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The Two-Way relationship between Economic Growth and CO2 Emissions

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***Abstract*—Starting from Environmental Kuznets Curve, Grossman and Krueguer (1991), Shafik and Bandyopadhyay (1992), Panayoto (1993), found a unidirectional relationship between economic growth level and environmental degradation. We try in this paper to investigate the two- way relationship between economic growth and environmental emissions CO2 in Tunisian context covering the period from 1980 to 2009 using the VAR model. Our empirical findings highlight that CO2 emissions rise monotonically with GDP per capita.**

***Keywords*— economic growth, CO2 emissions, Environmental Kuznets Curve, VAR model, Tunisia.**

I. INTRODUCTION

Simon Kuznets (1955), the American economist has disclosed the assumption that, beyond a certain level, there is a positive relationship between economic development and equity level of wealth distribution. He presented graphically the evolution of economic income (horizontal axis) and inequality (ordinate), he assumed the existence of a curve called 'Environmental Kuznets Curve'. This hypothesis allows other researchers to observe if this phenomenon may occur with environmental issues.

The concept of environmental Kuznets Curve has emerged in the early 1990's by Grossman and Krueguer (1991) dealing with the potential effects of the free trade agreement in North America and the preliminary study of global development Shafik and Bandyopadhyay (1992).

The main argument of environmental sustainability promulgated by the World Commission of Environment and Development is that economic growth is necessary for building and maintaining the quality of environment. The concept of 'Environment Kuznets Curve' was popularized by the international Bank of Reconstruction and Development (1992), "the view that economic activity which harms the environment, based on static assumptions about Technology, experience and environmental investments" and that "as incomes rise, the demand of enhancing environment will increase as well as the available resources for investment' (IBRD, 1992).

Theoretical explanations of the EKC hypothesis are based on three main effects; the scale effect, every increase in economic activity leads to pressure on environment. Increasing in productivity requires more inputs and engenders more emissions and harmful waste (Grossman and Krueger,1995). The structure effect; the contribution of different sectors in GDP affects the environmental degradation intensity caused bay economic growth. At a certain level of development, the society tends to increase its 'clean' activities. Technology effect; when an economy reaches a certain level of wealth, it devotes a part of its capital to research and development activities, towards a better environmental efficiency of production process.

The literature of EKC studied the existence of a statistically significant correlation between the level of economic activity and environmental degradation, the dependent variable is the environmental degradation. This implies a unidirectional causal relationship (Fodha and Zaghdoud, 2010).

Our contribution in this paper is the investigation of the two-way relationship between economic growth level and CO2 emissions in Tunisian context over the period 1980 to 2009 using VAR model. In the first section, we present the literature review of the relationship between economic growth and environment degradation, in the second section, we expose our empirical methodology and in the third section we provide our results and conclusion.

II. LITERATURE REVIEW

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Over the past few decades, the relationship between economic growth and environmental performance (environmental efficiency, emission intensity, eco strategies,..) has been the interest of intense research.

Porter (1991) assumes that it's possible to reduce simultaneously pollution with lower costs or better quality. Through the development of environmental technologies sector, environmental regulation provides private benefits to the company. The 'win win' situation addressed by Porter sparked a broad debat.

According to Porter and Van Der Linde (1995), enhancing the environmental performance tiggers innovation. Dechant and Altman (1994) have discussed the strengths which promote environmental firms to obtain a competitive advantage.

Improving environmental performance is a source for competitive advantage which provides a better efficient process, improvement in productivity, new market opportunities and lower costs. (Porter, 1991; Porter and Van Der Linde , 1995 and Schmidheiny, 1992).

Grossman and Kruger (1991) have included in their essay a great importance to open trade which leads to reduce environmental standards. Therefore, a dynamic link between the environment, exploitation of resources and economic activity has been established in the work of Kolstad and Krautkraemer (1993). Wherein, they found a negative long term impact of exploitation of resource on the environment.

Fodha and Zaghdoud (2010) investigated the relationship between economic growth and pollutant emissions, they used as environmental indicators Carbone Dioxide (CO2) and Sulfur Dioxide (SO2) and as an economic indicator the GDP. They found that it exists a long run co integrating relationship between GDP and SO2 emissions and a monotonically increasing relationship between GDP and CO2. Agras and Chapman (1998) stress the importance of including energy prices in the EKC to evaluate the relationship between energy-income and CO2 emission- income. The relationship between GDP and energy use in Turkey was studied by Erdal and al (2008) and Lise and Montford (2007) using co integration analysis to evaluate the relationship between environmental pollutant and output and energy use and output.

Lise (2007) in her study employed the Granger Co integration analysis in which she rejected the EKC hypothesis and identified a unidirectional relationship between GDP and energy use. While Erdal and al (2008), using the Johansen Co integration approach, found a bidirectional relationship between energy use and national income.

Akbostanci and al. (2009) treated the relationship between income – environment in Turkey using time series and provincial panel data for the periods1968-2003 and 1992-2001. They found a monotonically increasing relationship between CO2 emissions and income.

Shen (2006), in his study of China case, has found that economic growth and pollution in china are jointly determined. He (2008) employed the panel data for a sample of 29 Chinese provinces from 1992 to 2003. He found a quadratic and cubic relationship between SO2 emissions and income.

Samsul and Nurul (2013), in their study, have investigated the relationship between economic growth and environment in East and South East Asia countries. They used as indicator of environment, pollution and eco efficiency measures. As indicator of growth GDP per capita. They found that an increase in GDP per capita has a positive effect on pollution measures and mixed effect (positive and negative) on economic efficiency measures.

Based on the theoretical and empirical literature will test the following hypotheses;

- *H1: CO2 emissions have an effect on economic growth of country*
- *H2: A higher level of economic growth has a higher environmental pressure*

III. METHODOLOGICAL APPROACH AND EMPIRICAL FINDINGS

A. Data

In our empirical analysis, we use the Carbon Dioxide CO2 emissions as the environmental indicator and the GDP per capita as economic indicator. CO2 emissions cause a major problem on a global scale; it's classified as one of the major forces behind global warming in nowadays. All data used in this study cover the period 1980-2009, the GDP per capita, CO2 emissions, physical capital, labor force and innovation was taken from World Bank's Development Indicator.

B. Model

The basic model of this study is the Cobb Douglas function with two factors labor and physical capital, written as follows;

$$Y = AK^{\alpha}L^{\beta}$$

The linear function form is;

$$lnPIB_t = c + \beta_1 lnK_t + \beta_2 lnL_t + \beta_3 RD_t + \beta_4 lnCO2_t + \varepsilon_t$$

K: physical capital measured by gross Fixed Capital Formation
L: Labor Force measured by the number of employees
RD: Research and Development measured by expenditure on research and development
CO2: Dioxide Carbon Emissions expressed in metric tons per capita.

C. Stationarity test

Before proceeding to the estimation of the model, it is advisable to make sure of the stationarity of the observed series. Once the variables are not stationary, the estimated coefficients by the method of least squares (OLS) and the usual tests of t-Students and f-Fisher are not valid. Therefore, the estimated coefficients will not converge to their true value. Thus we say that the regressions are fallacious. Among the existing unit root tests, we use the Augmented Dickey Fuller test.

TABLE I
UNIT ROOT TEST

variables	ADF in level	ADF in first difference
GPD	**0,9**	**-6,67**
CO2	**-1,08**	**-5,26**

It appears from this table that the two series are non stationary in level. The stationary tests just to reassure that the used series are stationary in first difference therefore integrated of order one I(1).

D. VAR model

Vector autoregressive (VAR) models have been much used in empirical studies of macroeconomic issues since they were launched for such purposes by Sims (1980). The overall idea is exploited in models of short-term forecasting models of the type vector autoregression (VAR). The dynamics of short-term relationships that drive a system of interrelated time series can be used to make forecasting. As in the VAR models each variable is modeled as an endogenous variable, whose duties delayed his own values and those of all other endogenous variables included in the system.

Lûtkepohl (1991) provides an introduction to VAR modeling. Hamilton (1994) represents two detailed modeling of time series through univariate and multivariate models references.

In this paper, the two endogenous variables GPD and CO2 are integrated of order 1 which is therefore estimated the primary difference in the two series in a VAR (2).

TABLE II
VAR MODEL ESTIMATION

	Δ log GPD	Δ log CO2
Δ log GPD (-1)	-0,37	2,67
	(-1,6)	(0,82)
Δ log GPD (-2)	0,07	4,56
	(0,3)	(1,3)
Δ log CO2(-1)	-0,007	-0,54
	(-0,55)	(-2,9)*
Δ log CO2(-2)	-0,014	-0,47
	(-1,03)	(-2,42)*
C	1,85	26,03
	(1,84)**	(1,87)**
Log GPD	0,24	4,24
	(2,07)*	(2,55)*
Log CO2	0,02	0,82
	(2,28)*	(4,79)*
Log (K)	-0,13	-3,68
	(-1,49)	(-2,95)*
Log (L)	-0,48	-7,78
	(-2,13)*	(-2,45)*
RD	-1,9	-0,004
	(-0,01)	(-1,88)**
R-squared	0,57	0,78

T-student are in brackets ** 5% level of significance *1% level of significance

Table 2 shows that GDP per capita and CO2 emissions are associated in Tunisian Context, at the begining of the 80s, a higher level of economic growth has an important environmental pressure (CO2 emissions). An increase of 1% of economic growth causes a 4.24% increase of CO2 emissions. This result confirms that one reported by Environmental Kuznets Curve (the Scale Effects). Our hypotheses are verified.

Moreover, our results confirm the findings of Shafik and Bandyopadyay (1992), that have found that CO2 emissions increase monotonically with GDP per capita. An increase of 1% of CO2 emissions generate the level of GDP per capita by 0.02%. We can observe from our result the existence of a feedback relationship between economic growth and environmental degradation in Tunisia.

The augmentation of CO2 emissions means that an important proportion of GDP is dominated by industrial sector. We can show from this study that Tunisia doesn't devote any effort and investment in environmental innovation to reduce environmental degradation.

IV. CONCLUSIONS

In this paper we investigate the two- way relationship between economic growth and environmental degradation measured by CO2 emission indicator in Tunisia during the period 1980- 2009. The empirical results provide support for a bidirectional relationship indicating that CO2 emissions rise monotonically with GDP per capita. In Tunisia there are a limited numbers of emissions sources and investment can reduce their emissions with some measures such as 'end of pipe'.

So, the Tunisian authorities have instituted strategies to reduce emissions such as reduce the air pollution caused by chemical industry of Gabes. Policy makers in Tunisia should be aware that neglecting environmental quality engenders devastating consequences. They should invest environmental innovation and clean ant green technologies in order to reduce the effect of growth on the quality of environment.

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