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Abstract:

The design of this dissertation consists of shortening the nuance of pollution on Tunisian economic growth, taking into account domestic investment, energy consumption and trade openness. From 1971 to 2015, this impact is tested using the error correction model (ECM). The final consequences of estimating the long-run equilibrium relation show that pollution has a negative effect on economic growth in Tunisia but this facet is insignificant. This means that during this period pollution did not result in a reduction in economic growth, however, this result indicates that after an interval of years indeterminate pollution will negatively affect economic growth, The Tunisian State to demonstrate economic policies and instruments to protect it against the worsening of the future effects of pollution.

Keys Words: Pollution, Economic Growth, ECM, Economic Policy, Tunisia.

JEL Classification: O46, Q50.

I. Introduction

Over the past two decades, the interference between economic growth and carbon dioxide emissions has been represented as the fate of an increasing national and international subject, and is both complex and complex. Fundamentally, economic growth and the environment are linked because all economic activity is based on the environment. It is the latter that is produced directly by all basic inputs (metals, minerals, soil, and forest cover and fishery resources) and the energy required for their joints. This is also the environment that extracts the waste resulting from economic activity. However, following the addition of the scale of production a real deterioration of the environment is recognized. It is for these reasons; this phenomenon is now part of the political and economic choices of our countries. Nowadays, many countries, in particular developing countries and transition countries, are confronted with a constitutional challenge, namely, to take into account multidirectional suspenders between the economic, social and environmental aspects of development, so that they can simultaneously fight Poverty, develop their economic prospects and protect the environment. The neo-classical theory of the original growth of Solow (1956 and 1988) is the small, widely spread starting portion for modeling economic growth. Cass (1965) and Koopmans (1967) developed this theory in the form used in modeling that includes the interrelationships between the environment and economic growth. Maler (1974) and Uzawa (1975) presented neo-classical theories of economic growth that included and emphasized the reduction of pollution. Also, Solow (1974) provided an analysis that demonstrates that supply and demand for the use of products that cause pollution is exhaustible. a vast literature has been generated because of these theories as Keeler, Spence and Zeckhauser (1971), Forster (1973), Mäler (1974), Brock (1973), Gruver (1976), Dasgupta and Heal (1979), Becker (1982) and Luptacik and Schubert (1982). The question of causal relationship between CO2 emissions and economic growth has been well-studied in the economics literature. Different studies have focused on different countries, time periods, proxy variables and the different environment and growth relationship. The empirical outcomes of these studies have been varied and sometimes conflicting. The results seem to be different on the direction of causality and long-term versus short-term impact on energy policy. The relationship between economic growth and CO2 emissions, has been an active research area Selden and Song (1994); Shafik (1994); Agras and Chapman (1999); Heil and Selden (1999); Friedl and Getzner (2003); Jumbe (2004); Al-Iriani (2006); Dinda and Coondoo (2006); Ang (2007); Halicioglu (2007); Galeotti, Manera and Lanza (2009); Halicioglu (2009); Soytas et al (2007); Sheinbaum-Pardo et al (2012); Lean and Smith (2009); Chang et al (2009); Apergis and Payne (2009, 2010); Bartleet and Gounder (2010); Fodha and Zaghdoud (2010); Menyah and Rufael (2010); Ozturk (2010); Ozturk and Acaravci (2010); Jaunky (2011); Niu et al (2011); Pao and Tsai (2011); Arouri et al (2012); Omri, Nguyen and Rault (2014). Our objective, in this study, is to investigate the impact of CO2 emissions on economic growth for a time series of Tunisia during 1961 – 2015. The remainder of the study is systematic as follow: Section 2 talks about the data and methodology used in the study. Section 3 discusses the results in detail while Section 4 concludes the study with some policy implications.

II. Data and Methodology

The purpose of this study is to analyze the impact of pollution on economic growth in the case of Tunisia using annual data over the period of 1961 – 2015. In this study, we employed Cobb-Douglas production function to analyze the effect of pollution on economic growth including energy usage, trade openness and domestic investment as an additional factors of production.

Generally, the equation of the production function is written as follows:

$$\boldsymbol{Y = ACO_2^{\alpha 1} CE^{\alpha 2} T^{\alpha 3} DI^{\alpha 4}} \quad \textbf{(1)}$$

In Equation (1), Y is GDP per capita (measured in constant US \$),CO_2 is pollution measured in metric tons per capita, CE is energy consumption (measured as kg of oil equivalent per capita), T is real trade per capita (measured in constant US \$) , DI is domestic investment per capita (measured in constant US \$), while A shows the level of technology (assumed to be constant) utilized in the country. The returns to scale are associated with pollution, energy consumption, trade and domestic investment which are shown by α_1 , α_2 , α_3 and α_4 respectively. All the series are switched into logarithms in order to make linear the nonlinear form of Cobb–Douglas production.

The Cobb–Douglas production function is sculptured in linear functional form as follows:

$$\boldsymbol{Y_t = A + \alpha_1 CO_{2t} + \alpha_2 EC_t + \alpha_3 T_t + \alpha_4 DI_t + \varepsilon_t} \quad \textbf{(2)}$$

The overhead empirical will explore the influence of pollution on economic growth by keeping technology constant.

The linear model rendering the impact of pollution on economic growth after keeping technology constant can be written as follows:

$$\boldsymbol{Y_t = \alpha_0 + \alpha_1 CO_{2t} + \alpha_2 EC_t + \alpha_3 T_t + \alpha_4 DI_t + \varepsilon_t} \quad \textbf{(3)}$$

Where ε is error term and t is time index. This investigation clenches the Unit Root test, Cointegration, and an Error-Correction Modeling method to the initial model of pollution and growth, especially to detect the impact of pollution on economic growth in the long run and the short run.

III. Empirical Analysis

1) Tests for unit root

Coherent with the semblance of the bending [Log (GDP), Log (Domestic Investment), Log (Trade), Log (CO2) and Log (CE)], we adhere awarding to their general instruction at the selfsame time and the same movement, which put their stationary in level. For this ground, we are committed to testing the stationary of the variables employed in our model, in order to ascertain whether or not the stature of a unit root is the same we will use the augmented Dickey and Fuller (1979) (ADF) test. The general form of ADF test is estimated by the following regression:

$$\Delta \mathrm{Y}_t = \alpha + \beta \mathrm{Y}_{t-1} + \sum_{i=0}^{n} \beta_i \Delta \mathrm{Y}_i + \varepsilon_t \quad (4)$$

Where Δ is the first difference operator, Y is a time series, t is a linear time trend, α is a constant, n is the optimum number of lags in the dependent variable and ε is the random error term.

Table 2: Unit roots test

	ADF Test	Probability
Log (GDP)	9.195453	0.0000
Log (Domestic Investment)	4.376572	0.0011
Log (Trade)	6.643007	0.0000
Log (CO2)	8.394365	0.0000
Log (CE)	10.38637	0.0000

These marks denoted that study variables are trended and non-stationary when well-respected team at a level. However, after taking variables at first difference, all variables became stationary and integrated of order one i.e. I (1).

2) Cointegration Analysis

To ascertain the cointegration amongst the variables elaborated, it is needful to get across through two stages. First of all, it is essential to itemize the number of optimal delay which must be apt for our model. Then we will harness the Johanson Test to state the number of cointegration relationships between variables.

a- Lag Order Selection Criteria

The picking of the number of the lag has a very substantial role in the conception of a VAR model. Practically, most of VAR models are considered to entangle symmetric lags, he same lag length is exerted for all variables in all equations of the model. This lag length is often chosen tapping a specific statistical criterion such as the HQ, FPE, AIC or SIC.

Table 3: Lag Order Selection Criteria

VAR Lag Order Selection Criteria						
Lag	Log L	LR	FPE	AIC	SC	HQ
0	354.0384	NA	2.77e-14	-17.02627	-16.81729*	-16.95017
1	394.7173	69.45170*	1.31e-14*	-17.79109*	-16.53725	-17.33451*
2	412.3079	25.74243	1.98e-14	-17.42966	-15.13096	-16.59260
3	430.7354	22.47248	3.18e-14	-17.10904	-13.76549	-15.89150
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Generally, all the criteria for selecting the number of delays are acceptable since it has values greater than 5%. But, we are making our selection on the basis of the highest criterion (AIC). On the other hand, with regard to the selection of the number of the delay, we can make a choice using an economic aspect for voice that becomes the relation between the variables after a year since we work with an annual time series. But our case the choice of the optimum delay number is compatible with the economic reality (Number of delay = 1).

b- Johanson Test

Once the behest of integration is fixed for each series and the number of lags is determined, it may prosecute to the second step to assess the cointegration properties of variables. The cointegration test is to sight whether {Log (GDP), Log (DI), Log (Trade), Log (CE) and Log (CO2)} are individually non-stationary but become stationary when they are linearly combined. Two time series are said to be cointegrated if they have a long-term or an equilibrium relationship, although they may deviate from each other in the short term. There exist many approaches to test the possible existence of cointegration in the data set of macro variables. The popular approach to estimate the cointegration is Johansen test given by Johansen (1988) and Johansen and Juselius (1990) which is a vector auto-regression (VAR) based test. After determining the order of integration, two statistics named trace statistics ($\boldsymbol{\lambda}_{Trace}$) and maximum Eigenvalue ($\boldsymbol{\lambda}_{Max}$) are used to determine the number of cointegrating vectors. In trace statistics, the following VAR is estimated.

$$\Delta y_t = r_1 \Delta y_{t-1} + r_2 \Delta y_{t-2} + \dots\dots\dots .. r_p \Delta y_{t-p+1} \quad (5)$$

On the other hand, in maximum Eigenvalue, the following VAR is estimated:

$$y_t = r_1 \Delta y_{t-1} + r_2 \Delta y_{t-2} + \ldots\ldots\ldots\ldots r_P \Delta y_{t-p+1} \quad (6)$$

Where y_t the vector of the variables involved in the model and p is is the order of autoregression. In Johansen's cointegration test, the null hypothesis states there is no cointegrating vector ($r = 0$) and the alternate hypothesis makes an indication of one or more cointegrating vectors ($r > 1$).

Table 4: Johanson Test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.684793	126.6482	69.81889	0.0000
At most 1 *	0.505203	78.15808	47.85613	0.0000
At most 2 *	0.434760	48.60657	29.79707	0.0001
At most 3 *	0.302275	24.64535	15.49471	0.0016
At most 4 *	0.202971	9.528299	3.841466	0.0020
Trace test indicates 5 cointegrating eqn(s) at the 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.684793	48.49011	33.87687	0.0005
At most 1 *	0.505203	29.55152	27.58434	0.0276
At most 2 *	0.434760	23.96122	21.13162	0.0194
At most 3 *	0.302275	15.11705	14.26460	0.0366
At most 4 *	0.202971	9.528299	3.841466	0.0020
Max-Eigen value test indicates 5 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

To itemize the number of cointegration intercourse, we must consider the subsequent hypothesis. If the statistic of the trace is greater than the value criticized then one rejects H0 therefore there exists at least one cointegration relation. If the trace statistic is less than the critiqued value, then H0 is admitted so there is no cointegration relationship. According to the test of Trace and the test of Maximum Eigenvalue, there are five cointegration relationships, so the error-correction model can be held.

3) Estimation of Error-Correction Model

On the basis of the unit root and cointegration test results in the above, the following error-correction model (ECM) is used to ascertain the nature of the short-run and long-run relationships between the variables. ECM representation would has the following form, in equation:

$$\Delta GDP_t = \sum_{i-1}^{k} \alpha_0 \Delta GDP_{t-i} + \sum_{i-1}^{k} \alpha_1 \Delta DI_{t-i} + \sum_{i=1}^{n} \alpha_2 Trade_{t-i} + \sum_{i=1}^{n} \alpha_3 CE_{t-i} + \sum_{i=1}^{n} \alpha_4 CO2_{t-i} + Z_1 EC1_{t-1} + \varepsilon_{1t} \quad (7)$$

Where Δ is the difference operator, k is the number of lags, $\alpha_0, \alpha_1, \alpha_2 \alpha_3 and\ \alpha_4$: Short run coefficients to be estimated, $EC1_{t-1}$ is the error correction term derived from the long-run co integration relationship, Z_1 is the error correction coefficients of $EC1_{t-1}$ and ε_{1t} is the serially uncorrelated error terms in equation.

a- Long run

The error correction model provides the existence of long run equation between GDP, DI, Trade, CE and CO2, which can be written as:

$$\boldsymbol{Log(GDP) = \beta_0 + \beta_1\, Log\,(DI) + \beta_2\, Log\,(Trade) + \beta_3 Log\,(CE) + \beta_4\, Log\,(CO2)} \quad \textbf{(8)}$$

$$\boldsymbol{Log(GDP) = -0.0126072170317 - 0.057975\, Log\,(DI) + 0.220939\, Log\,(Trade) + 2.290772\, Log\,(CE) - 1.061704\, Log\,(CO2)} \quad \textbf{(9)}$$

Where β_0 is the constant and β_1, β_2, β_3 and β_4 are coefficient of the variables respectively DI, Trade, CE and CO2. According to the long-run equilibrium equation, an increase in energy consumption and trade openness directly leads to an increase in economic growth (positive effect). On the other hand, an increase in CO2 emissions and domestic investment leads to a decrease in economic growth (negative effect). In order to verify the credibility of these effects, the significance of the long-run equilibrium equation is studied using method of Least Squares (Gauss-Newton / Marquardt steps) which is shown in the table below.

Table 5: Estimation of the long run equation

Dependent Variable: D(DLOG(GDP))				
Method: Least Squares (Gauss-Newton / Marquardt steps)				
Equation of ECM Estimation: D(DLOG(GDP)) = C(1)*(DLOG(GDP(-1)) + 1.06170441254*DLOG(CO2(-1)) - 2.29077240554*DLOG(CE(-1)) + 0.0579747921153*DLOG(DOMESTIC_INVESTMENT(-1)) - 0.220938775525*DLOG(TRADE(-1)) + 0.0126072170317) + C(2)*D(DLOG(GDP(-1))) + C(3)*D(DLOG(CO2(-1))) + C(4)*D(DLOG(CE(-1))) + C(5)*D(DLOG(DOMESTIC_INVESTMENT(-1))) + C(6)*D(DLOG(TRADE(-1))) + C(7)				
	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.189313	0.163038	-1.161159	0.2534
C(2)	-0.365780	0.149934	-2.439611	0.0199
C(3)	0.154392	0.105313	1.466033	0.1516
C(4)	-0.322359	0.198820	-1.621365	0.1139
C(5)	0.046462	0.063400	0.732833	0.4685
C(6)	-0.037616	0.067380	-0.558266	0.5802
C(7)	-0.000656	0.004586	-0.143142	0.8870

If the coefficient of the variable C (1) is negative and possesses a significant probability. This means that all variables in the long-term relationship are significant in explaining the dependent variables. Our results show that the coefficient of the variable C (1) is negative, but he possesses a probability greater than 5%. These results provide en evidence that there is no relation between the variable in the long run.

b- Short run

We now proceed to the verification of the existence of a relation between the short-term variables. To achieve this goal, we will apply VEC Granger Causality / Block Exogeneity Wald Tests.

Table 6: Estimation of the short run

VEC Granger Causality/Block Exogeneity Wald Tests			
Dependent variable: D(DLOG(GDP))			
Excluded	Chi-sq	df	Prob.
D (DLOG(CO2))	2.149251	1	0.1426
D (DLOG(CE))	2.628824	1	0.1049
D (DLOG(DI))	0.537044	1	0.4637
D (DLOG(TRADE))	0.311661	1	0.5767

To have a short-term causality relation, the econometric rule states that the probability of the variable concerned must have a probability of less than 5%. In our case, there is a lack of a short-term causality relationship of trade openness, domestic investment, energy consumption and CO2 emissions to economic growth since all variables have probabilities Greater than 5%.

4) Checking the quality of the model

As usual at the end of each empirical investigation, we must apply a set of analysis to verify the robustness and credibility of our work, our model and the results of our estimation. To this we will try to apply a broad analysis to achieve this audit objective, including the use of heteroskedasticity tests, diagnostic tests and the stability of the VAR model

a- Heteroskedasticity Test

For the estimation of our model to be satisfactory, the probabilities of the Fisher statistic of the heteroskedasticity tests must be greater than 5%.

Table 7: Heteroskedasticity Tests

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.730771	Prob. F(15,26)	0.7336
Obs*R-squared	12.45580	Prob. Chi-Square(15)	0.6443
Scaled explained SS	11.38724	Prob. Chi-Square(15)	0.7247
Heteroskedasticity Test: Harvey			
F-statistic	0.866784	Prob. F(15,26)	0.6043
Obs*R-squared	14.00127	Prob. Chi-Square(15)	0.5254
Scaled explained SS	11.22589	Prob. Chi-Square(15)	0.7364
Heteroskedasticity Test: Glejser			
F-statistic	1.015899	Prob. F(15,26)	0.4700
Obs*R-squared	15.51988	Prob. Chi-Square(15)	0.4147
Scaled explained SS	14.58320	Prob. Chi-Square(15)	0.4818
Heteroskedasticity Test: ARCH			
F-statistic	0.310473	Prob. F(1,39)	0.5806
Obs*R-squared	0.323817	Prob. Chi-Square(1)	0.5693
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	2.854456	Prob. F(1,34)	0.1003
Obs*R-squared	3.252989	Prob. Chi-Square(1)	0.0713

The results in Table 7 show that all heteroskedasticity tests indicate that our estimate is acceptable and satisfactory since they have probabilities greater than 5%.

b- Diagnostics Tests

The normality tests, Watson Durbin test and the fisher test are performed to see if our estimate is acceptable or not. Of which Jarque-Bera must possess a probability greater than 5%, the Durbin Watson must be between 1.6 and 2.4 and the probability of the Fisher statistic must be less than 5%.

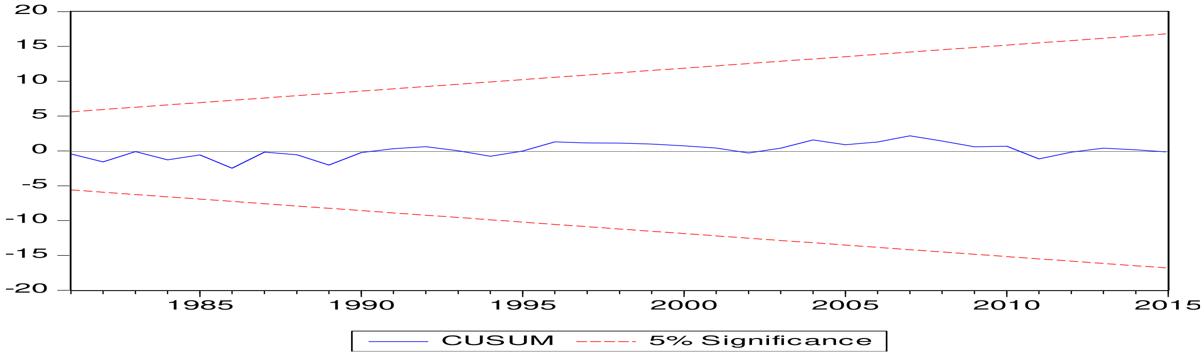
Table 8: Diagnostics Tests

Jarque-Bera	1.490252	Probability	0.474674
F-statistic	4.496525	Prob(F-statistic)	0.001783
Anova F-test	0.0000	Welch F-test	0.0000
Durbin-Watson stat		2.405191	

Diagnostic tests indicate that the overall specification adopted is satisfactory and well treated.

c- VAR Stability

Finally we will apply to use the test CUSUM, this test makes it possible to study the stability of the model estimated over time.



The test result of the stability VAR (CUSUM Test) shows that the Modulus of all roots is less than unity and lie within the unit circle. Accordingly we can conclude that our model the estimated VAR is stable or stationary.

IV. Discussion and Conclusion:

This study is one of very few studies that have studied empirically the impact of pollution on the economic growth of a small country rich in natural resources such as Tunisia during the period 1971-2015. Co-integration and error correction is applied to determine this relationship. The unit root properties of the data were examined using the Augmented Dickey Fuller (ADF) test after the cointegration and the error correction model were performed. The empirical results show that all variables are stationary in the first differences. The application of the co-integration test indicates the existence of co-integration relations, which of course requires us to apply the error correction model. The latter shows that in the long term, pollution affects negatively on economic growth but it is not significant, in this case it was concluded that there is no long-run equilibrium relationship between variables studied. Similarly, pollution has no effect on short-term economic growth. Our results and our empirical investigations are verified and confirmed by stable tests and diagnostic tests to demonstrate their robustness in their explanations of the cases of reality in this economic field in the framework of Tunisia. Despite the appearance of very serious population-related effects on some of the macroeconomic characteristics of Tunisia, such as the increase in the numbers of deaths (according to the international statistics of state of global air 2017), which revealed that air pollution in Tunisia is Responsible for the death of 4,500 people in 2015 due to exposure to prolonged periods), and the inability to have an agricultural yield and reduced agricultural profitability in some areas such as Gabes, Gafsa, Sfax. Gas emissions burned agricultural products such as pepper, pomegranate and dates, which are obvious damage that can be observed with the naked eye and hidden effects are the most important. But the effect of pollution is not yet large and its negative impact on Tunisian economic growth has the chance to be solved. According to known policies and strategies, the proposed solutions do not end pollution definitively, but move it from one region to another in response to community pressure; solutions may Workshops in the form of plant closures that can accommodate a significant number of tires and workers directly or indirectly. The Government therefore appears to be confronted with a difficult equation between the preservation of workplaces and the elimination of pollution, a formula which did not prejudge the Tunisian Constitution, which in several places devoted the right to the environment, Particularly in chapter 45 of the Tunisian Constitution, which states: A peaceful and balanced environment and a contribution to climate security and the State to provide means to eliminate environmental pollution ", which is frequently associated Between the environment and sustainability, which will prevail over the economic approach of the purely environmental approach and the Commission for Sustainable Development and Protection of the Rights of Future Generations, Text on them Article 129 of the Constitution Not yet promulgated and its own fundamental law has not been ratified, in addition to its limited consultative powers in draft legislation On economic, social and environmental issues and in development projects. In this situation, Tunisia must impose strict control and excessive laws and apply them equally to all those who violate them. These laws require anyone who commits an environmental violation, regardless of its low impact, with a deterrent penalty that prevents him from committing such an offense in the future. Government control and enforcement should also be strictly applied to factories that emit toxic gases and lethal fumes, as well as strict controls on public transport that also emit toxic gases and do not allow them to continue up to the point that the situation be resolved. Otherwise, Unreasonable human consumption must be stopped, which increases the volume of waste, leading to an increase of pathogens in the atmosphere. On the other hand, the state must activate laws that protect green spaces, which punish anyone who begs to attack this enormous wealth that will solve big problems that management and attention of the best men. In addition we must pay attention and pay more attention to the question of the rehabilitation of towns and make them comfortable for the population so that the streets do not cause congestion and congestion which make the atmosphere in the region a Not bad, which also affects the human psyche. It is also necessary to establish a practical transport network in all the countries so that all the regions of this country can join and all the districts of the same city. This reduces the citizens' dependence on their private cars in motion, thereby reducing air pollution by limiting exhaust gas. Finally, there is a need to increase community awareness of the need to reduce air pollution in different parts of the world. Air is the basis of all human life. Some categories are not allowed to be submerged and spoil it until it is comfortable.

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