Causality between Energy Consumption and Economic Development: Empirical Evidence from Morocco

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25 January 2020

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Abstract:

A handful number of contributions have been trying to find a proper modeling strategy that captures the true dynamic relationship between energy consumption and economic development in different economies, but none of them targeted Morocco. The relationship between these latter variables have been the point of interest of many economists, as they provide solid insights and guidance to policy makers related to monitoring the use of energy as well as the preparation of new energy infrastructures to meet the existing demand for the different existing consumers. For this, the following contribution determines this relationship using Granger causality test, and empirical findings shows that Morocco supports the conservation hypothesis, meaning that the only causal link is unidirectional and goes from GDP to energy consumption.

Keywords: Energy Consumption, GDP, Economic development, Granger causality, Morocco

JEL: O13, P28, P48, Q43,

Introduction:

The energy sector is considered to be one of the largest industries globally that has a significantly high impact on other industries, and in some case-countries, a significantly high impact on the whole economy. In addition to that, energy availability stands as the main prerequisite for the functioning of many industries since it directly impacts the production as well as the production costs of most goods. For this matter, the causal relationship between energy consumption and economic development has been the point of interest of many economists and scholars, mainly after the two energy crisis that occurred in 1974 and 1981 (e.g., Masih and Masih, 1997; Soytas and Sari, 2003; Huang et al., 2008; Lee and Chang, 2008; Georgantopoulos, 2012; Kwakwa, 2012). Also, this causal relationship provides to policy makers good insights and guidance about monitoring the use of energy or taking the necessary measures to prepare new infrastructures that will meet the existing and forecasted demand, taking into account the environmental impact.

Many theories indicate that the energy availability represents an important foundation for economic development and growth. Yet, the existence and direction of this causality is still debated among researchers and scholars, and is still not defined. For Chaudhry, Safdar, and Farooq (2012), they indicate that many economies are still facing energy shortages, which severely impacts their economic activities. But for Rezitis and Ahammad (2015), they indicate that the impact is more than just affecting economic activities, as it can go to the extent of impacting the long-run economic development of these countries.

The causal link between energy consumption and energy growth is not only unidirectional, as the GDP can sometimes force the increase or monitoring of energy consumption. For this, the literature review will present the different theories under the energy-growth nexus while the current study aims at analyzing the causal relationship between energy consumption and economic growth in the case of Morocco using the Granger causality test.

Literature Review:

Existing literature that assesses the relationship between economic development and energy consumption, that is also referred to as energy-growth nexus, leads to conflicting results related to the nature of the impact or the causality. This is mainly because each contribution has different datasets, different time frames, different countries' characteristics, and different econometric methodologies (Arfaoui, 2016). For this, the literature distinguishes between

four possible hypotheses that are: growth, conservation, feedback, and neutrality (Ozturk, 2010).

Concerning the growth hypothesis, it is a unidirectional causality that runs from energy consumption to economic growth. In this case, energy consumption plays an important role in the economic development, as any increase in energy consumption leads to economic growth, while any restrictions in the use of energy adversely impacts the economic development (e.g. Damette & Seghir, 2013; Javid, Javid & Awan, 2013; Ouedraogo, 2013; Haghnejad & Dehnavi, 2012; Shahiduzzaman & Alam, 2012; Kouakou, 2011; Mazbahul & Nazrul, 2011; Chandran et al., 2010; Chang, 2010; Odhiambo, 2010).

Concerning the conservation hypothesis, it is also a unidirectional causality that runs from economic growth to energy consumption, and is confirmed when an increase in economic growth causes an increase in energy consumption. This hypothesis suggests that policies related to the reduction of energy consumption have a negative impact on economic growth (Carfora, Pansini & Scandurra, 2019). Different contributions have proved this hypothesis for many economies (e.g. Damette & Seghir, 2013; Ouedraogo, 2013; Azlina & Mustapha, 2012; Haghnejad & Dehnavi, 2012; Adom, 2011; Abbasian, Nazary & Nasrindoost, 2010)

For the feedback hypothesis, it is a bi-directional causality between energy consumption and economic growth. This indicates that economic development leads to more energy consumption and vice versa. In this case, the two variables of concern are interrelated and serve as complements to each other. This hypothesis was proved in a series of contributions (e.g. Belaid & Abderrahmani, 2013; Hu & Lin, 2013; Shahbaz & Lean, 2012).

Finally, and with regards to the neutrality hypothesis, it refers to the no causality between economic development and energy consumption. The neutrality hypothesis is proved when economic development does not lead to an increase in the energy consumption, or when energy consumption does not lead to economic growth. In this case, energy conservation policies have no effect on the economic development. This hypothesis has been proved in many contributions (e.g. Ozturk & Acaravci, 2010).

The table below is extracted from the contribution of Jakovac (2018), and summarizes the existing literature on single as well as multiple country studies that assess the causal link between energy consumption and GDP.

Table 1: Summary of the literature review of the causal relationship between energy (EC) consumption and GDP

Contribution	Country	Period	Methodology	Results
Stern (2000)	USA	1948-1994	Johansen-Juselius, static and dynamic cointegration analysis	GDP←EC
Hondroyiannis et al. (2002)	Greece	1960-1996	Johansen-Juselius, cointegration, VEC	GDP↔EC
Soytas and Sari (2003)	France, Italy, Japan, Canada, Germany, Turkey, USA and United Kingdom	1950-1992	Johansen-Juselius, cointegration, VEC, VD	France (GDP←EC), Italy (1953-1991; GDP→EC), Japan (GDP←EC), Canada (no causality), Germany (GDP←EC), Turkey (GDP↔EC), USA and United Kingdom (no causality)
Ghali and ElSakka (2004)	Canada	1961-1997	Johansen-Juselius, cointegration, VEC, VD	GDP↔EC
Oh and Lee (2004a)	South Korea	1970-1999	Johansen-Juselius, cointegration, VEC	GDP↔EC
Oh and Lee (2004b)	South Korea	1981-2000	Johansen-Juselius, cointegration, VEC	GDP→EC
Hatemi-J and Irandoust (2005)	Sweden	1965-2000	Granger causality test	GDP→EC
Lee (2006)	Belgium, France, Italy and Japan, Canada, Netherlands, Germany, USA, Sweden, Switzerland and United Kingdom	1960-2001	Toda-Yamamoto causality test	Belgium (GDP←EC), France, Italy and Japan (GDP→EC), Canada (1965-2001; GDP←EC), Netherlands (GDP←EC), Germany (1971-2001: no causality), USA (GDP↔EC), Sweden (no causality), Switzerland (GDP←EC) and United Kingdom (no causality).
Soytas and Sari (2006)	France, Italy and Japan, Canada, Germany, USA and United Kingdom	1960-2004	Johansen-Juselius, cointegration, VEC, GVD	France (1970-2002; GDP←EC), Italy and Japan (GDP↔EC), Canada (GDP↔EC), Germany (1971-2002; GDP→EC), USA (GDP←EC) and United Kingdom (GDP↔EC)
Jobert and Karanfil (2007)	Turkey	1960-2003	Johansen-Juselius, no cointegration, VAR	No causality

Lee and Chang (2007)	Australia, Austria, Belgium, Denmark, Finland, France, Ireland, Island, Italy, Japan, Canada, Luxembourg, Mexico, Netherland, Norway, New Zealand, Germany, Portugal, USA, Spain, Sweden, Switzerland, Turkey and United Kingdom	1965-2002	panel VAR, GMM, IR	GDP↔EC
Mahadevan and Asafu-Adjaye (2007)	Australia, Japan, Norway, United Kingdom, USA and Sweden	1971-2002	Pedroni, cointegration, panel VEC	GDP↔EC
Sica (2007)	Italy	1960-2001	Engle-Granger, cointegration, Granger causality test, VEC	GDP←EC
Chiou-Wei et al. (2008)	USA and South Korea	1954-2006	Johansen-Juselius, cointegration, VEC, VAR	No causality
Erdal et al. (2008)	Turkey	1970-2006	Johansen-Juselius, cointegration, Granger causality test	GDP↔EC
Huang et al. (2008)	Australia, Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Island, Italy, Israel, Japan, Canada, China, Luxembourg, Netherlands, Norway, New Zealand, Germany, Portugal, Singapore, USA, Spain, Sweden, Switzerland and United Kingdom	1972-2002	panel VAR, GMM	GDP→EC
Karanfil (2008)	Turkey	1970-2005	Johansen-Juselius, cointegration, VEC	GDP→EC
Lee et al. (2008)	Australia, Austria, Belgium, Denmark, Finland, France, Greece, Ireland, Island, Italy, Japan, Canada, Netherlands, Norway, New Zealand, Germany, Portugal, USA, Spain, Sweden, Switzerland and United Kingdom	1960-2001	Pedroni, cointegration, panel VEC	GDP↔EC
Narayan and Smyth (2008)	France, Italy, Japan, Canada, Germany, USA and United Kingdom	1972-2002	Pedroni and Westerlund, cointegration, panel VEC	GDP←EC
Bartleet and Gounder (2010)	New Zealand	1960-2004	ARDL approach, cointegration, VEC	GDP→EC
Belke et al. (2010)	Australia, Austria, Belgium, Czech Republic, Denmark, Finland, France, Greece, Ireland, Italy, Japan, South Korea, Canada,	1981-2007	Johansen-Juselius modified test, cointegration, panel VEC	GDP↔EC

	Luxembourg, Hungary, Mexico, Netherlands, Germany, Poland, Portugal, USA, Slovakia, Spain, Sweden and United Kingdom			
Lee and Chien (2010)	France, Italy, Japan, Canada, Germany, USA and United Kingdom	1960-2001	Toda-Yamamoto causality test, IR, VD	France (GDP→EC), Italy (GDP←EC), Japan (GDP→EC), Canada (1965-2001; GDP←EC), Germany (1971-2001; no causality), USA (no causality) and United Kingdom (GDP←EC)
Ozturk and Acaravci (2010)	Albania, Bulgaria, Hungary and Romania	1980-2006	ARDL approach, cointegration, VEC	GDP↔EC
Tsani (2010)	Greece	1960-2006	Toda-Yamamoto causality test	GDP←EC
Altunbas and Kapusuzoglu (2011)	United Kingdom	1987-2007	Johansen-Juselius, no cointegration, Granger causality test	GDP→EC
Zikovic and VlahinicDizdarevic (2011)	Belgium, Denmark, Ireland, Norway, Sweden, Austria, Czech Republic, Slovakia, Finland and Switzerland	1980-2007	Johansen-Juselius, cointegration, VEC	Belgium, Denmark, Ireland, Norway and Sweden (GDP→EC); Austria, Czech Republic and Slovakia (GDP←EC); Finland and Switzerland (no causality)
Glasure and Lee (1997)	South Korea and Singapore	1961-1990	Engle-Granger, cointegration, VEC	GDP↔EC
Aqeel and Butt (2001)	Pakistan	1955-1996	Engle-Granger, no cointegration, Granger causality test (Hsiao's version)	GDP→EC
Soytas and Sari (2003)	Argentina, Indonesia, South Korea, Poland	1950-1992	Johansen-Juselius, cointegration, VEC, VD	Argentina (1950-1990; GDP↔EC), Indonesia (1960-1992; no causality), South Korea (1953-1991; GDP→EC), Poland (1965-1994; no causality)
Paul and Bhattacharya (2004)	India	1950-1996	Engle-Granger and Johansen-Juselius, cointegration, Granger causality test, VEC	GDP↔EC
Lee (2005)	Argentina, Chile, Philippines, Ghana, India, Indonesia, South Korea, Kenya, Colombia, Hungary, Malaysia, Mexico, Pakistan, Peru, Singapore, Sri Lanka, Thailand and Venezuela	1975-2001	Pedroni, cointegration, panel VEC	GDP←EC

Lee and Chang (2005)	Taiwan	1954-2003	Johansen-Juselius, cointegration, weak exogenity test	GDP↔EC
Lee and Chang (2007)	Argentina, Chile, Philippines, Ghana, India, Indonesia, Kenya, Colombia, Malaysia, Nigeria, Pakistan, Peru, Singapore, Sri Lanka, Thailand and Venezuela	1965-2002	panel VAR, GMM, IR	GDP→EC
Mahadevan and Asafu-Adjaye (2007)	Net exporters of energy: Argentina, Indonesia, Kuwait, Malaysia, Nigeria, Saudi Arabia, Venezuela Net importers of energy: Ghana, India, South Africa, South Korea, Senegal, Singapore, Thailand	1971-2002	Pedroni, cointegration, panel VEC	GDP↔EC (net exporters of energy) GDP←EC (net importers of energy)
Akinlo (2008)	Gambia, Ghana and Senegal, Sudan, Zimbabwe, Cameroon, Ivory Coast, Congo, Nigeria, Kenya and Togo	1980-2003	ARDL approach, cointegration (7 countries), VEC, VAR (4 countries)	VEC: Gambia, Ghana and Senegal (GDP↔EC), Sudan and Zimbabwe (GDP→EC), Cameroon and Ivory Coast (no causality); VAR: Congo (GDP→EC), Nigeria, Kenya and Togo (no causality)
Chiou-Wei et al. (2008)	VEC: Taiwan (GDP←EC); VAR: Thailand (no causality), Philippines and Singapore (GDP→EC), Hong Kong, Indonesia and Malaysia (GDP←EC)	1954-2006	Johansen-Juselius, cointegration (1 country), VEC, VAR (6 countries)	VEC: Taiwan (GDP←EC); VAR: Thailand (no causality), Philippines and Singapore (GDP→EC), Hong Kong, Indonesia and Malaysia (GDP←EC)
Yuan et al. (2008)	China	1963-2005	Johansen-Juselius, cointegration, VEC, IR	GDP↔EC
Apergis and Payne (2009)	Guatemala, Honduras, Costa Rica, Nicaragua, Panama and Salvador	1980-2004	Pedroni, cointegration, panel VEC	GDP←EC
Belloumi (2009)	Tunisia	1971-2004	Johansen-Juselius, cointegration, VEC	GDP↔EC
Gelo (2009)	Croatia	1953-2005	Granger causality test, VAR	GDP→EC
Odhiambo (2009)	Tanzania	1971-2006	ARDL approach, cointegration, VEC	GDP←EC
Imran and Siddiqui (2010)	Bangladesh, India and Pakistan	1971-2008	Kao, cointegration, panel VEC	GDP←EC
Odhiambo (2010)	South Africa, Kenia and Congo	1972-2006	ARDL approach, cointegration, VEC	GDP↔EC
VlahinicDizdarevic and Zikovic (2010)	Croatia	1993-2006	Johansen-Juselius, cointegration, VEC	GDP→EC
Binh (2011)	Vietnam	1976-2010	Engle Granger and JohansenJuselius,	GDP→EC

			cointegration, VEC	
Kakar and Khilji (2011)	Pakistan	1980-2009	Johansen-Juselius, cointegration, VEC	GDP←EC
Shuyun and Donghua (2011)	China (provinces)	1985-2007	Pedroni, cointegration, panel VEC	GDP↔EC
Zikovic and VlahinicDizdarevic (2011)	Croatia, Latvia, Lithuania, Moldavia, Slovenia, Bosnia and Herzegovina, Bulgaria, Malta, Albania, Cyprus, Estonia and FYR Macedonia	1993-2007	Johansen-Juselius, cointegration, VEC	Croatia, Latvia, Lithuania, Moldavia and Slovenia (GDP→EC); Bosnia and Herzegovina, Bulgaria and Malta (GDP←EC); Albania, Cyprus, Estonia and FYR Macedonia (no causality)
Borozan (2013)	Croatia	1992-2010	Johansen-Juselius, no cointegration, VAR, block exogeneity Wald test, IR, VD	GDP←EC
Huang et al. (2008)	The sample consists of 19 low income countries, 22 lower-middle income countries and 15 upper-middle income countries	1972-2002	panel VAR, GMM	no causality (low income countries) GDP→EC (middle income countries)
Ozturk et al. (2010)	The sample consists of 14 low income countries, 24 lower-middle income countries and 13 upper-middle income countries	1971-2005	Pedroni, cointegration, panel VEC	GDP→EC (low income countries) GDP↔EC (middle income countries)

Data and methods:

The following contribution assesses the causal relationship between energy consumption (EC) and GDP in Morocco. For EC, it is stated in terms of quad Btu, and the dataset was extracted from IEA, or International Energy Agency. But concerning the GDP, it is stated in terms of USD using the purchasing power parity (PPP) rates, and the dataset was extracted from the World Bank. These two time series variables cover the period between 1990 and 2017.

In order to assess the nature and the causal relationship between the variables of interest, the table below formulates the different hypotheses that will be tested.

Table 2: Hypotheses formulation to assess the causality between EC and GDP

Set of hypotheses that assesses the unidirectional causality from EC to GDP	H_0: EC does not cause GDP
	H_a: EC causes GDP
Set of hypotheses that assesses the unidirectional causality from GDP to EC	H_0: GDP does not cause EC
	H_a: GDP causes EC

In order to test the causal link between these two variables, the Granger causality test will be used. This latter test indicates that x causes y if the variable x increases the accuracy of the prediction of the variable y, and vice versa (Driouchi & Harkat, 2017). This is given by the following equations:

$$X_t = \alpha + \sum_{i=1}^{m} \beta_i X_{t-1} + \sum_{j=1}^{n} \tau_j Y_{t-1} + \mu_t \qquad (1)$$

$$Y_t = \theta + \sum_{i=1}^{p} \emptyset_i Y_{t-1} + \sum_{j=1}^{q} \psi_j X_{t-1} + \eta_t \qquad (2)$$

The following two equations result in four different scenarios that are:

- Unidirectional causality, where X causes Y:

$\sum_{j=1}^{n} \tau_j \neq 0$, and $\sum_{j=1}^{q} \psi_j = 0$

- Unidirectional causality, where Y causes X:

$\sum_{j=1}^{n} \tau_j = 0$, and $\sum_{j=1}^{q} \psi_j \neq 0$

- Bidirectional causality between X and Y:

$\sum_{j=1}^{n} \tau_j \neq 0$, and $\sum_{j=1}^{q} \psi_j \neq 0$

- Independence between X and Y:

$\sum_{j=1}^{n} \tau_j = 0$, and $\sum_{j=1}^{q} \psi_j = 0$

The following section will show the results of the Granger causality test, and based on them, the nature as well as the direction of the causal relationship between EC and GDP will be determined for the case of Morocco.

Results:

Running the Granger causality test consists of the data being stationary. For this, the Augmented Dickey Fuller (ADF) test was performed in order to check whether if there is a unit root presence in each of the variables (Kim & Choi, 2017). Table 3 summarizes the ADF test results for EC and GDP variables, and indicates the t-statistic for each level with the p-value between brackets. Findings indicate that EC is non-stationary at its level, but it become stationary at both the first difference and the second difference, as the p-values are 0.0059 and 0.0001 that are significant at $\alpha = 1\%$. But for the GDP variable, it remains non-stationary at its own level and at the first difference, and only become stationary at the second difference with a p-value of 0.0000 that is significant at $\alpha = 1\%$. Thus, the Granger causality will use both EC and GDP using their second differences.

Table 3: ADF test results

	ADF statistics		
Variables	**Levels**	**First differences**	**Second differences**
EC	0.95 (0.9948)	-3.91* (0.0059)	-5.57* (0.0001)
GDP	-0.29 (0.9135)	-1.68 (0.4277)	-9.14* (0.0000)
Critical values			
EC	-2.967767		
GDP	-2.991878		

Concerning the first set of hypotheses (Null hypothesis: GDP does not granger cause EC), it resulted in an F-statistic of 10.51 that corresponds to a probability of less than 1% (Table 4). This means that there is enough evidence to reject the null hypothesis, which leads to concluding that in the case of Morocco, the GDP causes EC. But with regards to the second set of hypotheses (Null hypotheses: EC does not Granger cause GDP), it resulted in a low F-statistic with the value of 0.71 that corresponds to a probability of 50.58% (Table 4). This latter value exceeds the significance level $\alpha = 5\%$, which indicates that there is enough evidence not to reject the null hypothesis, and thus conclude that EC does not cause GDP.

Table 4: Granger causality results

Null Hypothesis:	Obs.	F-Statistic	Prob.
GDP does not Granger Cause EC*	24	10.51	0.0008
EC does not Granger Cause GDP		0.71	0.5058

Conclusion and discussion:

The literature that assesses the causal relationship between energy consumption and GDP is enormous, yet, it still did not reach a consensus on which variable causes the other. While many studies have analyzed countries as a group using panel data analysis techniques, this study focuses on assessing the energy-growth nexus for a single country –Morocco, in the period between 1990 and 2017 using the Granger causality test.

Results indicate in the case of Morocco, the only causal link between the two variables of interest (EC and GDP) is unidirectional and goes from GDP to EC. This supports the conservation hypothesis, which indicates that policies related to the reduction of the energy consumption have a negative impact on economic growth.

It is of prime importance to note that the Moroccan government needs to continuously focus on preparing the necessary infrastructures to meet the future energy demand for all type of consumers (mainly industrials). In addition to that, policy makers need to pay close attention to the type of energy to be introduced and take into account its prices and environmental impact.

For this, and while planning for new infrastructures in Morocco, future work need to relate to the impact of energy prices on the industry value added as well as the impact of the type of energy on the environment.

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