

# The relationship between energy consumption and economic growth: a Status Report

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**Abstract:** Since the oil crisis, and in most industrialized countries, energy management has become a topic that attracts their interest, in order to understand the type of the relationship that exists between energy consumption and the growth of GDP. Moreover, such an interest becomes more important, for economies which are essentially based on the use of energy, therefore any energy policy can have an effect on economic growth.

In addition, the main objective of this work is to compare and identify the different theoretical and conceptual aspects of the results concerning the studies that have examined the causal relationship between energy consumption and economic growth for several African countries and mainly Morocco, during different periods.

These different studies were based on different econometric methods depending on the type of data used and the vision of each author, so we will try to determine for each work: the country concerned, the study period, the method used and the results obtained.

This diversification between these works has made the results very different, and this discrepancy is perhaps mainly due to the method used: time series, panel data, the bi-variate approach where the work is carried out with only two variables (energy consumption and GDP) or the multi-variate approach (the addition of other variables that can influence GDP or energy consumption). In addition, the sample size or the choice of years can play a role in this difference between the results. Such as, for two different studies carried out on the same country, we can find contradictory results. Therefore, the choice of the years or the method adopted has a direct impact on the result obtained.

**Keywords:** Energy consumption; Economic growth; GDP; Causality.

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## 1. Introduction

Energy has always played and continues to play a major role in human development and the well-being of individuals and social groups all over the world. Thus, energy can be presented as an economic good that is characterized by the multiplicity of its uses (consumer good for households, production factor, raw material for business ...). It is one of the major elements on which the growth of countries is based, because it is necessary for the realization of any production process and therefore for economic development.

Moreover, since the oil shocks of the 1970s, the proper use of energy has begun to be a great concern for all countries in the world who have become aware that they are threatened, given their intensive use of natural exhaustible resources. So recently, the causality between economic growth or GDP and energy consumption has become an issue that attracts the attention of researchers around the world, who question the sense of the causal relationship between these two variables.

The empirical results of some of these researchers' work are very different and even contradictory. Especially in Africa, because African economies cannot always be based on the old economic development models adopted by other countries, on the one hand because of the demographic and geographic trends that characterize this region, and on the other hand it is found that the latter faces external problems that other continents had not faced.

In general, we find that the relationship between energy consumption and economic growth is not well resolved at the level of underdeveloped and developing countries. For this reason, it is important to understand the direction of the causal relationship between these two variables, the thing that can facilitate the elaboration of measures adapted to energy policies and that stimulate economic growth.

So, the important role that energy consumption plays in the development of several countries raises several questions, and the divergence of the conclusions obtained on this issue raises questions about the methods used. However, the plurality of empirical results needs more research, and new econometric methods to better test the sense of this causal relationship between economic growth and energy consumption. Also that the results of some works are very different, as they sometimes show the presence of a unidirectional causal relationship, sometimes bidirectional and in some cases a total absence of causality noted.

Therefore, the results that can be obtained on this subject can be very different depending on the choice of countries, the years of observation or the econometric methods used. So, the objective of our work is to study the different results of the studies done on the relationship between economic growth (GDP) and energy consumption in a number of African countries, including Morocco, for different periods of time, and by comparing the results obtained in each of these studies. These countries were chosen either because of their geographic proximity to Morocco or because of the similarity between their economies and Morocco's.

## 2. Previous work

Among the first works that examine the relationship between economic growth and energy consumption, we find the seminal paper by Kraft and Kraft (1978), where they demonstrated the existence of a unidirectional causality between GNP and energy consumption (EC) in the United States between 1947 and 1974. But in 1980, this article was criticized by Akarca and Long, because for them the choice of the period was wrong, because it was unstable where it included the first oil shock. So this causal link between energy consumption and economic growth has given rise to several studies, but based on different techniques and many samples of countries.

In addition, using other methods and techniques of econometric analysis at the level of different countries a number of studies have shown the existence of unidirectional or bidirectional causality, or indeed an absence of causality, but they have failed to provide an overall trend for countries with different levels of development or economic structures.

The hypothesis of no causality or neutrality has been supported by the conclusions of Menegaki (2011) , Jobert and Karanfil (2007) for example, and among the studies that support the hypothesis of bidirectional causality we find those of Ghali and El Sakka (2004), Belloumi (2009), Apergis and Payne (2012), Shahbaz et al. (2012), Fuinhas and Marques (2012), Hondroyiannis et al. (2002) , Bloch et al (2015).While the results for example of Mozumder and Marathe (2007), Stern (2000) and Lee (2005) support the hypothesis of unidirectional causality.

In most of these works, the general model with which these works have modeled the influence of energy consumption on GDP is given as follows:

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

$$Y_t = \theta + \sum_{i=1}^p \phi_i Y_{t-1} + \sum_{j=1}^q \varepsilon_j X_{t-1} + \eta_t \quad (2)$$

Where Y is the gross domestic product of a country i at a particular date or the (GDP), X is the energy consumption, ε and μ are the error terms.

### 3. Comparative study

Our comparative study was made on the results obtained by ten most cited works in the field of energy and its relation with the GDP. To facilitate this comparative study, we have summarized these works in the form of a table that contains the following information: the name of the author, the country concerned by the study, the period of study, the methodology adopted by the author, and the results obtained for each country.

**Tableau 1:** Summary of results for all studies

Authors	Country	period	Methodology	Results
<b>Wolde-Rufael (2006)</b>	17 African countries	1971–2001	ARDL bounds test of cointegration;  Yamamoto Causality test	- Gabon, Morocco and Egypt: ELC↔GDP - Sudan, Congo Rep, South Africa Kenya and Algeria: ELC — GDP - Congo DR, Tunisia and Benin: ELC → GDP - Senegal, Zimbabwe, Cameroon, , Nigeria, Zambia and Ghana : GDP → ELC
<b>Belloumi (2009)</b>	Tunisia	1971- 2004	Granger causality test ;VECM; Johansen cointegration technique;	GDP ↔ EC

<b>Wolde-Rufael (2009)</b>	17 African countries	1971-2004	Variance decomposition , Toda and Yamamoto Causality test,	-Zimbabwe, Ghana, Gabon, and Togo: EC ↔ GDP -Kenya and Cameroon: EC — GDP -Benin ,South Africa and Algeria, : EC → GDP -Morocco, Ivory Coast, Zambia, Nigeria, Sudan, Egypt, Tunisia and Senegal: EC ← GDP
<b>Belmokaddem and Seghir Guellil (2014)</b>	-Algeria, Libya, Morocco, Tunisia, Mauritania. - Malaysia, Thailand, Turkey, South Africa	1992 - 2007	Panel cointegration test	EC → GDP
<b>Palakiyem Kpemoua(2016)</b>	Togo	1979 - 2013	Johansen cointegrationTest	GDP — EC
<b>Feride Ozturk (2017)</b>	The countries of the MENA region	1971-2011	Toda and Yamamoto Causality test	- Egypt, Iran, Lebanon and Tunisia: EC → GDP - Algeria, Morocco and Saudi Arabia : GDP → EC - Bahrain and Malta: EC — GDP - Oman and the United Arab Emirates : EC ↔ GDP
<b>Fathy Sharaf(2017)</b>	Egypt	1980-2012	Toda and Yamamoto Causality test	- GDP → Electricity and oil consumption  - Oil consumption → physical capital
<b>Lahoual and Taouch (2019)</b>	Algérie	1980-2014	ARDL and Toda and Yamamoto Causality test	GDP → EC
<b>Jamai Mouhtadi and Sadefo Kamdem (2019)</b>	Morocco	1975 - 2017	Johansen-Juselius, cointegration, VECM	GDP ↔ EC EC ↔ The CO2 emissions
<b>Tahar Harkat</b>	Morocco	1990 - 2017	Granger	GDP → EC

(2020)			causality test	
<b>Najia Saqib (2021)</b>	The countries of the MENA region	1987-2019	Vector Auto-regression model, Granger causality approach	-Bahrain and Malta : EC— GDP - Egypt, Iran and Tunisia : EC → GDP - Algeria, Kuwait, Morocco, Qatar, Saudi Arabia and Turkey: GDP → EC
<b>Mohammed Touitou (2021)</b>	The countries of the MENA region	1995–2017.	Panel cointegration test	EC and GDP → CO2

**EC:** Energy consumption; **ELC:** electricity consumption; **GDP:** Gross domestic product

**EC → GDP:** Unidirectional causality from EC to GDP

**GDP → EC:** Unidirectional causality from GDP EC.

**GDP ↔ EC:** two-way causality.

**EC— GDP:** no causality between GDP and EC.

### Conclusion

The objective of this paper is to compare and identify the different theoretical and conceptual aspects of the results of the different studies that have investigated the link between energy consumption and economic growth in several African countries, over different periods.

It should be recalled that the methodological approaches that consist in modeling the link between energy consumption and economic growth adopted by the authors differ from one study to another according to the type of data used and the vision of each author, but in general we find that the most used method is the Granger and Toda Yamamoto causality test, which allows to determine the direction of causality.

By comparing these works, we note the following points:

- Some studies focus on the relationship between economic growth and energy consumption in general without indicating which form of energy. For others they are based more specifically on the consumption of electricity (Wolde-Rufael, 2006), knowing that in the field of industry other forms of energy are used such as fuel oil, coal, etc.
- At the level of the results of these studies, we find that there are works that have obtained as results the existence of a causality from energy consumption to economic growth (Belmokaddem and Seghir Guellil (2014), Feride Ozturk (2017), etc.), or from economic growth to energy consumption (Belloumi (2009), Lahoual and Taouch (2019), etc). While others show the existence of causality in both directions at the same time (Jamai Mouhtadi (2019), Wolde-Rufael (2009) for Gabon, Ghana, Togo and Zimbabwe, etc.), but at the level of other works we find that there is an absence of causality in both directions (Palakiyem Kpemoua(2016), Wolde-Rufael(2006) in Algeria, Congo, Kenya, South Africa and Sudan).
- In addition, it is noted that these empirical studies on the relationship between these two variables are based on different methodological approaches, where there are those who use, the VAR method and the Granger causality test. Others use the unit root test and Co-integration, as well as the Johansen causality test or Toda and Yamamoto.
- In addition, we find that within of the same country the results can be different, taking for example the case of Morocco during the period 1971-2001, the study carried out by Wolde

Rufael in 2006 showed the existence of bidirectional causality between electricity consumption and economic growth.

In another study, also by Wolde Rufael in 2009, he re-examined this causal relationship during the period 1971-2004, but in a multivariate framework by including labor and capital as additional variables, to assess the causal effect of energy consumption on economic growth compared to labor and capital. This difference in results is mainly due to the econometric method chosen, the sample, the type of energy studied.

Then the results can be different depending on the years chosen for the study, or on the econometric method adopted, or on the variables included in the study.

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