

*Full Length Research Paper*

# Does economic growth and financial development spur energy consumption in Tunisia?

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**This study investigates the link between energy consumption, financial development and growth in Tunisia. The causal relationship between energy consumption growth (ENC), per capita GDP growth (GDP) and credit to the private sector as a proxy of financial development (CSPV) during the 1972 to 2010 period was examined using the cointegration and vector error correction models for Granger causality tests. The main empirical results show that in the long term there is bidirectional causality between ENC and GDP, as well as a unidirectional causality going of ENC to CSPV. On the short term, only the variable ENC causes CSPV which demonstrates the interest to include this variable in the relation energy-growth. The research results strongly support the neoclassical perspective that energy consumption is not a limiting factor to economic growth in Tunisia. Accordingly, an important policy implication resulting from this analysis is that government can pursue the conservation energy policies that aim at curtailing energy use for environmental friendly development purposes without creating severe effects on economic growth. In future, the energy should be efficiently allocated into more productive sectors of the economy.**

**Key words:** Energy, financial development, growth, cointegration.

## INTRODUCTION

The relationship between energy consumption and economic growth has been one of the most widely investigated in the economic literature in the three last decades. However, existing outcomes have varied considerably. Whether energy consumption stimulates, retards or is neutral to economic activities has motivated curiosity and interest among economists and policy analysts to investigate the direction of causality between energy consumption and economic variables.

The direction of causality between energy consumption and economic growth has significant policy implications for countries, enjoying implicit generous subsidies (low domestic prices) for energy. If, for example, there exists unidirectional Granger causality running from growth to energy, it may be implied that energy conservation policies such as phasing out energy subsidies or elimination of energy price distortions have little adverse or no effects on economic growth. On the other hand, if unidirectional causality runs from energy consumption to growth, reducing energy consumption, for example through bringing domestic energy prices in line with market prices, could lead to a fall in income. And lastly,

no causality in either direction would indicate that policies for increasing energy consumption do not affect economic growth.

The objective of this paper is to assess the relationship among energy consumption, financial development, and economic growth in Tunisia. Much of the literature on energy focuses on the nexus of output-energy that only portray a partial picture of the problem. Being one of the fastest growing economies in North African region, Tunisia is an interesting case study as it faces the energy shortage in fulfilling its growing energy needs.

According to Chtioui and Boujelbene (2007), financial development causes economic growth in Tunisia which may further causes more energy consumption. To the best knowledge of the authors, this is the only comprehensive study that takes into account financial development, in the energy-growth nexus for Tunisia and uses the longest available data from 1972 to 2010, making the estimation more reliable. The finding may help policy makers to better understand some of the intricate development that confront Tunisia.

The purpose of this paper is therefore, to investigate

the causality between energy consumption, financial development and economic growth: The remainder of this paper is organized as follows: Subsequently, the study reviews the literature on the subject. It then gives an overview of the energy sector in Tunisia. A discussion on the methodology of the study is presented. Thereafter, the study describes the data used and reports on our empirical results. The study also provides the policy implications of the empirical results and finally, it was concluded.

## LITERATURE REVIEW

Interest in the causal relationship between energy consumption and economic growth was spawned by Kraft and Kraft's (1978) seminal work. Empirical approaches to test the causal relationships between energy consumption and economic growth have been synthesized into four testable hypotheses (Apergis and Payne, 2009).

The first hypothesis is that energy consumption is a prerequisite for economic growth given that energy is a direct input in the production process and an indirect input that complements labor and capital inputs (Masih and Masih, 1996; Toman and Jemelkova, 2003). In this case a unidirectional Granger causality running from energy consumption to GDP means that the country's economy is energy dependent, and that policies promoting energy consumption should be adopted in to stimulate economic growth because inadequate provision of energy may limit economic growth.

The second hypothesis asserts that when causality runs from economic growth to energy consumption, an economy is less energy dependent, and thus energy conservation policies, such as phasing out energy subsidies may not adversely affect economic growth (Mehra, 2007).

Ferguson et al. (2000) find strong evidence that an increase in wealth is positively related to energy consumption. Masih (1998) provides anecdotal evidence that increased energy provision played an important role in the development process of industrialized countries.

The third hypothesis assumes that there is no causality between energy consumption and economic growth (also known as the neutral hypothesis). Thus, policies aimed at conserving energy will not retard economic growth (Asafu-Adaye, 2000; Jumbe, 2004).

Finally, the fourth hypothesis assumes a bidirectional relationship between energy consumption and economic growth. The implication of the bidirectional relationship is that energy consumption and economic growth are complementary, and that an increase in energy consumption stimulates economic growth, and vice-versa.

Empirical research on the energy consumption-economic growth nexus has yielded mixed results, mainly

because of estimation techniques, choice of study period, and level of development of the country being studied.

Ghali and El-Sakka (2004) analyzed the causal relationship between energy use and output growth in Canada. They found that energy enters significantly into the cointegration space by testing for multivariate cointegration between output, capital, labor and energy use. Moreover, the short-run dynamics of the variables showed that the flow of causality ran in both directions between output growth and energy use.

Lee (2005) applies panel estimation techniques to 18 developing countries, including sub-Saharan African, Kenya and Ghana, and finds evidence of causality running from energy consumption to GDP. Lee et al. (2008) use a panel error correction model to examine the short-run and long-run causality between energy consumption and economic growth for a panel of 22 OECD countries. Their results show a bidirectional relationship between energy consumption, capital stock, and GDP.

Mozumder and Marathe (2007) examined the causal relationship between the per capita electricity consumption and the per capita GDP for Bangladesh using a cointegration and vector error-correction model. Their results showed that there was unidirectional causality running from per capita GDP to per capita electricity consumption.

Yuan et al. (2007) applied the cointegration theory to examine the causal relationship between electricity consumption and real GDP for China during the 1978 to 2004 period. Their estimates indicated that real GDP and electricity consumption for China were cointegrated and that there was only unidirectional Granger causality running from electricity consumption to real GDP, but not vice versa.

Similarly, Mehra (2007) applies panel estimation techniques to 11 oil exporting countries and finds evidence of a strong unidirectional causality running from energy consumption to per capita GDP. In a recent effort, Ciarreta and Zarraga (2008) apply the heterogeneous panel cointegration tests and panel system GMM to estimate the causal relationship between economic growth and electricity consumption for 12 European countries. They find no evidence of a short-run causal relationship, but establish a long-run relationship running from electricity consumption to GDP.

Furthermore, positive and significant relationships between energy consumption and economic growth are found by Lee and Chang (2008) by including capital stock in the model for some Asian countries. Bartleet and Gounder (2010) studied the casual relationship between energy consumption and economic growth using both bivariate and multivariate models. They found that economic growth, employment and energy consumption have cointegration relationship.

The causality results show that economic growth causes energy consumption and economic activity

determines the increase of energy demand. Using the neo-classical production function, they found that capital stock plays an important role in determining the direction of casual relationship between energy consumption and economic growth; and real GDP and employment also significantly affect the energy consumption.

Indeed, according to Karanfil (2008), the causality between economic growth and energy consumption is not just justified by a simple bivariate model. He suggested adding one of the financial variables such as domestic credit to private sector, stock market capitalization or liquid liabilities into the model. He also argued that interest rate and exchange rate can affect the energy consumption through energy prices. In this regard, Stern (2000) indicated the omission of relevant variables from the model.

Sadorsky (2010) used different indicators of financial development in twenty-two emerging economies during the period of 1990 to 2006. They found that the impact of financial development on energy demand is positive and significant but small.

Shahbaz et al. (2010) suggested a significant and positive effect of financial development on energy consumption in Pakistan. The causality analysis indicated bidirectional casual relation between financial development and energy consumption.

In Malaysia, Islam et al. (2011) revealed that financial development and economic growth have positive impact on energy consumption. Different from Pakistan, a unidirectional causality was found running from financial development to energy consumption in Malaysia.

Thus, financial development helps industrial growth, creates demand for new infrastructure; and positively, impacts energy use. Financial development can lower energy consumption by achieving efficiency in its use. At the consumer end, financial development makes credit cheap and accessible (Karanfil, 2009) and thus enables consumers buy big tickets items e.g., home appliances, which directly add to energy use. Developed financial market can enhance consumer and business participation in economic activity and thus energy use.

In a summary of the literature on the causal relationship between energy consumption, and economic growth, there are a number of evidences to support bidirectional or unidirectional causality between energy consumption and economic growth.

Also, from this literature review, we can conclude that when applying the Granger causality analysis, we should be cautious with the empirical results and explain them carefully.

## Overview of the energy sector in Tunisia

The energy structure of Tunisia is dominated by oil and natural gas. Since the end of the 1960s and during the 1970s and 1980s, the Tunisian energy sector had played a determining role in its economic development. Indeed,

with an annual production, except for biomass, exceeding five million tons of oil equivalents (Mtoe), hydrocarbons widely contributed to the economic growth of the country during this period.

Tunisian's total primary energy supply was 8.451 Mtoe in 2005, which is distributed as follows: oil (50.0%), gas (36.6%), combustible renewables and waste (13.3%) and hydropower (0.1%)<sup>1</sup>

The acceleration of Tunisia's economic development has entailed a strong growth in energy demand. Since the early 1990s, Tunisia has dealt with the problem of energy dependence and recorded its first energy balance deficit in 1994.

On 2001, deficits appeared again as a result of increasing demand and stagnating supply. Tunisian energy consumption grew by 326% between 1971 and 2004. For the same period, the Tunisian energy production grew by only 38%.

Tunisian consumption of primary energy, which was 8.5 Mtoe in 2004, is dominated by oil with 48.7%, but natural gas is also significant at 37.6%. The biomass-energy, essentially used for the preparation of bread and cooking food in rural areas, contributes rather significantly, amounting to 13.1% of the primary consumption of energy. Finally, renewable energies (hydropower, wind energy and solar heating of water) represent 0.6% of the consumption of primary energy for the year 2004 (Amous, 2007).

Tunisia has modest proven oil reserves of 308 million barrels. The majority of Tunisia's oil reserves are located in the Gulf of Gabes and the Ghadames Basin in the southern part of the country<sup>2</sup>.

As domestic petroleum demand increases, the country's modest domestic production capacity is proving unable to meet it. Tunisia is increasingly turning to natural gas as a way of coping with steadily increasing domestic demand for energy. Tunisia has 2750 billion cubic feet (Bcf) of proven natural gas reserves, with about two-thirds of it offshore. In 2000, Tunisia produced 66 Bcf of natural gas<sup>3</sup>. Output rose significantly to 79 Bcf in 2001.

In 2005, the Miskar field achieved record production levels of 200 million cubic feet per day (MMcf/d) of natural gas, which supplied more than 50% of Tunisia's

<sup>1</sup> Source: Energy Information Administration (EIA), 2006.

<sup>2</sup> The majority of Tunisia's oil production (73%) comes from six concessions, which include Adam, Ashtart, Didon, El Borma, Miskar and Oued Zar. The remaining production comes from 26 smaller concessions. In 2005, the Adam field, located in the Borj el Khadra prospect in the Ghadames Basin, became Tunisia's largest producing oil field with 18,000 barrels per day (bbl/d). The onshore El Borma oil field, which was discovered in 1964 near the Algerian border, produces 12,000 bbl/d. This production level is down from the 1985 peak of 70,000 bbl/d. The Ashtart field, which is operated by ETAP, produces 11,500 bbl/d. In 2003, Tunisia produced around 66,000 bbl/d of oil. This represents a 45% decline from the country's peak oil output of 120,000 bbl/d during the 1982–1984 period (EIA, 2006).

<sup>3</sup> The majority of Tunisia's natural gas output comes from the Miskar field, located about 80 miles offshore in the Gulf of Gabes. The field was discovered in 1975 by Elf, but is now fully owned and operated by British Gas (BG), the largest investor in Tunisia's energy sector. According to BG, the field contains 1500 Bcf of natural gas reserves.

total natural gas demand. British Gaz also holds the Amilcar and Ulysse exploration permits in the Gulf of Gabes.

Tunisia has four other producing natural gas fields (El Franning, El Borma, Baguel and Zinnia). Together, these fields account for most of the remaining domestic natural gas production. Demand growth for natural gas has been even faster than for petroleum; between 2000 and 2001, Tunisia's consumption of natural gas grew from 109 to 135 Bcf (24%). Since 1990, demand for natural gas has grown almost 9% per year. Much of the demand growth comes from the electricity sector, but industrial and domestic use of natural gas has also increased. The state-owned natural gas and electricity company, STEG has promoted the use of natural gas through an incentive program.

According to STEG, natural gas represented 44% of the total initial energy consumption in Tunisia in 2005, compared to just 14% in 2003. The role of natural gas is growing, as it is currently the second largest fuel source, as well as being a main source for the industrial and electricity sectors (EIA, 2006).

During the 2005 to 2008 period, Tunisia launched an energy conservation program. This program helped to reduce demand (8% lower in 2007, nearly 700,000 Toe savings), improve investments in renewable energy and developments in the widespread use of natural gas. In light of these results, the government has decided to launch a new four-year program covering the 2008 to 2011 period. This program intends to reduce energy consumption by 20% (or 2 Mtoe) between 2008 and 2011, involves energy conservation in all sectors of the economy, and focuses on the development of renewable energies in Tunisia.

Energy conservation may be achieved through the promotion of energy-efficient appliances (lamps, refrigerators and others), energy efficiency standards, subsidies/incentives on energy efficiency improvement and energy technology standards. A strategic study on energy efficiency in Tunisia has shown that Tunisia can save 3 Mtoe by 2010, 30 Mtoe by 2020 and 80 Mtoe by 2030.

Tunisia also has great potential in the field of renewable energy (e.g., solar and wind). It is working hard to develop renewable energy resources. There are plans to build at least two wind farms in the northern part of the country, with the goal of producing about 400,000 MWh of renewable electricity annually. A strategic study on the development of renewable energy in Tunisia in 2004 showed that Tunisia has high potential for valorization of modern renewable energies, estimated at an aggregate 1.3 Mtoe by 2010, 7 Mtoe by 2020 and 19 Mtoe by 2030<sup>4</sup>.

The mobilization of this potential will allow for significant improvement of the contribution of renewable energies in the consumption of primary energy. It is in power

production that the penetration of renewable energies would be the most significant, with 5.8% by 2010, 11.7% by 2020 and 12.2% by 2030. The wind energy branch for power production represents the most significant portion of this potential according to the time frames (between 70 and 80%). Solar water heating is ranked second (10% of the potential), followed by biogas (NAEC, 2004).

**ECONOMETRIC METHODOLOGY**

Many macroeconomic time series contain unit roots dominated by stochastic trends, as developed by Nelson and Plosser (1982). Unit root tests are important in examining the stationarity of a time series because a nonstationary regressor invalidates many standard empirical results and thus requires special treatment. Granger (1969) have found by simulation that the F-statistic calculated from the regression involving the nonstationary time-series data does not follow the standard distribution. This nonstandard distribution has a substantial rightward shift under the null hypothesis of no causality. Thus the significance of the test is overstated and a spurious result is obtained. The presence of a stochastic trend is determined by testing the presence of unit roots in timeseries data. Non-stationarity or the presence of a unit root can be tested using the Dickey and Fuller (1981) tests. The test is the t statistic on  $\phi$  in the following regression:

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \phi Y_{t-1} + \sum \omega_i \Delta Y_{t-i} + \varepsilon_t \tag{1}$$

Where  $\Delta$  is the first-difference operator,  $\varepsilon_t$  is a stationary random error.

The cointegration test is based in the methodology developed by Johansen and Juselius (1993). Johansen's method is to test the restrictions imposed by cointegration on the unrestricted variance autoregressive, VAR, involving the series.

The mathematical form of a VAR is:

$$Y_t = A_1 Y_{t-1} + \dots + A_p Y_{t-p} + B X_t + \varepsilon_t \tag{2}$$

Where  $y_t$  is an  $n$ -vector of non-stationary  $I(1)$  variables,  $x_t$  is a  $d$ -vector of deterministic variables,  $A_1, \dots, A_p$  and  $B$  are matrices of coefficients to be estimated, and  $\varepsilon_t$  is a vector of innovations that may be contemporaneously correlated with each other but are uncorrelated with their own lagged values and other right-hand side variables. We can rewrite the VAR as (Equation 3):

$$\Delta y_t = \pi y_{t-1} + \sum \tau_i \Delta Y_{t-i} + B x_t + u_t \tag{3}$$

Where (Equation 4):

$$\pi = \sum A_i \cdot I_n \quad ; \quad \tau_i = -\sum A_j \tag{4}$$

Granger's representation theorem asserts that if the coefficient matrix  $n$  has reduced rank  $r < n$ , then there exist  $n \times r$  matrices  $\alpha$  and  $\beta$  each with rank  $r$  such that  $\pi = \alpha \beta'$  and  $\beta' y_t$  is stationary.

Here,  $r$  is the number of cointegrating relations and each column of  $\beta$  is a cointegrating vector. For  $n$  endogenous non-stationary variables, there can be from 0 to  $n-1$  linearly independent, cointegrating relations.

<sup>4</sup> Source : The National Agency for Energy Conservation (NAEC, 2005)

**Table 1.** Test ADF applied on the endogenous and exogenous variables of the model.

Variables	Stationarity in the level			Stationarity in first difference		
	Estimated V	Tabled V	Integration level	Estimated V	Tabled V	Integration level
ENC	-2.43	-2.62	I (1) **	-15.65	-1.95	I (0)*
GDP	-1.55	-1.95	I (1)*	-6.52	-1.95	I (0)*
CSPV	0.65	-1.95	I (1)*	-6.16	-1.95	I (0)*
CO <sub>2</sub>	1.24	-1.95	I (1) *	-7.77	-1.95	I (0) *

\*: Threshold 5%. \*\*: Threshold 1%.

The existence of cointegration relationships indicates that there are long-run relationships among the variables, and thereby Granger causality among them in at least one direction.

The ECM was introduced by Sargan (1964), and later popularized by Engle and Granger (1987). It is used for correcting

disequilibrium and testing for long and short-run causality among cointegrated variables. The ECM used in this paper is specified as follows:

$$\Delta ENC_t = a_0 + \sum_{t=1}^m a_{11} \Delta ENC_{t-1} + \sum_{t=1}^m a_{21} \Delta GDP_{t-1} + \sum_{t=1}^m a_{31} \Delta CSPV_{t-1} + \lambda ECM_{t-1} + u_t$$

$$\Delta GDP_t = b_0 + \sum_{t=1}^m b_{11} \Delta ENC_{t-1} + \sum_{t=1}^m b_{21} \Delta GDP_{t-1} + \sum_{t=1}^m b_{31} \Delta CSPV_{t-1} + \theta ECM_{t-1} + \varepsilon_t$$

$$\Delta CSPV_t = c_0 + \sum_{t=1}^m c_{11} \Delta ENC_{t-1} + \sum_{t=1}^m c_{21} \Delta GDP_{t-1} + \sum_{t=1}^m c_{31} \Delta CSPV_{t-1} + \delta ECM_{t-1} + z_t$$

Where  $\Delta$  is the difference operator,  $m$  and  $n$  are the numbers of lags,  $a$ ,  $b$  and  $c$  are parameters to be estimated and,  $\lambda$ ,  $\theta$  and  $\delta$  are the error correction term, which is derived from the long run cointegration relationship.

In each equation, change in the endogenous variable is caused not only by their lags, but also by the previous period's disequilibrium in level. Given such a specification, the presence of short and long-run causality could be tested.

## DATA AND EMPIRICAL RESULTS

Our empirical study uses the time series data of per capita GDP growth (GDP), per capita energy consumption growth (ENC) and credit to the private sector/GDP (CSPV) used as a proxy of financial development for the period (1972 to 2010) in Tunisia.

To control the negative effect of the energy consumption on the environment (pollution), we shall use an explanatory variable which expresses the level of emission of CO<sub>2</sub>:

CO<sub>2</sub>: Per capita of carbon dioxide emissions CO<sub>2</sub> as proxy for the level of pollution and environmental degradation.

Data are obtained from the World Development Indicators (2006) produced by the World Bank.

### Result of unit roots and cointegration test

The results of the unit root tests for the series of ENC,

GDP, CSPV and CO<sub>2</sub> variables are shown in Table 1<sup>5</sup>. The ADF test provides the formal test for unit roots in this study. The  $p$ -values corresponding to the ADF values calculated for the four series are larger than 0.05. This indicates that the series of all the variables are non-stationary at 5% level of significance and thus any causal inferences from the two series in levels are invalid.

As indicated, the basic idea behind cointegration is to test whether a linear combination of two individually non-stationary time series is itself stationary. Given that integration of four series is of the same order, it is necessary to test whether the two series are cointegrated over the sample period. The results of the Johansen cointegration test for four the series are reported in Table 2.

The likelihood ratio tests show that the null hypothesis of absence of cointegrating relation ( $r = 0$ ) can be rejected at 5% level of significance, and that the null hypothesis of existence of at most one cointegrating relation ( $r \leq 1$ ) can be rejected at 5% level of significance. We can see that both tests suggest the existence of two cointegrating vectors driving the series with two common stochastic trends in the data. Thus, we can conclude ENS, GDP, and CSPV and CO<sub>2</sub> are cointegrated. That is, there are four long-run relationships between the four variables in Tunisia. The normalized long term Equation is the following:

<sup>5</sup> The critical values are calculated from MacKinnon. The lag lengths are selected using the AIC criterion.

**Table 2.** Results of Johansen's cointegration test.

Unrestricted Cointegration Rank Test (Trace)				Prob.**
Hypothesized No. of CE(s)	Eigen value	Trace statistic	0.05 Critical Value	
None*	0.515704	71.81264	47.85613	0.0001
At most 1*	0.495692	44.98549	29.79707	0.0005
At most 2*	0.267762	19.65647	15.49471	0.0111
At most 3*	0.197165	8.125412	3.841466	0.0044

Trace test indicates 4 cointegrating equation(s) at the 0.05 level. \* denotes rejection of the hypothesis at the 0.05 level. \*\*MacKinnon-Haug-Michelis (1999) p-values.

$$ENC = 2.12 GDP + 0.44 CSPV - 0.01 CO_2 - 0.34$$

(3.88)            (3.37)            (-2.76)

causes a deficient use of the energy.

The long-term Equation shows that the variable (ENC) reacts positively to an increase of 1% of the variable GDP and CSPV with an increase respectively of 2.12 and 0.44. Both found coefficients are statistically significant.

The level of growth of the economy as well as the variable CSPV used as proxy to measure the financial development affect positively the consumption of the energy in Tunisia.

However, the level of emission of CO<sub>2</sub> is negatively correlated to the endogenous variable (ENC). This result is expected if we take into account the fatal effect of pollution which exercises on the environment that can

**Results of error-correction model and causality sense**

If the series are non-stationary and the linear combination of these variables is stationary, then the error correction modeling rather than the standard Granger causality test should be employed. Therefore, an ECM was set up to investigate both short-run and long-run causality. In the ECM, first difference of each endogenous variable was regressed on a period lag of the cointegrating equation and lagged first differences. The result of error correction model is shown as follows:

$$\Delta ENC_t = 0.05 - 0.45 \Delta ENC_{t-1} + 0.32 \Delta GDP_{t-1} - 0.35 \Delta CSPV_{t-1} - 0.007 CO_2 - 0.54 ECM_{t-1} + u_t \quad (1)$$

(-3.86)            (1.55)            (-2.36)            (-4.01)            (-4.37)

$$\Delta GDP_t = 0.02 + 0.11 \Delta ENC_{t-1} - 0.19 \Delta GDP_{t-1} - 0.11 \Delta CSPV_{t-1} - 0.003 CO_2 - 0.29 ECM_{t-1} + \varepsilon_t \quad (2)$$

(1.26)            (-1.26)            (-1.00)            (-3.16)

$$\Delta CSPV_t = 0.03 - 0.13 \Delta ENC_{t-1} + 0.22 \Delta GDP_{t-1} + 0.37 \Delta CSPV_{t-1} + 0.012 CO_2 + 0.14 ECM_{t-1} + z_t \quad (3)$$

(-1.16)            (1.15)            (2.61)            (6.62)            (1.18)

**F-statistic = 18.9 (the model is strongly significant)**

**R<sup>2</sup> = 0.75 (Excellent quality of adjustment)**

The statistical advantage of error correction equations is that they permit to find the sense of long-term causality between variables through a test of weak exogeneity. This test consists in testing the significance of the coefficient associated on the correction term (ECM); if it is significant and with negative sign it is said not weakly exogenous.

Equation (1) and (2) demonstrates that these two coefficients are not weakly exogenous. On Equation (3), this coefficient is weakly exogenous: thus, the following

sense of causality<sup>6</sup>:

$$ENC \rightarrow GDP$$

$$GDP \rightarrow ENC$$

Bidirectionnel long term causality

$$ENC \rightarrow CSPV$$

Unidirectionnel long term causality

<sup>6</sup>We can also detect another long term causality running from GDP to CSPV

**Table 3.** Granger causality test.

Null hypothesis	Obs	F-Statistic	Prob.
GDP does not granger cause ENC	38	0.09726	0.7570
ENC does not granger cause GDP		0.10474	0.7481
CSPV does not granger cause ENC	38	8.37230	0.0065
ENC does not granger cause CSPV		0.79774	0.3779
CO <sub>2</sub> does not granger cause ENC	38	1.52853	0.2246
ENC does not granger cause CO <sub>2</sub>		0.08407	0.7736
CSPV does not granger cause GDP	38	3.11858	0.0861
GDP does not granger cause CSPV		0.82530	0.3698
CO <sub>2</sub> does not granger cause GDP	38	0.11288	0.7389
GDP does not granger cause CO <sub>2</sub>		0.08096	0.7777
CO <sub>2</sub> does not granger cause CSPV	38	31.2195	3. E-06
CSPV does not granger cause CO <sub>2</sub>		0.49421	0.4867

Pairwise Granger causality tests. Date: 01/10/11. Time: 15:28 Sample: 1972 2010. Lags: 1

**Table 4.** Decomposition of the variance of ENC.

Period	S.E.	ENC	GDP	CSPV	CO <sub>2</sub>
1	0.035972	100.0000	0.000000	0.000000	0.000000
2	0.042791	73.91498	7.837790	18.24690	0.000328
3	0.049173	66.61998	15.58589	17.27478	0.519358
4	0.053134	57.06138	19.23254	22.89010	0.815973
5	0.057303	53.16702	22.55727	23.42930	0.846409
6	0.060564	47.84231	24.90930	26.26004	0.988350
7	0.063998	44.87517	27.09868	26.96822	1.057937
8	0.066949	41.51573	28.72583	28.62190	1.136545
9	0.069952	39.29880	30.20355	29.31238	1.185270
10	0.072697	36.99064	31.40343	30.36472	1.241202

We can also deduct from Equation (1) that the speed of adjustment that permit to reestablish the equilibrium of ENC is 54% so, under the effects of ENC (own variations), GDP, CSPV and CO<sub>2</sub>; 54% of fluctuation of ENC can be corrected<sup>7</sup>: This result is consistent and reinforce our good choice of explanatory variables and our empirical findings. Table 3 present the short term causality between variables.

One short term causality can be found; running from ENC to CSPV.

ENC → CSPV

Unidirectionnel short term causality

As shown on Table 4, the decomposition of the variance of ENC is explained in particular by the fluctuation of GDP and CSPV. In year 6, more than 50% of the

<sup>7</sup>Equation (2) Shows that 29% of disequilibrium of GDP can be reestablish under the effects of GDP, ENC, CSPV and CO<sub>2</sub>.

<sup>8</sup>Another short term causality from GDP to CSPV.

variance of the endogenous variable ENC is caused respectively by GDP (25%) and CSPV (25%). This finding justifies the positive link shown on cointegration equation between ENC, GDP and CSPV and confirms our conclusion about the effect of economic growth and financial development in stimulating energy consumption in Tunisia.

Figure 1 precise the response of (ENC) S.D innovations and highlight that energy consumption reacts negatively following a shocks on GDP and (CSPV): this reaction reflects the sensibility of the energetic variable to economic growth or financial development shocks.

## Conclusion

The determinants of the energy consumption and the link energy-economic growth are the main issues discussed in this work.

Whereas the majority of the energy consumption; this work includes another critical variable such as the

Response to Cholesky One S.D. Innovations

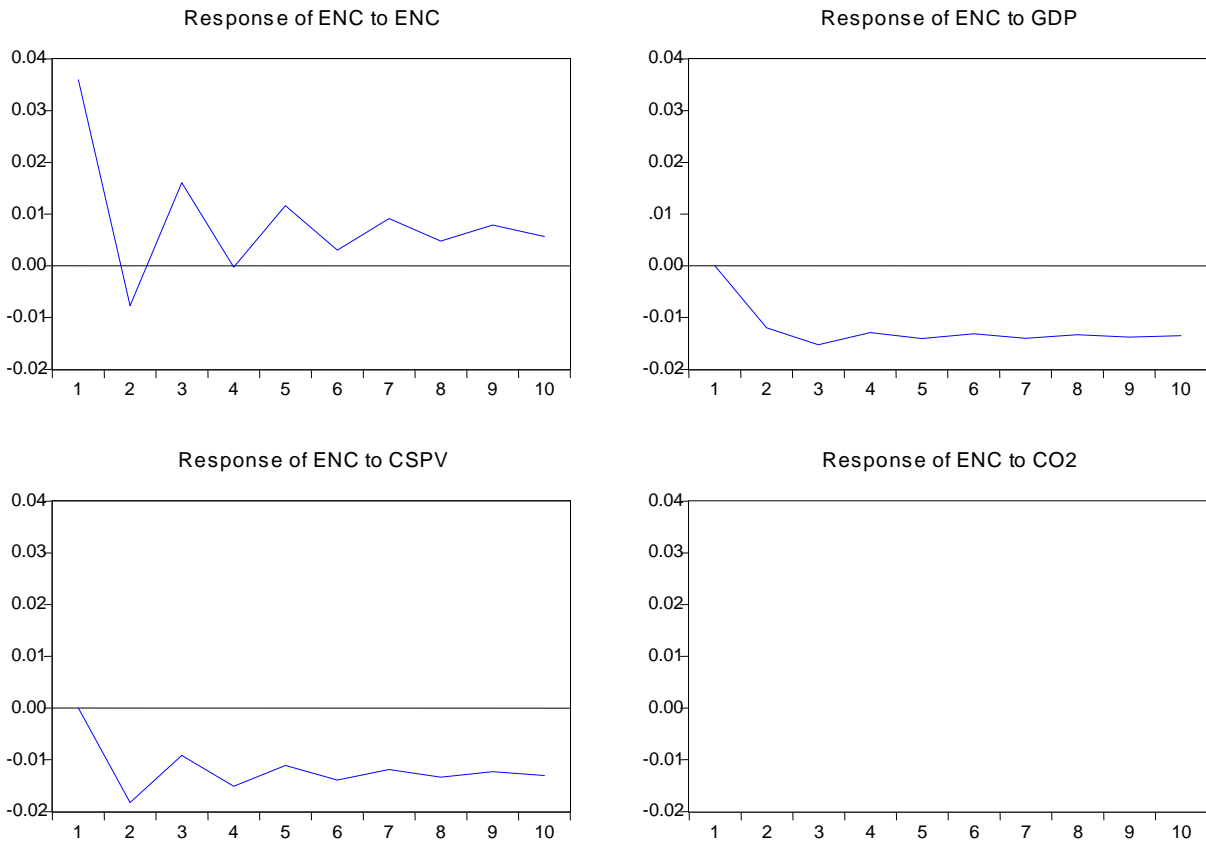


Figure 1. Response one ENC S.D innovations.

financial development measured by the credits allocated to the private sector and those in accordance with the recent work in the empirical literature.

While the economic growth permit to created a heavy investment projects in various sectors in the economy and which require an extensive use of the energy ,the financial development constitutes a capital variable for an efficient use of energy which combines both the rationality in the energy consumption and the best allocation toward productive sectors and high profitability.

Our empirical results show that in Tunisia; the link between energy consumption and economic growth detected on the cointegration equation is positive and there is bidirectional causality between these two variables on the long term. This finding proves the dependence of the Tunisian economy to the energy regarding the modest resources of the country on different forms of energy. In this sense, Tunisia has registered a deficit on its energy balance on 1990 and 2001 that is why it is very crucial to find others sources of energy like the renewable energies.

We conclude that energy is a limiting factor to GDP growth in Tunisia, and, therefore, shocks to the energy supply will have a negative effect on GDP. A high level of

economic growth leads to a high level of energy demand and vice versa.

Indeed, we find a positive correlation between energy consumption and financial development (with a proxy: credits allocated to the private sector): the focus on the error correction equation detected demonstrates that's on the long term energy consumption causes the financial development. This result is very important because it reflects another channel by witch energy consumption positively affects economic growth is the financial sector: in this way, demand of energy by householders and investors permit to diversify the modality of financing this needs and so spur financial sector in Tunisia: This result seems to be the most contribution on this work.

Empirically, on the error correction equation, in which the endogenous variable is energy consumption, 54% of the disequilibrium oh this latter is corrected under the effects of its lagged values, economic growth, credit to the private sector and the emission of CO<sub>2</sub>: we can conclude that the speed of adjustment is very interesting and confirms the statistic availability of the model.

On this way, the decomposition of variance of energy consumption is more explained by economic growth and credit to the private sector and in the six year 50% of the



deviation is due to these two variables. Tunisia's economy is also energy-dependent and is relatively vulnerable to energy shocks.

In order not to adversely affect economic growth, energy conservation policies that aim at curtailing energy use must instead find ways of reducing consumer demand. In the long run, for Tunisia's development to be sustainable, Tunisia has to change its economic structure to a more efficiency-oriented and less resource-depleting one and rely more on renewable energy sources. Renewable energy technologies have an enormous potential to solve energy problems in Tunisia. The energy provided by the sun (solar energy) is many times greater than the current energy demand. The wind, waves and tides have a large potential as well.

In this way, a strategic study on the development of renewable energy in Tunisia in 2004 showed that Tunisia has high potential for valorization of modern renewable energies. The mobilization of this potential will allow for significant improvement of the contribution of renewable energies in the consumption of primary energy.

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