The Relationship of Oil Prices and Economic Growth in Tunisia: A Vector Error Correction Model Analysis

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This paper seeks to investigate the causal relationship between oil prices and economic growth in Tunisia over a period from 1960 to 2009. The empirical analysis starts by analyzing the time series properties of the data which is followed by examining the nature of causality among the variables. Tunisian is not oil producing rather oil-importing country. An increase in oil price decrease economic growth. The rising oil prices are the major concern for all the developing economies and Tunisian is suffering from it too. The increase in oil price has further effect the daily consumption pattern of households badly. This study analyzes that, how change in real crude oil price effects the real GDP of Tunisia negatively and many other factors differently. The results show that both series are integrated of order one (I(1)), the existence of a long-term relationship between energy prices and economic growth and Granger pairwise causality test revealed unidirectional causality from real GDP to oil prices.

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1.Introduction

After the two oil shocks in 1973 and 1979, energy markets have become complex and volatile. The confrontation between oil supply and demand sets each day an unstable equilibrium based on many factors. Indeed, the instantaneous oil demand depends on many factors (economic growth level, changes in temperature and expectations of applications ...). In other words, oil supply depends on meeting quotas of member countries of OPEC and the social and political events affecting production or transportation (strike in Nigeria, government intervention in Venezuela).

Oil prices are characterized by strong fluctuations. This volatility has reached its limits in 1998 when the Brent price fell below $ 10 by barrel, a price that some economists regard as close to the price of perfect competition. The explanation of this volatility in oil prices stems from geopolitical issues that determine a price range is important. The determination of oil prices appears to be dependent on many factors:

Political factors:

• Lack of security: Iraq war, possible terrorist attacks in Saudi Arabia, Iran threat, Hugo Chavez declarations...

• *Uncertainty about future investment in the general context:* nationalist reflexes, close to foreign investors, tightening fiscal, policy instability, social unrest...

Situational factors:

• *Exchange rate euro / dollar "impact on oil prices.*

• *Decreases inventory.*

• *Climate Change.*

Soaring oil prices was triggered in 2003 with acceleration from 2004 who have reached the $ 78 by barrel with fluctuations at 5 to 10% from one week to another in 2005.
However since September 2005, the upward trend in prices marked acceleration. Indeed, the Brent price crude raised $ 10 in early 1999 to $ 73 in August 2006 and $ 93 in October 2007. The prices are seeing as fast as the outbreak. After beating the record $ 78 by barrel, oil is trading these days about $ 98 by barrel.

Moreover, the several studies to draw additional conclude. Thus, the effect of oil shocks is asymmetric. Indeed, rising oil prices have a larger impact that cuts on economic growth (and to a lesser extent inflation). This finding may be explained by downward rigidities of wages and prices. Moreover, the allocate effects on the labor market and uncertainty in financial markets as a result of fluctuations in oil prices. An obvious conclusion is that the impact of dearer oil is generally more pronounced in developing countries than in advanced countries. The oil has indeed a more important place in those countries mainly because of the weight of manufacturing and machinery generally less modern. This leads us to ask: ***What is the impact of a continuous increase of oil prices on economic growth in Tunisia?***

The remaining of the paper is organized in the following way. Section II dwells on literature review. Section III presents the econometric methodology, section IV contains empirical results and discussion, and finally, concludes are drawn in section V.

Literature Review

A number of empirical studies have explored the relationship between economic growth and oil price. Hamilton (1983) was showed a negative relationship between oil prices and macroeconomic activity in the United States. Hooker (1994) confirmed Hamilton's results and demonstrated that from 1948 to 1972, oil price variability exert influence on GDP growth. His results show that an increase of 10% in oil prices led to a lower GDP growth of roughly 0.6 % in the third and fourth quarters after the shock. Later, Mork (1989), Lee et al., (1995) and Hamilton (1996) introduced non-linear transformations into the models and Granger causality tests. Results confirmed incidence of negative relationship between oil prices fluctuations and economic downturns as well as Granger causality from oil prices to growth before 1973 but no Granger causality from 1973 to 1994. Other studies include: Mork (1989), Federer (1996), Hamilton (1997), Lee and Ni (2002) and Balke et al., (2002).

Recently, Gounder and Barleet (2007) using both linear and nonlinear oil price transformation discovered a direct link between net oil price shock and economic growth in New Zealand. In addition, oil price shock was discovered to have substantial effect on inflation and exchange rate. In a comparative study of the impact of oil price shock and exchange rate volatility on economic growth, Jin (2008) discovered that the oil price increases exerts a negative impact on economic growth in Japan and China and a positive impact on economic growth of Russia. Specifically, a 10% permanent increase in international oil prices is associated with a 5.16% growth in Russian GDP and a 1.07% decrease in Japanese GDP.

Methodology

1. Granger Causality Tests Effect

Several studies have been devoted to the study of causality between variables (Granger, 1969; Sims, 1972). Furthermore, we carried out the Granger causality test where Granger (1969) proposed a time series data based approach in order to determine causality. For example if we want to explore the causal relationship between oil prices (p_t) and economic growth (y_t):

$$p_t = \sum_{i=1}^{n} \alpha_i p_{t-i} + \sum_{i=1}^{n} \beta_i y_{t-i} + \varepsilon_{1t}$$
(3.1)

$$y_t = \sum_{i=1}^{n} \lambda_i p_{t-i} + \sum_{i=1}^{n} \delta_i y_{t-i} + \varepsilon_{2t}$$
(3.2)

With n the number of lags
If β_i coefficients are jointly significantly different from zero, the Granger test suggests that oil prices (p_t) is a cause of real GDP (y_t) and if λ_i is jointly significantly different from zero, the Granger test suggests that real GDP (y_t) is a cause of oil prices (p_t).
If the two causalities are verified, we can conclude the return causality "feedback causality" between the two variables.

2. Causality Test and Cointegration Variable

The relationship causality between different time series is based as following steps:

2.1. Unit Root Tests

The vector error correction model results to lead us to examine the stationary of the series. A stochastic process is stationary if its first and second moments are constant.
Analytically, y_t is stationary if:

$$E(y_t) = \mu \quad \forall t$$
(3.3)

$$E\left[(y_t - \mu)(y_{t-h} - \mu)'\right] = \Gamma_y(h) = \Gamma_y(-h)'$$
(3.4)
With $\Gamma_y(h)$ is a finite covariance matrix.

Dickey-Fuller (DF) tests is that the non-stationary statistical series. In other words, this test detects the presence or absence of a unit root. Base models of the construction of this test are:

$$\Delta y_t = (\varnothing_1 - 1)y_{t-1} + \varepsilon_t$$
$$\Delta y_t = (\varnothing_1 - 1)y_{t-1} + \beta + \varepsilon_t$$
$$\Delta y_t = (\varnothing_1 - 1)y_{t-1} + \beta + \partial t + \varepsilon_t$$
(3.5)

By using the statistical Student's $t = \frac{\hat{\varnothing}_1 - 1}{\sigma_{\hat{\varnothing}_1}}$, unit root test using:

$$\begin{cases} H_0 : |\varnothing_1| = 1 \\ H_1 : |\varnothing_1| \langle 1 \end{cases}$$

To get a broader view, Dickey-Fuller took an autoregressive process of higher order known as the Augmented Dickey-Fuller (ADF). This test is represented as a following:

$$\Delta y_t = (\varnothing_1 - 1)y_{t-1} + \sum_i \theta_i \Delta y_{t-i} + \varepsilon_t$$
$$\Delta y_t = (\varnothing_1 - 1)y_{t-1} + \sum_i \theta_i \Delta y_{t-i} + \beta + \varepsilon_t$$
$$\Delta y_t = (\varnothing_1 - 1)y_{t-1} + \sum_i \theta_i \Delta y_{t-i} + \beta + \partial t + \varepsilon_t$$
(3.6)

2.2. Cointegration

The main objective of this paper is to assess not only the pairwise nature of causality among the variables, but, also the short run and long run dynamic impact as well, we tested for cointegration using two well known approaches: the one developed by Engle and Granger (1987) and the other one by Johansen (1988).

2.2.1. Engel - Granger Method

The Engle–Granger test is a procedure that involves an OLS estimation of a pre-specified cointegrating regression between the variables. This was followed by a unit root test performed on the regression residuals previously identified. We applied the Engle-Granger two-step procedure:

Step 1: Static regression between integrated variables.

Step 2: Test to verify the residual stationary.

This procedure has some weaknesses, as the test is sensitive to which variable is used as a conditioning left-hand-side variable, which is problematic in the case of more than two variables.

2.2.2. Johansen method

Johansen developed the maximum likelihood estimator for cointegration analysis. Johansen's cointegration test is used as a starting point in the vector autoregression (VAR) model. The vector autoregression model of order *p* (VAR (*p*)) is constructed as a following equation:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + C + \varepsilon_t$$

(3.7)

The number of cointegrating relationship of the system is based on determining the rank of the matrix $\prod$. Three cases are distinguished:

- If rank Π=0, then the matrix Π is null and the VAR model to writing as a VAR in difference.
- If rank Π = n, then the matrix Π is full rank and y_t is stationary
- If 0 < rank Π = r <n, then there are r cointegrating relationship between the process which consists Y_t.

The Lokelihood ratio is the ratio that gives the LR statistic defined as follows:

$$LR = -T\sum_{i=r+1}^{K}\log(1-\lambda_i) \qquad for\ r = 0.1..........K-1$$

(3.8)

With T: The number of observations

λ : The eigenvalue of the matrix Π

K: number of variables

r: rank of matrix Π

The number of cointegrating relationship is determined by through a sequential procedure. The decision rule is as a following:

- If rank Π=0 (r = 0), we test the hypothesis H_0: r = 0 against H1: r> 0, if LR is greater than the critical value, we reject H_0 and we move to the next step.
- We test the hypothesis H_0: r = 1 against H_1: r> 1 if H_0 is rejected, we proceed to the next test.
- If after rejecting the various hypotheses H_0, the last step, we test H_0: r = K-1 against H_1: r = K.

2.3. An Error Correction Model

For interpret the vector error correction model found in the different regression equations. Indeed, an error correction model (ECM) can detect the dynamics of short-term and long term of a variable around its stationary equilibrium value. Thus, for an adjustment error correction requires that the sign of the coefficient of the residual is negative and statistically significant. In this regard, the higher the absolute value of the coefficient is higher, faster we reach the long-run equilibrium.

The model error correction reads:

$$\Delta p_t = \alpha_1 z_{t-1} + lagged(\Delta p_t, \Delta y_t) + \varepsilon_{1t}$$

(3.9)

$$\Delta y_t = \alpha_2 z_{t-1} + lagged(\Delta p_t, \Delta y_t) + \varepsilon_{2t}$$

(3.10)

With z_{t-1} the error correction term to resulting from estimating the cointegrating relationship, ε is the error term stationary $|\alpha_1| + |\alpha_2| \neq 0$.

2.4. Causality Test

The causality test based on the model vector error correction has the advantage of providing a causal relationship even if no estimated coefficient of lagged variables used is significant. Thus, an error correction model after processing can be rewritten as following equations:

$$\Delta p_t = \alpha + \sum_{i=1}^{k} \lambda_i \Delta p_{t-i} + \sum_{i=1}^{k} \delta_i \Delta y_{t-i} + \theta z_{t-1} + \varepsilon_t$$

(3.11)

$$\Delta y_t = \beta + \sum_{i=1}^{k} \phi_i \Delta y_{t-i} + \sum_{i=1}^{k} \varphi_i \Delta p_{t-i} + \psi z_{t-1} + \mu_t$$

(3.12)

From these both equations, p_t does not cause y_t the sense of Granger if $\varphi_i = \psi = 0$, y_t does not cause p_t if $\delta_i = \theta = 0$.

IV. Empirical Results and Interpretation

Statistical Data Properties

The variables that we used in our application are the real GDP and the oil price (p_t). We applied the natural logarithm to homogenize the data and smooth the fluctuations.
Figure 1 shows the evolution of real GDP and oil price in Tunisia from 1961 to 2009.
The real GDP is characterized by an upward trend while the price of oil is presented as an additive model. The correlation between the real GDP and oil price is 0.68.
However, it should be noted the continuing rise in oil prices since 1997. This increase was due to continuing political factors and other cyclical order.

Figure 1

Real GDP and oil price evolution

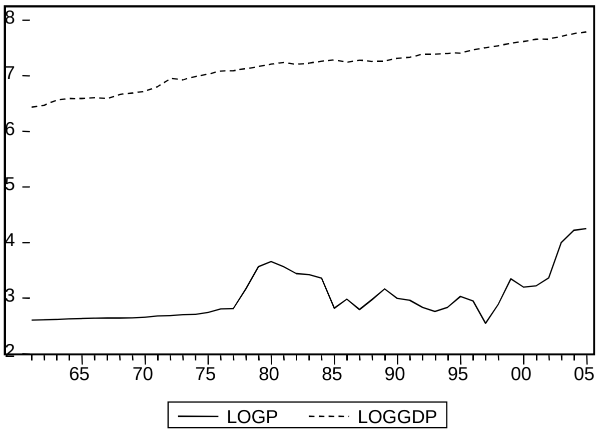
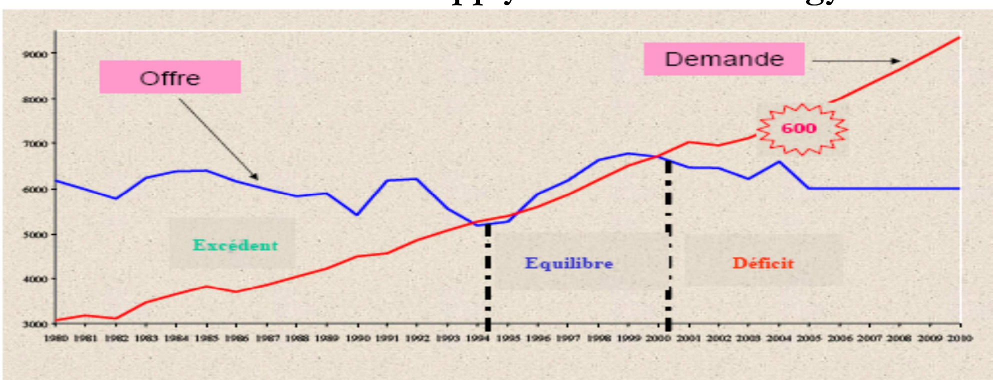


Figure 2 shows the likely supply and demand energy in Tunisia between 1980 and 2010. This figure reveals the energy resources that has caused and largely fueled the economic growth especially during the 80s. Now become a heavy burden on the economy, particularly in the current context soaring oil prices. This situation pushes the Tunisian authorities to adopt an energy policy appropriate and compatible with sustainable development.

Figure 2
Evolution of supply and demand energy in Tunisia



2- Unit Root Tests

Table 1 represents the results of unit root tests. The results show that all the series are non stationary at level. Taking the variables in their first difference, results show that all are I(1) at 1 percent level of significance. For consistency, therefore, all the series were considered as I(1) and taken at their first difference in the analysis.

Table 1

Unit Root Tests

	Test de Dickey-Fuller						
Variable	**Level**			**First difference**			
	DF	DW	R^2	DF	DW	R^2	Order
Log (P)	-1.76	1.96	0.11	-5.00***	1.99	0.46	1
Log(GDP)	-1.86	1.91	0.10	-4.69***	1.99	0.55	1

***, ** and * denote rejections of the null hypothesis at the 1%, 5% and 10% levels

Critical values of DF test: 1% -4.19; 5% -3.52; 10% -3.19

3. Johansen Cointegration Tests

The different models are construed as a following:

- ***Model 1:*** no constant and linear trends in the VAR and the cointegrating relationship.
- ***Model 2:*** no constant (linear trends) in the VAR, but the cointegrating relationship includes a constant (not linear trends).
- ***Model 3:*** there are constants (no linear trends) in the VAR and the cointegrating relationship.
- ***Model 4:*** there are constants (no linear trends) in the VAR, but the cointegrating relationship includes a constant and linear trends.
- ***Model 5:*** the existence of a quadratic trend in each component of the system.

Table 2

Model and Number of lags k Choice

	Akaike Information Criteria by Model and Rank				
0	-3.795106	-3.795106	-4.117353	-4.117353	-4.174197*
1	-4.084645	-4.060432	-4.054867	-4.049968	-4.013275
2	-3.935168	-3.941318	-3.941318	-3.929215	-3.929215

Akaike information criterion has been used to find an appropriate model and number lags (Model 5 for r = 0 and k= 1). This model indicates the presence of a quadratic trend in each component of the system.

Table 3 presents the test results for the number of cointegrating vectors. The results show that the trace statistic suggests the presence of one cointegrating equation among the two variables in the Tunisian economy at 1 percent level.

Table 3

Johansen Cointegration Test

Test de la trace				
Null Hypothesis	alternative hypothesis	Trace	5%	1%
r=0	r≥1	9.76	18.17	23.46
r≤1	r≥2	4.38	3.74	6.40

4. An Error Correction Model Estimate

Next we apply the Johansen procedure to obtain the long run coefficients of the model. Table 4 presents the normalized coefficient of the variables in the model. The coefficient was correctly signed and statistically significant at 1 percent level. A variable depict negative relationship with the log of real GDP. This is consistent with the expectation for an oil importer country like Tunisia. Similar findings were reported by Grounder and Barleet (2007) and Jin (2008) like New Zealand and Japan, which are a net oil importer. Theoretically, positive sign is, however, expected for net oil exporting countries.

Thus, we can derive the cointegrating equation from the above results – with log of real GDP as the regress and while log of oil price as regressors, as follows:

LOGPIB = -0.366047 LOGP- 0.021237 TREND -5.572572 (3.13)

(-1.88383)

Looking critically at the numerical values of the coefficients and their respective signs, Equation (3.13) is saying that a 10 percent permanent increase in crude oil price internationally will cause the real GDP to decrease by 3.36 percent, while the same 10 percent. This shows that Tunisia's GDP decreases more by oil price increase.

Table 4

Vector Error Correction Model

Date: 11/09/09 Time: 18:47
Sample (adjusted): 1963 2009
Included observations: 47 after adjusting endpoints
Standard errors & t-statistics in parentheses

Cointegrating Eq:	CointEq1	
LOGGDP(-1)	1.000000	
LOGP(-1)	-0.366047	
	(0.19431)	
	(-1.88383)	
@TREND(61)	-0.021237	
C	-5.572572	
Error Correction:	D(LOGGDP)	D(LOGP)
CointEq1	-0.015122	0.765843
	(0.05777)	(0.34156)
	(-0.26177)	(2.24222)
D(LOGGDP(-1))	-0.061577	-0.523313
	(0.15337)	(0.90684)
	(-0.40149)	(-0.57708)
D(LOGP(-1))	0.054628	0.310594
	(0.02971)	(0.17565)
	(1.83885)	(1.76821)
C	0.041302	0.004665
	(0.01233)	(0.07290)

	(3.34986)	(0.06399)
@TREND(61)	-0.000467	0.001648
	(0.00043)	(0.00252)
	(-1.09499)	(0.65371)
R-squared	0.136114	0.152131
Adj. R-squared	0.045178	0.062882
Sum sq. resids	0.043325	1.514668
S.E. equation	0.033766	0.199649
F-statistic	1.496818	1.704563
Log likelihood	87.34072	10.92472
Akaike AIC	-3.829801	-0.275569
Schwarz SC	-3.625010	-0.070778
Mean dependent	0.030729	0.038189
S.D. dependent	0.034555	0.206239
Determinant Residual Covariance		3.55E-05
Log Likelihood		98.28541
Akaike Information Criteria		-4.013275
Schwarz Criteria		-3.521777

The estimation of this model shows the existence of a long-term relationship between oil prices and economic growth. This is explained by the fact that the coefficient of error correction is negative and significant in the equation of GDP. Moreover, this coefficient indicates that in case of unbalanced short-term economic growth converges more slowly towards its equilibrium state with a speed of about 1.5%.

5. Granger Causality Test

Causality tests between oil prices and economic growth by the vector error correction model shows the existence of a unidirectional causality emanates from economic growth (LogGDP) to oil price (LogP). Table 5 presents the results of pairwise Granger causality among the real GDP and oil price. This is consistent with the expectation and with the realities in the Tunisian economy, that is, a rise in oil prices could leads to no reduce the Tunisian development economic.

Table 5

Pairwise Granger causality test

Pairwise Granger Causality Tests
Date: 10/09/09 Time: 10:39
Sample: 1961 2009
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
LOGP does not Granger Cause LOGGDP	48	0.18694	0.66774
LOGGDP does not Granger Cause LOGP		3.06551	0.08745

Conclusion

This paper employs an empirical analysis to examine the impacts of oil price fluctuations on the level of real economic activity in Tunisia using a sample of observations from 1960 to 2009. The first step in the empirical analysis involves testing the time series characteristics of the data series using ADF test and running the pairwise Granger causality test. This was followed by applying the Johansen cointegration test and the estimation of the long run cointegrating vectors. The analysis was capped with the estimation of short run Vector Error Correction Model (VECM).

We found that the variables were characterized by a unit root at level, but, the hypothesis of non stationarity was rejected at first difference. This is consistent with strand of empirical studies on characteristic of time series data, which according to Engle-Granger require differencing before they could attain stationarity. The Granger pairwise causality test showed that the null hypotheses that oil price shock each do not Granger cause real GDP could be safely rejected at the 1 percent level. In other words, oil price shock each Granger cause real GDP in Nigeria within the period of the study. These findings expose the fact that international oil price is a key variable that influence economic growth in Tunisia within the sample period. A number of empirical studies earlier cited in the paper have reported similar findings, namely, Mork (1989), Hamilton (1996 and 1997), Balke *et al.*, (2002) and Jin (2008).

Next, the Johansen cointegration test revealed one cointegrating equation at 1 percent level using the trace statistic. Using the long run vector coefficients, we examined the sensitivity of real GDP in Tunisia to shock in international oil prices. The results of the long run analysis, for instance, indicated a 10 percent permanent increase in crude oil price internationally will cause the real GDP to decrease by 3.36 percent. This shows that Tunisia's GDP decreases more by oil price increase and this is consistent with the expectation. Finally, the results from the short run vector error correction model showed the coefficient is correctly signed and statistically significant. This implies that long run equilibrium condition influences the short run dynamics. Real GDP in Tunisia has an automatic adjustment mechanism and that the economy responds to deviations from equilibrium in a balancing manner.

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