014 period in case of Egypt, Jordan, Lebanon, Tunisia, Algeria, Iranian, Iraq and Saudi Arabia.

Table 1 shows economic growth of MENA countries for the period of 2010–2017. Based on Table 1, it is indicated that MENA countries have showed no joint progresses and there are perpetual fluctuations in economic growth. None of the countries shows consistent economic growth rates.

Due to the broadness of the region and rich oil reserves, the MENA countries suffer from several challenges. These challenges can be summarized as follows (Saidi and Yared, 2003):

First of all, since 1990's, the growth rates of the countries have slowed down considerably due to the stagnation of per capita incomes and high population growth rates. Secondly, the growth which is due to rather factor accumulation than factor productivity reflects technological advancements very slightly. Thirdly, a remarkable digital discrimination appears in media, information and communication technologies. Furthermore, water

Table 1
MENA countries' economic growth rates (2010–2017).
Source: World Bank, Retrieved on 14 November 2018.

Country	2010	2011	2012	2013	2014	2015	2016	2017
Egypt	5.1	1.7	2.2	2.1	2.9	4.3	4.3	4.1
Jordan	2.3	2.5	2.6	2.8	3.09	2.3	2	1.9
Lebanon	8.03	0.91	2.8	2.63	2	0.81	2	2.02
Morocco	3.81	5.24	3	4.53	2.66	4.54	1.22	4.1
Tunisia	3.51	−1.91	3.9	2.8	2.9	1.15	1.1	1.95
Algeria	3.6	2.8	3.3	2.7	3.7	3.7	3.3	1.7
Iran	5.7	2.6	−7.4	−0.19	4.6	−1.32	13.3	4.3
Yemen	7.7	−12.7	2.3	4.8	−0.18	−37.14	−34.3	–
Iraq	6.4	7.5	13.9	7.6	0.7	4.8	11	−0.78
Saudi Arabia	5	9.9	5.4	2.6	3.6	4.1	1.6	−0.73
Oman	4.8	−1.1	9.3	4.3	2.7	4.7	5.3	−0.27
UAE	1.6	6.9	4.4	5	4.3	5	2.9	0.79
Bahrain	4.3	1.9	3.7	5.4	4.3	2.8	3.2	3.8
World	4.3	3.1	2.5	2.6	2.8	2.8	2.5	3.1

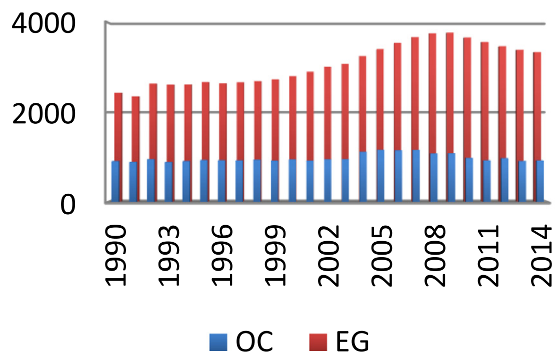

Fig. 2. Jordan's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

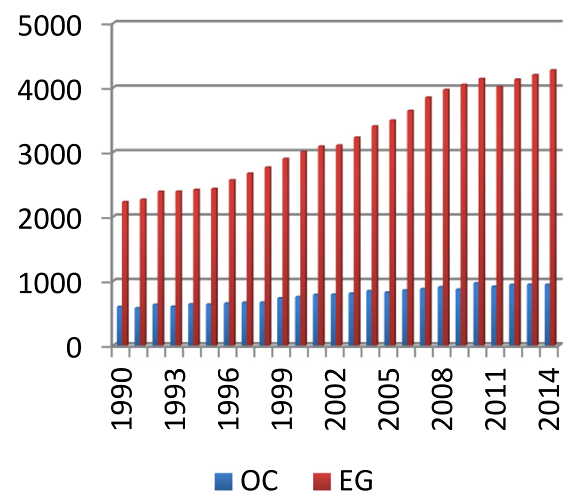

Fig. 4. Tunisia's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

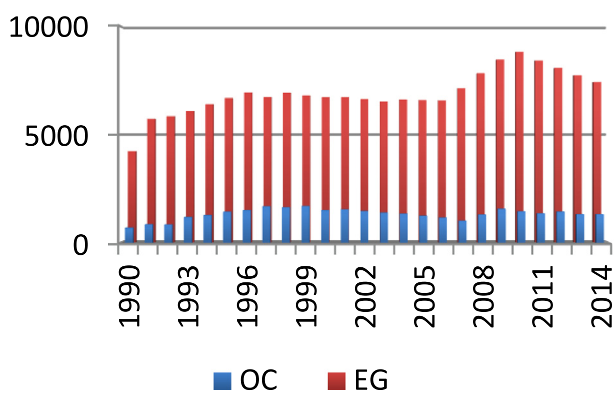

Fig. 3. Lebanon's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

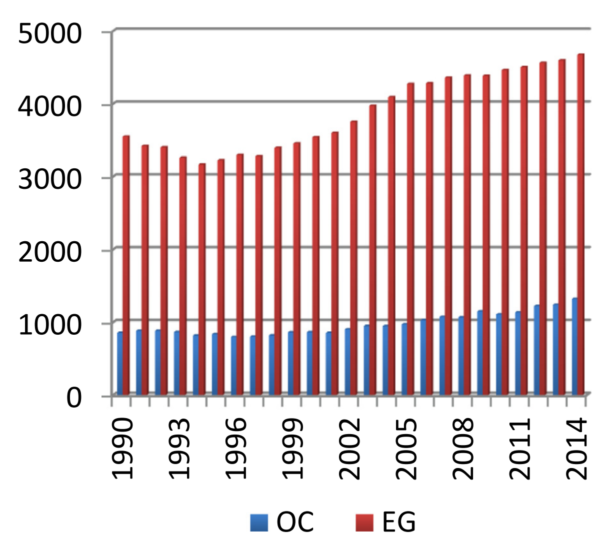

Fig. 5. Algeria's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

shortage and the conflicts over water rights increase water and environmental problems. Besides, MENA region is dependent on the exportation of natural resources and is very fragile against energy price shocks. And also, public sector still plays a dominant role in economic activities despite the initiation of privatization and reforms. And finally, high political and security problems, which are due to the Arab-Israeli conflicts, lead to investment risks. The MENA countries fail to make good use of their oil reserves as a result of the problems above. Thus, we can state that there are no sustainable increases in the economic growth rates of these countries.

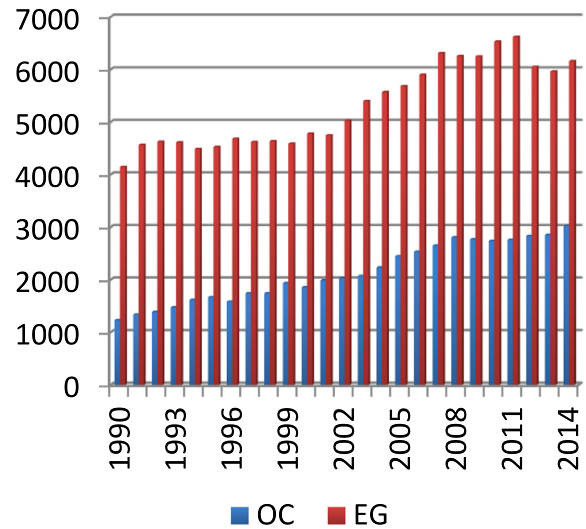

Fig. 6. Iran's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

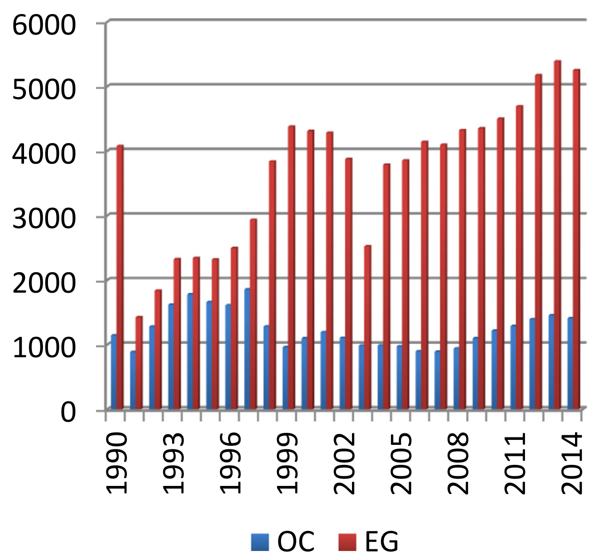

Fig. 7. Iraq's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

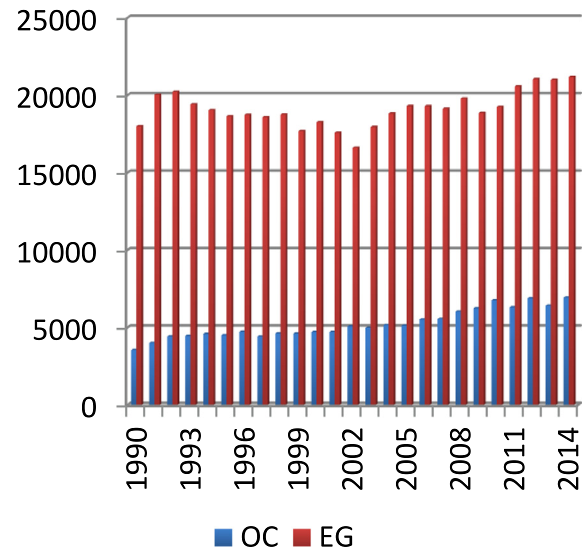

Fig. 8. S. Arabia's Oil–Growth relationship. *OC: oil consumption per capita (kg). EG: GDP per capita (constant 2010 US$).
Source: World Bank; Retrieved on 3 October 2018.

3. Literature review

There are numerous studies on the relationship between energy consumption and economic growth providing ambiguous empirical results. Table 2 shows the previous studies examining relationship between energy consumption by various researches within growth, feedback, conservation and neutrality hypotheses.

The studies verifying a unilateral causality running from energy consumption to economic growth are in Table 2 as follows: Oh and Lee (2004), Shiu and Lam (2004), Lee (2005), Narayan and Singh (2007), Yuan et al. (2007) and Ummalla and Samal (2018) for the short run; Lee and Chang (2008), Apergis and Payne (2009), Abosedra et al. (2009), Odhiambo (2009), Ciarreta and Zarraga (2010), Adom (2011), Pirlogea and Cicea (2012), Ouedraogo (2013) and Aslan (2013) for Portugal and Iceland, Araç and Hasanov (2014), Uçan et al. (2014), Abosedra et al. (2014) and Mudarissov and Lee (2014) in the long run, Alshehry and Belloumi (2015), Paramati et al. (2017), Bhat (2018), and Nasreen et al. (2018).

The causality runs from economic growth to energy consumption is confirmed by Yang (2000) and Yoo (2006) for Indonesia and Thailand, Mehrara (2007), Mozumder and Marathe (2007), Zhang and Cheng (2009), Acaravcı (2010), Shaari et al. (2013) and Ouedraogo (2013) for the short run, Öcal and Aslan (2013), Aslan (2013) and Cowan et al. (2014) for South Africa, Mudarissov and Lee (2014) in the short run, Mutascu (2016) for France and Germany, and Bakırtaş and Çetin (2016) and Zortuk and Karacan (2018) for Georgia, Slovak Republic and Slovenia.

Some of the researches that reported no causal relationship between energy consumption and growth are as follows: Chen (1997) and Lee and Chang (2008) for the short run, Ozturk and Acaravcı (2011), Yalta (2011) and Cowan et al. (2014) for Brazil, China and India, Shahateet (2014) and Soares et al. (2014) for Indonesia and Mutascu (2016) for Italy and UK, Zortuk and Karacan (2018) for Caucasian countries and some of the Eastern and Central Europe countries.

The studies found feedback hypothesis i.e. bilateral causality between energy consumption and economic growth are reported by Paul and Bhattacharya (2004) and Oh and Lee (2004) for the long run, Yoo (2006) for Malaysia and Singapore, Apergis and Payne (2010), Ouédraogo (2010), Al-mulali (2011), Wang et al. (2011), Al-mulali and Che Sab (2012), Gross (2012), Dagher and Yacoubian (2012), Fuinhas and Marques (2012), Omri (2013), Shafiei et al. (2013), Tang and Tan (2013) and Cowan et al. (2014) for Russia, Nasreen and Anwar (2014), Omay et al. (2014), Rezitis and Ahammad (2015), Siddique and Majeed (2015), Osigwe and Arawomo (2015) and Mutascu (2016) for Canada, Japan and USA, Mirza and Kanwal (2017) and Zaidi et al. (2017) for Tunisia and Egypt, Ummalla and Samal (2018) for the long run, Nasreen et al. (2018) for medium- and high-income countries, Ballı et al. (2018) and Zortuk and Karacan (2018) for Armenia, and Rathnayaka et al. (2018) for China.

4. The data and estimation strategy

4.1. The data

This paper investigates the relationship between energy consumption and economic growth for 8 countries i.e. Egypt, Jordan,

Table 2
Researches on the energy consumption–economic growth nexus.
Source: Created by the authors. FH: Feedback hypothesis; CH: Conservation hypothesis; NH: Neutrality hypothesis; GH: Growth hypothesis; LR: Long run; SR: Short run.

Author (Date)	Period (Country-ies)	Variables	Method	Conclusion*
Chen (1997)	Brazil, Mexico and Venezuela	Energy consumption and economic growth	Granger causality test	NH
Yang (2000)	1954–1997 Taiwan	Coal consumption, economic growth	Cointegration analysis & Granger causality test	CH
Oh and Lee (2004)	1970–1999 Korea	Real GDP, energy consumption, labor, capital	Granger causality test	LR: FH SR: GH
Paul and Bhattacharya (2004)	1950–1996 India	Energy consumption, economic growth	Engle–Granger cointegration approach	FH
Shiu and Lam (2004)	1971–2000 PRC	Power consumption, real GDP	Johansen cointegration and error correction model	GH
Lee (2005)	1975–2001 18 developing countries	GDP, energy consumption, capital formation	Cointegration analysis	GH
Yoo (2006)	1971–2002 ASEAN county	Power consumption, economic growth	Granger causality test	Malaysia, Singapore: FH Indonesia, Thailand: CH
Mehrara (2007)	1971–2002 11 petroleum exporting countries	Real GDP, energy consumption	Panel cointegration analysis	CH
Mozumder and Marathe (2007)	1971–1999 Bangladesh	Power consumption, real GDP	Johansen cointegration test	CH
Narayan and Singh (2007)	1971–2002 Fiji	Real GDP, power consumption, workforce	Granger causality test	GH
Yuan et al. (2007)	1978–2004 PRC	Power consumption, real GDP	Cointegration analysis	GH
Lee and Chang (2008)	1971–2002 16 Asian countries	Energy consumption, real GDP	Panel cointegration analysis & error correction model	SR: NH LR: GH
Apergis and Payne (2009)	1980–2004 6 central American countries	Energy consumption, real GDP, workforce, gross fixed capital formation	Panel cointegration & error correction model	GH
Abosedra et al. (2009)	1995–2005 Lebanon	Power consumption, economic growth	Granger causality test	GH
Odhiambo (2009)	1971–2006 Tanzania	Power consumption, economic growth, energy consumption	ARDL bounds testing	GH
Zhang and Cheng (2009)	1960–2007 PRC	Real GDP, capital formation, energy consumption, carbon dioxide emission, urban population	Granger causality test	CH
Apergis and Payne (2010)	1985–2005 20 OECD countries	GDP, renewable energy consumption, gross fixed capital, workforce	Granger causality test	FH
Ciarreta and Zarraga (2010)	1970–2007 12 European countries	Energy consumption, real GDP, energy prices	Panel causality tests	GH
Ouédraogo (2010)	1968–2003 Burkina Faso	GDP, capital formation, power consumption	Cointegration analysis	FH
Acaravcı (2010)	1977–2006	Electricity consumption and GDP	Granger causality test	GH
Adom (2011)	1971–2008 Ghana	Power consumption, economic growth	Toda–Yomamoto Granger causality test	GH
Al-mulali (2011)	1980–2009 MENA	CO_2 emission, oil consumption, economic growth	Cointegration test	FH
Ozturk and Acaravcı (2011)	1971–2006 11 MENA countries	Power consumption, real GDP	Granger causality test	NH
Yalta (2011)	1950–2006 Turkey	Real GDP, energy consumption	Cointegration test	NH
Wang et al. (2011)	1995–2007 PRC	CO_2 emission, energy consumption, RGSYİH	Panel cointegration, VECM	FH
Al-mulali and Che Sab (2012)	1980–2008 30 Sub-Saharan African countries	Energy consumption, CO_2 emission, real GDP	Panel cointegration, Granger causality test	FH
Dagher and Yacoubian (2012)	1980–2009 Lebanon	Energy consumption, economic growth	Hsiao, Toda-Yamamoto & Granger causality tests	FH
Fuinhas and Marques (2012)	1965–2009 Portugal, Italy, Greece, Spain, Turkey	Energy consumption, economic growth	ARDL bounds testing	FH

(*continued on next page*)

Table 2 (*continued*).

Author (Date)	Period (Country-ies)	Variables	Method	Conclusion*
Gross (2012)	1970–2007 USA	Energy consumption, sectorial value added, import penetration rate, stock of fixed capital	VECM, ARDL bounds testing	FH
Pirlogea and Cicea (2012)	1990–2010 EU	Energy consumption, economic growth	Granger causality test	GH
Omri (2013)	1990–2011 MENA	CO_2 emission, energy consumption, GDP	GMM	FH
Ouedraogo (2013)	1980–2008 15 ECOWAS	Energy consumption, power consumption, energy prices, GDP	Granger causality test	SR: CH LR: GH
Öcal and Aslan (2013)	1990–2010 Turkey	GDP, workforce, gross fixed capital formation, renewable energy sources	Toda-Yamamoto causality test	CH
Shaari et al. (2013)	1980–2010 Malaysia	GDP power consumption, crude oil consumption, gas consumption, coal consumption	Johansen cointegration test	CH
Shafiei et al. (2013)	1980–2011 OECD	Energy consumption, economic growth	Panel Granger causality test	FH
Shahbaz et al. (2013)	1975–2011 Indonesia	Energy consumption, economic growth, financial development, international commerce, CO_2 emission	VECM Granger causality test	FH
Tang and Tan (2013)	1970–2009 Malaysia	Power consumption., energy prices, technological innovation, growth	VAR, Granger causality test	FH
Chang et al. (2013)	1970–2010 12 Asian countries	Energy consumption and economic growth	Granger causality test	India:GH Philippines:CH Thailand and Vietnam:FH
Aslan (2013)	1960–2005 OECD countries	Energy consumption and economic growth	Panel cointegration test	Iceland and Portugal: CH other countries: GH
Abosedra et al. (2014)	2000–2010 Lebanon	Financial development, energy consumption, economic growth	VECM Granger causality test	GH
Araç and Hasanov (2014)	1960–2010 Turkey	Economic growth, energy consumption	VAR analysis	GH
Cowan et al. (2014)	1990–2010 BRICS	Power consumption, CO_2 emission, economic growth	Panel causality analysis	Russia-FH S. Africa-CH Brazil, PRC, India-NH
Nasreen and Anwar (2014)	1980–2011 15 Asian countries	Economic growth, trade openness, energy consumption	Panel Granger causality test	FH
Omay et al. (2014)	1977–2007 G7	Energy consumption, GDP	Cointegration, Granger causality test	FH
Shahateet (2014)	1980–2011 17 Arab countries	Energy consumption, real economic growth	Granger causality test	NH
Uçan et al. (2014)	1990–2011 15 EU member countries	Real GDP, renewable/nonrenewable energy consumption, greenhouse gas emission	Granger causality test	GH
Soares et al. (2014)	1971–2010 Indonesia	Energy consumption, economic growth	Granger causality test	NH
Mudarissov and Lee (2014)	1990–2008 Kazakhstan	Energy consumption and economic growth	Granger causality test	CH: Long run; GH: Short run
Alshehry and Belloumi (2015)	1971–2010 Saudi Arabia	Energy consumption, energy prices, CO_2 emission, economic growth	Johansen multivariate approach	GH
Rezitis and Ahammad (2015)	1990–2012 9 South-Southeastern Asian countries	Energy consumption, economic growth	Panel Granger causality test	FH
Siddique and Majeed (2015)	1980–2010 5 South Asian countries	Financial development, energy, trade, economic growth	Panel cointegration test	FH

(*continued on next page*)

Lebanon, Tunisia, Algeria, Iran, Iraq and Saudi Arabia in the MENA region. We use oil consumption per capita (kg) as measure of energy consumption. Economic growth is measured by real GDP per capita (constant 2010 US$). Energy consumption and economic growth data used in the analysis were taken from the World Bank (2018a,b) database. The data for both variables is taken from

Table 2 (*continued*).

Author (Date)	Period (Country-ies)	Variables	Method	Conclusion*
Osigwe and Arawomo (2015)	1970–2012 Nigeria	Oil prices, energy consumption, economic growth	Granger causality test	FH
Meng and Niu (2015)	1993–2007 PRC	Energy consumption and economic growth	Partial least squares method	GH
Bakırtaş and Çetin (2016)	1992–2010 G20 countries	Real GDP, renewable energy consumption	Cointegration	CH
Mutascu (2016)	1970–2012 G7 countries	Energy consumption, economic growth	Bootstrap panel Granger causality test	Canada, Japan, USA: FH France, Germany: CH Italy, UK: NH
Arora and Shi (2016)	1973Q1–2014Q1 USA	Energy consumption and economic growth	Granger causality test	FH
Mirza and Kanwal (2017)	1971–2009 Pakistan	Energy consumption, CO_2 emission, economic growth	Dynamic causality analysis	FH
Paramati et al. (2017)	1990–2012 11 developing countries	Renewable energy consumption, economic growth, CO_2 emission	Panel cointegration test	GH
Zaidi et al. (2017)	1980–2011 selected African countries	Energy consumption, economic development	Modified OLS	Tunisia and Egypt: FH; Other countries: CH
Ballı et al. (2018)	1992–2013 CIS	Real GDP energy consumption, capital sum, workforce	Panel data analysis	FH
Bhat (2018)	1992–2016 BRICS	Renewable/nonrenewable energy consumption, economic growth, CO_2 emission	Panel cointegration test	GH
Nasreen et al. (2018)	1990–2016 63 developing countries	Economic growth, shipment, energy consumption	GMM	High income-middle income: FH Low income: GH
Ummalla and Samal (2018)	1965–2016 PRC	Economic growth, CO_2 emission, hydroelectric energy consumption	ARDL bounds test approach	SR:GH LR: FH
Rathnayaka et al. (2018)	1980–2013 PRC	Energy consumption and economic growth	Johansen cointegration with vector error correction model (VECM)	FH
Zortuk and Karacan (2018)	1990–2011 Central and Eastern Europe and Caucasian region	Energy consumption and economic growth	Granger causality test	Armenia: FH; Georgia, Slovak Republic and Slovenia:GH Other Countries:NH
Saidi et al. (2018)	1990–2012 13 MENA countries	Energy consumption, ICT, FDI, and economic growth		FH
Muhammad (2019)	2001–2017 68 Developed, developing and MENA countries	Energy consumption, CO_2 emissions and economic growth	SUR, GMM, Sys GMM	Developed and emerging countries: CH
Gorus and Aydin (2019)	1975–2014 8 Oil-rich MENA countries	Energy consumption, CO_2 emissions and economic growth	Granger Causality test	Short and middle run: CH

world development indicators (CD-ROM, 2018). Since the data is defined as energy consumption (oil consumption per capita), in the database per capita oil consumption is used to represent energy consumption data. As a great part of the world's energy needs is provided by fossil fuels, oil consumption is taken as one of the variables and the relationship between oil consumption and economic growth is included in many academic studies. In the literature, like many other researchers, Mehrara (2007), Ozturk et al. (2010) and Chontanawat et al. (2008) used those two variables for their analysis on energy consumption and economic growth nexus. Similarly, we preferred those two variables for our study. Besides, by using those two variables, it was aimed to focus on specifically on them and make a more detail research on the effects of those two variables.

4.2. Econometric methods

In the economic literature, Panel Data Analysis proposes three approaches to analyze causality in a given period of time (Kar et al., 2011). The first approach consists of estimating a panel vector error correction model (VECM) through the generalized method of moments (GM) estimator which estimates a panel model by eliminating fixed effects. However, this approach cannot explain either heterogeneity or cross-sectional dependency (Şen et al., 2015). The second approach proposed by Hurlin (2008) is based on the fixed effects panel data approach. Although this approach explains slope heterogeneity, it does not take into account horizontal cross-sectional dependence. Thus, significant deviations and size distortion can occur in this dataset (Dumitrescu and Hurlin, 2012). Finally, the approach proposed by Kónya (2006) allows us to examine both heterogeneity and horizontal cross-sectional dependence. Due to this advantage, Bootstrap Panel Granger Causality Analysis developed by Kónya (2006) was used for the test.

So, by applying Panel data analysis we planned to test the presence and direction of causal relationship between energy consumption and economic growth in multiple country groups.

4.2.1. Cross-sectional dependence

There are various tests for detecting the presence of cross-sectional dependence. We choose Breush–Pagan Lagrange Multiplier (LM) Test for examining the presence of cross-sectional dependence in the variables of sampled countries.

In the LM test, the null hypothesis with no cross-sectional dependence is written as H_0: Cov (μit, μjt) = 0. The LM test is based on the sum of coefficients' squares of the correlation between the cross-sectional residuals obtained from least squares estimation. The null hypothesis shows the nonexistence of cross-sectional correlation under fixed N and T $\rightarrow \infty$. The LM test assumes asymptotic chi-square distribution with N(N-1)/2 degree of freedom and asks for the validity of the T>N condition. The Breush–Pagan Lagrange Multiplier (LM) test statistic for testing cross-sectional dependence is calculated for null hypothesis as follows:

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \dot{\hat{\hat{p}}}_{ij}^{2} \tag{1}$$

The LM test is usually proposed for fewer Ns and wider Ts. However, Pesaran (2004) has developed CD_{LM} test for the researches with N $\rightarrow \infty$ and T $\rightarrow \infty$ panels. Pesaran's LM test statistic is calculated as follows:

$$CD_{LM} = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \left(T\hat{\rho}_{ij}^{2} - 1\right) \tag{2}$$

Pesaran (2004) has used the CD test for the detection of cross-sectional dependence if N is greater and T is smaller. The CD test is based on the sum of correlation coefficients between cross sectional residuals. This test statistic is written as follows:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{J=i+1}^{N} \hat{\rho}_{ij} \tag{3}$$

The CD test may become weaker and lead to deviation when population average pair-wise correlations are zero and those of individual average are non-zero. Pesaran et al. (2008) has corrected this deviation by adding mean and variance to the test statistic. The LM statistic with corrected deviation is calculated as follows:

$$LM_{adj} = \sqrt{\frac{2T}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \frac{(T-k)\,\hat{\rho}_{ij}^{2} - u_{Tij}}{\sqrt{v_{Tij}^{2}}} \tag{4}$$

4.2.2. Testing slope homogeneity

The first studies to determine whether or not the slope coefficients in the cointegration equations of the horizontal sections forming the panel are homogeneous started with Swamy (1970). Pesaran and Yamagata (2008) improved Swamy test. The equation used in the test is as follows (Pesaran and Yamagata, 2008):

$$Y_{it} = \alpha + \beta_i X_{it} + \varepsilon_{it} \tag{5}$$

With the general cointegration equation shown in (5), it is tested that whether β_i slope coefficient is different between horizontal sections. The hypotheses of test are as follows (Pesaran and Yamagata, 2008):

H_0: $\beta_i = \beta$ The slope coefficients are homogeneous

H_1: $\beta_i \neq \beta_j$ The slope coefficients are not homogeneous

The standard F test is the most widely used method to test the null hypothesis of slope homogeneity H0: $\beta_i = \beta_j$ for all i against the hypothesis of heterogeneity H1: $\beta_i \neq \beta_j$ for a non-zero fraction of pair-wise slopes for i $\neq$ j. Nevertheless, for this purpose, explanatory variables must be external based and error variances should be covariant. Swamy (1970) developed a slope homogeneity test that explores the distribution of individual slope estimates from the pooled estimator to soften the assumption of covariance in the F test.

Pesaran and Yamagata (2008) emphasize that F-test and the Swamy test will necessitate panel data analysis when T is relatively greater than N. Swamy has developed a slope heterogeneity test for the case when heteroscedasticity is no more a constraint. Swamy's statistic is written as follows (Pesaran and Yamagata, 2008):

$$\tilde{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right)' \frac{X_i' M_\tau X_i}{\hat{\sigma}_i^2} \left(\hat{\beta}_i - \hat{\beta}_{WFE}\right) \tag{6}$$

Pesaran and Yamagata (2008) have promoted the Swamy test and proposed the following standardized distribution statistic in Eq. (6) (Pesaran and Yamagata, 2008).

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}}\right) \tag{7}$$

$\tilde{\Delta}$ test will display standardized asymptotic distribution if $\sqrt{N}$/T $\rightarrow \infty$ under the null hypothesis, (N, T) $\rightarrow \infty$, and error terms are normally distributed. The following version of variance with corrected mean and deviation can be used in case of normally distributed errors (Pesaran and Yamagata, 2008).

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - E\left(\tilde{Z}_{it}\right)}{\sqrt{var\left(\tilde{Z}_{it}\right)}}\right) \tag{8}$$

mean E($\tilde{Z}_{it}$) = k, and var($\tilde{Z}_{it}$) = 2k(T − k − 1)/(T + 1)

4.2.3. Panel causality test

The panel bootstrap causality test is based principally on the seemingly unrelated regression (SUR) model. This method includes Wald testing for sectional critical values in the determination of causal relationship. This method needs no requirement for testing unit root problem and cointegration analysis, which are necessarily conducted just before the causality test. This shows stationarity or non-stationarity of variables is unimportant. The following bivariate SUR model including EG for economic growth and OC for oil consumption contains two equation sets.

$$EG_{1,t} = \alpha_{1,1} + \sum_{l=1}^{p_1} \beta_{1,1,l} EG_{1,t-1} + \sum_{l=1}^{p_1} \delta_{1,1,l} OC_{1,t-1} + \varepsilon_{1,1,t}$$

$$\vdots$$

$$EG_{N,t} = \alpha_{1,N} + \sum_{l=1}^{p_1} \beta_{1,N,l} EG_{N,t-1} + \sum_{l=1}^{p_1} \delta_{1,N,l} OC_{N,t-1} + \varepsilon_{1,N,t}$$

and,

$$OC_{1,t} = \alpha_{2,1} + \sum_{l=1}^{p_2} \beta_{2,1,l} EG_{1,t-1} + \sum_{l=1}^{p_2} \delta_{2,1,l} OC_{1,t-1} + \varepsilon_{2,1,t}$$

$$\vdots$$

$$OC_{N,t} = \alpha_{2,N} + \sum_{l=1}^{p_2} \beta_{2,N,l} EG_{N,t-1} + \sum_{l=1}^{p_2} \delta_{2,N,l} OC_{N,t-1} + \varepsilon_{2,N,t}$$

In the SUR system, the presence of alternative causal relationship is important for testing the unilateral Granger causality for a country. For instance, there is unilateral Granger causality from OC to EG if all $\delta_{1,i}$ are non-zero while all $\beta_{2,l}$ are zero, and vice

Table 3
Cross sectional dependence and slope homogeneity tests.

Cross sectional dependence tests	Statistic	p-Value
LM	3525.085	0.000
CD_{LM}	467.318	0.000
CD	58.207	0.000
LM_{adj}	497.378	0.000
Slope homogeneity tests		
$\tilde{\Delta}$	3.328	0.000
$\tilde{\Delta}_{adj}$	3.353	0.000

Note: * shows the null hypothesis is rejected at 1% level of significance.

versa. There is bilateral causality between OC and EG if $\delta_{1,i}$ and $\beta_{2,i}$ are non-zero. Furthermore, there is no causal relationship if all $\delta_{1,i}$ and $\beta_{2,i}$ are zero (Kónya, 2006).

5. Empirical results

The first step is to test if there is any heterogeneity between countries and any cross-sectional dependence between the series Table 3 shows slope homogeneity results and cross-sectional dependence between the series in the model.

The results in Table 3 show the null hypothesis with no cross sectional dependence is rejected at 1% level of significance. There is cross-sectional dependence in the model and between the variables. According to $\tilde{\Delta}$ ve $\tilde{\Delta}_{adj}$ test results, the null hypothesis that the variables are homogeneous is rejected at 1%, 5% and 10% significance levels. The slope parameter of the variable used in the model is heterogeneous.

Existence of horizontal cross-sectional dependence and rejection of slope homogeneity show that this study is suitable for Bootstrap Panel Granger causality analysis developed by Kónya (2006).

Table 4 illustrates the analysis results of panel Granger causality from energy consumption to economic growth in the MENA countries. Under the null hypothesis that expresses there is no Granger causality from energy consumption to economic growth, the null hypothesis cannot be rejected for Algeria, Iraq and Iran. This statistical result points that there is no causal relationship from energy consumption to economic growth in those countries. In other words, any energy conservation policy implemented by Algeria, Iraq and Iran will have no effect on their economic growth. Contrary, null hypothesis is rejected for Egypt, Jordan, Lebanon, Tunisia and Saudi Arabia. This means that a causality relationship running from oil consumption to economic growth has been found in Egypt, Lebanon, Tunisia and Saudi Arabia at a significance level of 1%, 5% and 10%. In Jordan however, a causality relationship was found from oil consumption to economic growth at a significance level of 5% and 10%. Accordingly, any energy conservation policy in Egypt, Jordan, Lebanon, Tunisia and Saudi Arabia will have an adverse effect on their economic growth.

Table 5 shows the analysis results of panel Granger causality from economic growth to energy consumption in the MENA countries.

Under the null hypothesis that expresses there is no Granger causality from economic growth to energy consumption, the null hypothesis cannot be rejected for Jordan, Tunisia, Algeria, Iran and Iraq. This statistical result points that there is no causality relationship from economic growth to energy consumption in these countries. In Lebanon and Saudi Arabia, a significant causal relationship has been found from economic growth to oil consumption at 1%, 5% and 10% significance levels. In Egypt, there is a significant causality from economic growth to oil consumption at a significance level of 5% and 10%. Table 6 illustrates the direciton of causality. As a policy implication, it can be suggested that in order to increase their economic growth rates, Lebanon, Saudi Arabia and Egypt can use their natural resources more effective and efficiently (see Table 6).

Based on the horizontal cross-sectional results of 8 MENA countries, a significant causal relationship was found from energy consumption to economic growth. This finding confirms the validity of the growth hypothesis for these MENA countries. These empirical findings are consistent with the findings of Oh and Lee (2004), Shiu and Lam (2004), Lee (2005), Narayan and Singh (2007), Yuan et al. (2007), and Ummalla and Samal (2018) for the short run; Lee and Chang (2008), Apergis and Payne (2009), Abosedra et al. (2009), Odhiambo (2009), Ciarreta and Zarraga (2010), Adom (2011), Pirlogea and Cicea (2012), Ouedraogo (2013) and Aslan (2013), for Portugal and Iceland, Araç and Hasanov (2014), Uçan et al. (2014), Abosedra et al. (2014) and Mudarissov and Lee (2014) in the long run, Alshehry and Belloumi (2015), Paramati et al. (2017), Bhat (2018), and Nasreen et al. (2018).

6. Conclusion and policy implications

This paper investigated the relationship between energy (oil) consumption and economic growth using data for 8 MENA countries for the period of 1990–2014. Based on the results of horizontal cross-sectional results, we found that there is a causality from energy consumption to economic growth. The fact that these countries own 61% of the world's total oil reserves explains the increase in their economic growth.

The empirical results show that energy consumption causes economic growth and economic growth causes energy consumption in Egypt, Lebanon and Saudi Arabia. Nevertheless, economic growth in Egypt, Lebanon and Saudi Arabia is still dependent on energy (oil) consumption. As there is a massive oil resource in Saudi Arabia, instead of applying environmental friendly alternative energy resources, oil and fossil fuels are mostly used for production, heating/cooling and for other areas. Since the share of oil has a great effect on economic growth, with a feedback, as economy grows, oil expenditure increases. Like Saudi Arabia, the other MENA countries which have rich oil resources should take precautions to decrease the environment pollution and the side effects of greenhouse effects. Accordingly, they should apply new technologies in order to have less pollutive energy resources. Besides, they should ponder on energy efficiency and energy productivity. As an example, in daily life electric vehicles can be used. Energy efficient equipment should be encouraged to use.

It is a fact that these countries will be reluctant to implement renewable energy investments since oil and fossil fuels are abundant and very cheap in these countries. However, for a sustainable economic growth, they have to initiate sustainable energy policies. For wise energy transition strategies, they should have collaborations with their trade partners in green energy usage. And also, it may be a good policy to have incentives for energy friendly investments of foreign direct investors. As an example, applying tax incentives for environment friendly investments can be a good attraction. Smart cities can be a good

Table 4
Panel Granger causality results from energy consumption to economic growth in MENA.

Country	Wald test	Bootstrap critical values		
		1%	5%	10%
		H_0 : There is no Granger causality from energy consumption to economic growth		
Egypt	30.265*	22.921	16.353	13.831
Jordan	23.702*	29.593	22.427	19.365
Lebanon	47.408*	28.649	21.338	18.085
Tunisia	55.658*	16.980	11.014	8.913
Algeria	3.311	15.801	10.576	8.219
Iran	0.051	31.355	22.671	19.105
Iraq	6.111	46.109	35.847	30.114
Saudi Arabia	59.395*	45.830	34.067	28.746

Note: * shows 1%, 5% and 10% level of significances. Data includes the entire 1990–2014 sample period. Critical values have been collected with 1000 bootstrap iteration. We have used the Schwarz Information Criterion (SIC).

Table 5
Panel Granger causality results from economic growth to energy consumption in MENA.

Country	Wald test	Bootstrap critical values		
		1%	5%	10%
		H_0: There is no Granger causality from economic growth to energy consumption		
Egypt	33.823*	34.319	26.662	21.823
Jordan	13.601	32.318	23.806	19.161
Lebanon	37.074*	33.253	23.474	19.556
Tunisia	0.077	39.611	30.070	24.831
Algeria	0.112	44.005	33.429	28.861
Iran	0.334	57.232	45.173	40.124
Iraq	9.747	42.231	34.356	29.305
Saudi Arabia	104.428*	41.694	32.625	28.638

Note: * shows 1%, 5% and 10% level of significance. Data includes the entire 1990–2014 sample period. Critical values have been collected with 1000 bootstrap iteration. We have used the Schwarz Information Criterion (SIC).

Table 6
Direction of Granger causality.

Direction of causality	Country & relationship	
	Causal	Non-Causal
EC → EG	Egypt, Jordan, Lebanon, Tunisia, Saudi Arabia	Algeria, Iran, Iraq
EG → EC	Egypt, Lebanon, Saudi Arabia	Jordan, Tunisia, Algeria, Iran, Iraq

Note: → shows the direction of causality.

solution for having less pollution. For having urban transformations and infrastructure renovations processes, energy save and environment friendly technologies can be preferred. As energy is very cheap in those countries, it is not expected to face with energy decoupling.

In Egypt and Lebanon, to decrease low productive technologies which have low value addition and high environment degradation effects, environment friendly investments should be encouraged. Foreign direct investments, urban transformation strategies as well as energy expenditure models should be designed accordingly.

Energy consumption is a cause of economic growth for Jordan and Tunisia. However, the impact of a decline in economic growth rate in Tunisia and Jordan on energy consumption is negligible. Also in these countries, policy makers should produce environmentally friendly energy policies that restrict energy consumption such as energy taxes, energy savings in order to achieve growth.

Neither energy consumption causes economic growth nor economic growth causes energy consumption in case of Algeria, Iran and Iraq. The rising political conflicts, economic performance loss in all sectors, weak industrialization and lack of reliable data to make precise evaluations could be some of the reasons of these findings. In those countries, infrastructure renovation and reconstruction strategies can be designed with environmental friendly investments. International organizations which plan to provide financial support to these countries should also take into consideration these strategies. The impact of energy consumption on growth can be neglected when determining the policy for growth in Algeria, Iran and Iraq.

All in all, the validation of the growth hypothesis in MENA countries reveals that economic growth in MENA countries is dependent upon the energy consumption. Any protection policy on the reduction of energy consumption in MENA countries will have a reverse effect on economic growth. If MENA countries use their natural resources with efficient and effective production techniques, it will be possible for them to be able to have a strong growth performance. MENA countries should collaborate and develop a joint investment program for the production of oil and the other important natural resources they have. It is of great importance to train qualified labor force for the effective use of the natural resources in MENA countries. In the near future, MENA countries might play a more active role in terms of energy production and find a considerable place for themselves in the world market by attaching importance not only to human capital investments but also to R&D investments. In MENA countries, since pollutant energy resources both cause ecocide and negatively affect the sustainable growth, the use of ecofriendly energy resources should be promoted instead of the use of pollutant energy resources that increase carbon dioxide emissions. Urbanization and urban transformation processes should be designed considering energy efficiency and energy conservation. The use of both high value added and less polluting production technologies should be encouraged instead of the production units that have low value added and more damage to the environment.

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