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Economic growth and environment impact in the Union of Mediterranean Countries

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Abstract
Our work focuses on the impact of economic growth on the evolution of CO2 emissions in the twenty-seven Euro-Mediterranean countries. Our analysis used CO2 emissions data for 27 countries of the Union for the Mediterranean. Of these, 16 have managed to reduce their emissions while increasing their GDP over the period 1969 to 2019.
The graphical output takes the form of an inverted U-shaped curve (environmental Kuznets curve (EKC)). An accurate re-estimation of the EKC was allowed by basing the study on panel data and three proposed models to compare the results: linear, semi-log-linear and log-linear models. The results confirm the EKC hypothesis for European countries. The turning points for the linear and log-linear models are 21084, 20038 respectively. These values are comparable to the turning points found by Dijkraaf and Vollebergh (2005), Galeotti et al (2006), and Sebri (2009), due to the fact that the GDPs of all EU countries are above the turning points (the CO2 emission reduction phase). This is not the case for the MEDA countries, as CO2 emissions are still increasing. Previous EKC studies have not provided evidence of the existence of EKC for developing countries such as MEDA countries. The increasing curves observed for the MEDA countries.

Keywords: *Euro-Mediterranean countries; CO2 emissions per capita; Kuznets environmental curve; Panel data; Parametric estimation;*

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I. Introduction

With each publication of the Global Environment Outlook, the United Nations Environment Programme sounds the alarm about the state of the global environment, which has been steadily deteriorating since its first edition in 1997. The sixth edition released in March 2019 concludes that unsustainable human activities around the world have exacerbated the degradation of the planet's ecosystems, jeopardizing the ecological foundations of society. Urgent action is needed to reverse this situation.

At the European level, the European Commission aims in its European Green Charter to achieve a "zero pollution environment for a zero-toxin environment" in December 2019 and plans to adopt a "zero pollution action plan for air, water and soil" in 2021." The European Green Deal also includes a new circular economy action plan, published in March 2020, which will reduce resource consumption as well as waste production, and improve its management.

Historically, emissions have increased as the global economy has developed. In many cases, development has also been associated with an increase in the carbon intensity of industrial activity. Most countries that have reduced their emissions have also increased their economies. This means that, for a small number of countries, the process of decoupling emissions from the economy is underway.

Since 1995, there has been a downward trend in CO2 emissions in the Euro-Mediterranean area. However, this trend has not been identical in all countries of the area. While the European Union (EU) member countries have made the best progress in this area, the southern and eastern Mediterranean countries have achieved much more modest results. This leads us to believe that these trends can be explained by the inverted U-shaped curve known as the environmental Kuznets curve (EKC). The EKC hypothesis therefore proposes that a country's level of development (expressed as GDP per capita) is likely to have a positive impact on the environment. However, Grossman and Krueger applied this logic to environmental protection. They came to the ambitious conclusion that economic growth leads to environmental degradation, but at a certain threshold, growth promotes environmental quality.

Our analysis used CO2 emissions data for 27 countries. Of these, 16 were able to reduce their emissions while increasing their GDP over the period 1969 to 2019.

EKC is essentially an empirical phenomenon, but most of the econometric literature on EKC does not consider issues of model adequacy, such as the possibility of omitted variable bias. Most studies, in order to test EKC, seek to find regression coefficients of the explanatory variables retained in the explanation of the endogenous variable individually or jointly significant and having the expected signs. The identification of causal relationships is a central objective of econometrics. It provides methods to test the validity of apparent relationships, or "stylized facts". More realistically, it appears that emissions of most pollutants and waste streams are monotonically increasing functions of income, if the income elasticity is less than one and is not a simple function of income alone. In some middle-income countries, growth is rapid, but the scale effect increases pollution. And in some rich countries, growth rates are slow, and with pollution reduction efforts can overcome the scale effect.

The validation of this work was based on the cylindrical panel data technique. Our model tested the impact of economic growth on the evolution of CO2 emissions and a verified hypothesis of economic growth in favor of the evolution of CO2 emissions. An estimation by the "static panel" method seemed more relevant. A positive relationship between economic growth and the evolution of CO2 emissions is confirmed for 16 developed economies.

II. Literature and Theories of the relationship between income and the environment

An important theoretical literature has been developed around the EKC. Several arguments have been put forward to interpret this relationship by Selden and Song (1995), and Kelly (2003) in the context of the contribution of neoclassical growth theory and Stokey (1998) in the context of the contribution of endogenous growth theory. Selden and Song (1995) seek to find the EKC through a Forster (1973) Model, based on the following assumptions:

(i) the flow pollutant is a secondary product of production
(ii) concentration can be reduced by pollution control expenditures
(iii) preferences depend on consumption.

They determine the points of indifference between incurring or not incurring pollution abatement expenses. These points form a set called the D (K,C) frontier. Below this frontier, pollution abatement is zero because the marginal benefit of an increase in D (pollution reduction) is less than its cost. From there, if economic expansion begins in this area, the magnitude of pollution increases with investment. Once the economy expands, pollution decreases under certain conditions as wealth increases in the second phase. The authors demonstrate the inverted U-shaped curve based on the model of Forster (1973). This curve represents the link between capital accumulation and pollution during the transition dynamics to the steady state. Kelly (2003) analyzes the nature of the relationship between growth and the environment during the transition to the stationary state of an optimal growth model with pollution. In this context, the author seeks to demonstrate how this relationship varies according to the type of pollution measure considered: emissions (flow), pollutant concentration (stock) or pollution control. Thus, unlike the previous study, Kelly studied pollution as a flow and also as a stock (pollutant accumulation hypothesis). The study argues that the analysis of the relationship between capital accumulation and pollution is based on cleanup efforts (cost-benefit). He highlighted the presence of EKC thanks to restrictions on the parameters of the cost function (he imposes the convexity of the cost function) and of the pollution evolution law (the environment is a normal good). If this EKC hypothesis is confirmed by a set of data, Stokey (1998) addresses the question of EKC to know under which condition it is theoretically possible to obtain it. He built a static model, and a dynamic AK model, incorporating technology in both models (with pollutant flow, then pollutant stock). In the AK Model, the total output is the product of the potential output and the implementation of the technology. The pollution flow is proportional to the potential output and then the pollution/output ratio is determined by an increasing, convex function of the degree of technology use. In this framework, EKC implies restrictions on preferences and necessarily on the intertemporal elasticity of substitution, such as, $\eta<1$ (consumption satiation effect). Indeed, everything depends on a trade-off between gain and cost of pollution control. In the first phase of development, the benefit is still less than the cost of pollution removal, the economy no longer prefers to implement an environmental policy, and the increase in wealth results in the deterioration of environmental quality. As wealth increases, the economy reaches a level beyond which the gain is sufficient to induce pollution control. If $\eta<1$, then, as potential output rises, the marginal benefit of increasing pollution emissions (caused by increased consumption) becomes insufficient relative to its cost (measured by environmental damage) and pollution falls with income. Consequently, the curve will take the form of an inverted U between pollution and capital, which comes from a change of regime in the type of technology implemented. But it seems that the balanced growth is no longer an optimal equilibrium growth since the decrease of the emission standard coincides with a decrease of the capital returns. The investment motive gradually weakens until a certain point where it is cancelled out, and the economy then converges towards the stationary state. The use of external technology provides the opportunity to create sustained growth.

There are several empirical studies on the link between growth and the environment. Many of them analyze the Environmental Kuznets Curve (EKC). Grossman and Krueger (1993, 1995) drew the attention of thinkers and researchers to this statistical finding. They found an inverted U shape for water pollution and SO2 with turning point values alternating between 4000 and 5000 (in US$1985) for a variety of developed and developing countries using the random effects model. Within this framework, several explanations of the EKC are developed by Shafik and Bandyopadhyay (1992), Cropper and Griffith (1994), Selden and Song (1994), Stokey (1998), Andreoni and Levinson (2001), etc. Shafik and Bandyopadhyay (1992) verified the existence of an inverted U-shaped relationship only for three variables: SO2, deforestation and carbon emissions with turning points of 3000, 2000 and 4000 (US$ 1985) respectively. Selden and Song (1994) considered four pollutants (SO2, SPM, NOx and CO). The inverted U-curve hypothesis was verified for all four pollutants. However, the turning points for the case of SO2 and SPM are high and exceed 8000 ($1985). Cropper and Griffith (1994) found an inverted-U curve with turning points around (in US$1985) 4760 and 5420 respectively for deforestation in the case of African and Latin American countries (64 countries over the period 1961-1991). They advised the use of two non-linear parametric functional forms (Gamma and Weibull functions) as alternatives to the standard specification (polynomial function). Galeotti and Lanza (2005) confirmed an inverted U-shaped curve (EKC) for CO2 emissions for the three groups of countries (OECD, non-OECD and the two groups together) during 1960-1995 whose turning points are estimated, respectively, at US$ 150001990 for the first group, US$ 170001990 for the second and US$ 130001990 for the third group. Richmond and Kaufmann (2006) constructed three models: the fixed-effects model, the random-effects model, and the random-coefficients model; they favored the last model. The two environmental indicators considered gave the inverted U shape for the whole panel and in OECD countries, but the hypothesis was not valid for developing countries.

Other authors approach the EKC hypothesis in a different way, they set up time series models as Roca and Alcántara (2001) who seek to test the validity of this hypothesis for the case of Spain over the period 1972-1997 while choosing to study the role of energy in the evolution of CO2 emissions. The results of these authors rejected the basic EKC hypothesis. Kriström and Lundgren (2005) conducted a study on Swedish data for a period between 1900 and 1999, in order to forecast the evolution of CO2 emissions between 2000 and 2010. According to the predictions of this study, the emissions will gradually decrease. Soytas et al (2007) tested the causality between income, energy consumption and CO2 emissions. The authors showed that there is causality between energy consumption and CO2 emissions; while income does not cause CO2 emissions in the Granger sense. Therefore, economic growth alone cannot solve the environmental issue. The study of Focassi (2005) on the evolution of interrelated environmental indicators: the intensity of CO2 emissions and the intensity of energy of Brazil, China and India, does not confirm the hypothesis of EKC for the three countries; for the case of China, the Chinese curve is decreasing and the Indian curve is increasing and the Brazilian curve increasing with a very low slope. The third group of authors referred to the "snapshot" regression. Among them are Berrens et al (1997), Halkos and Tsionas (2001). Berrens et al. (1997) chose the Gamma function as the econometric specification to show an inverted U-shaped curve with a turning point around $20,000. While Halkos and Tsionas (2001) employed a regime-switching model for deforestation and CO2, but the results rejected the EKC hypothesis.

III. Empirical analysis

In this empirical analysis, we are based on a specification that tests the hypothesis of a relationship between the indicator of environmental degradation and GDP per capita. We test the existence of the environmental Kuznets curve, which states that in the early stages of economic growth, emissions increase and environmental quality decreases, but beyond a certain level of income per capita (which varies according to the indicators), the trend is reversed, so that at high levels of GDP, economic growth leads to environmental improvement. This implies that per capita emissions have an inverted U-shape as a function of GDP per capita. The model we propose in this study is based on two main variables GDP and GDP edge

$$\mathrm{CO2_{it}} = \alpha_i + \alpha_1 PIB_{it} + \alpha_2 PIB_{it}^2 + \varepsilon_{it}$$

$$CO2_{it} = \beta_i + \beta_1 logPIB_{it} + \beta_2 (logPIB_{it})^2 + u_{it}$$

$$\mathrm{logCO2_{it}} = \gamma_i + \gamma_1 logPIB_{it} + \gamma_2 (logPIB_{it})^2 + u_{it}$$

Where "i" represents each country (with i= 1, 2,.....27) and "t" represents each time period (with t = 1, 2,.....2019). We have chosen as a study area the Mediterranean which has made many efforts in environmental protection and has ratified the Kyoto Protocol - the case of CO2 pollution - which is one of the most serious greenhouse gases and indeed there are data for the member countries of the Euro-Mediterranean partnership[i]. The statistical data of CO2 emissions (metric tons per capita) and GDP per capita (constant 2005 US$) are taken from the database of the World Bank Development Indicators (WDI).

Before proceeding to the analysis of the estimation results, we present some descriptive statistics for this group.

Table 1.2: Descriptive statistics for the European Union group

Variable	Obs	Mean	Std. Dev.	Min	Max
co2	464	8.20181	2.263046	2.77	13.74
pib	464	15080.8	7564.547	139.8	33259.2

Source: developed by the author

The EU[ii] countries have a very high average GDP per capita compared to the MEDA countries; this is a preliminary indication of an inverted U curve for this group. But we also find that the levels of CO2 emissions (average, min and max) are higher than those of the MEDA[iii] countries. To perform the Hausman test, the procedure is to first use the Fisher test to confirm whether there is an absence or presence of a fixed effect. Then, the Breush and Pagan test is used to empirically validate the choice of a compound error structure.

There are a variety of techniques that can be used to estimate our model. The standard methods for panel estimation are fixed effects or random effects. The estimated coefficients are significantly different in both cases[iv]. The Hausman (1978) specification test can be a means of evaluation. The realization of the Hausman test statistic is 9.50. Since the model has two explanatory variables (K=2), this statistic follows a Chi-square with two degrees of freedom. We therefore accept the alternative hypothesis of the presence of correlation between the individual effects and the explanatory variables. Thus, we must adopt the Within estimator and reject the random effects model[v]. There is thus a commonality between countries and the error term decomposes. The result of our estimation is reported in the Table below.

IV. Results and discussion: the Kuznets environmental curve

European Union Group

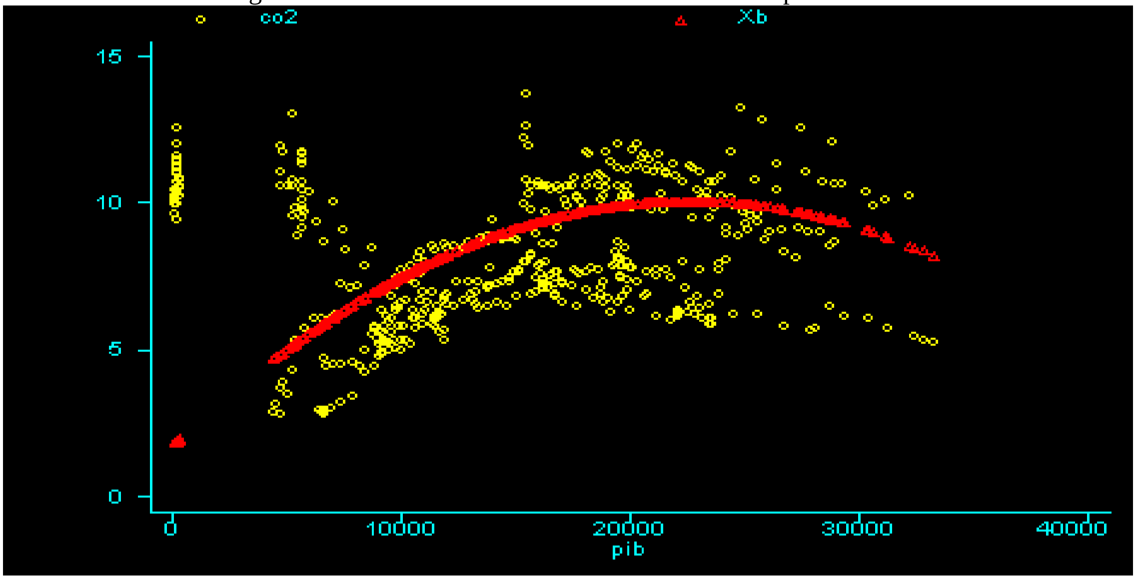
Table 1: Estimating results

	Linear model	Log-linear model
GDP	*0,000738* *(-16,12)*	*0,398* *(0.055)*
GDP^2	-1,66E-08 *(-14,16)*	*-2,01E^{-02}* *(0.84)*
Constant	*1,717* *(-4,44)*	*-1,45* *(0.13)*
R F	*0,39* *143,45*	*0.26* *80.06*
Fixed effect	*217,96*	*103.65*
turning point	*21084*	*20038*
Observation	*464*	*464*
Note: Values without parentheses represent coefficients of the estimates and values in parentheses represent probabilities.		

Source: developed by the author

The estimation results show that for both models, the linear term (GDP) is significantly always positive, while the sign of the quadratic term (GDP2) is significantly always negative. This is a necessary condition for obtaining an inverted U shape of the Kuznets Environmental Curve (KEC). By a graphical representation, this observation is confirmed. Indeed, three inverted U curves are obtained by fitting the data by the different models. The CO2 emission levels increase with economic growth up to a certain level of GDP per capita (the turning point) at which there will be an improvement in the state of the environment. The turning points for the linear, and log-linear models are respectively 21084,20038 these values are comparable to the turning points found by Dijkraaf and Vollebergh (2005), Galeotti et Al (2006), Sebri (2009). These turning point values are reached by most of the European Union (EU) countries in our sample. In other words, the EU countries have reached a very high level of economic growth, reflected in the increase in per capita income, which allows them to prioritize the protection of their environment, notably through the reduction of CO2 emissions.

Figure 1: Environmental Kuznets curve for the European Union



Source: developed by the author

MEDA Countries

As with the EU group countries, it is first necessary to present the descriptive statistics for the MEDA group countries. These are presented in Table 2 below.

Table 2: Descriptive statistics

. sum co2m pibm

Variable	Obs	Mean	Std. Dev.	Min	Max
co2m	203	2.453734	.9328445	.789	4.168
pibm	203	5427.335	8714.077	913.878	32767.44

Source: developed by the author

The descriptive statistics for the MEDA countries show that they are more homogeneous in terms of CO2 emissions/head and GDP/head than the EU countries. Indeed, the standard deviations obtained are much lower than those of the first group, especially for the variable GDP/head. We also notice that the average GDP per capita is about 1/10 of that of the EU countries. This implies that an inverted U-shaped curve is hardly likely.

Looking at Table 3, we notice that unlike the EU group, the variables are statistically insignificant individually, which could be due mainly to the small size of individuals (only 7 countries). But the overall fit of the three models is acceptable.

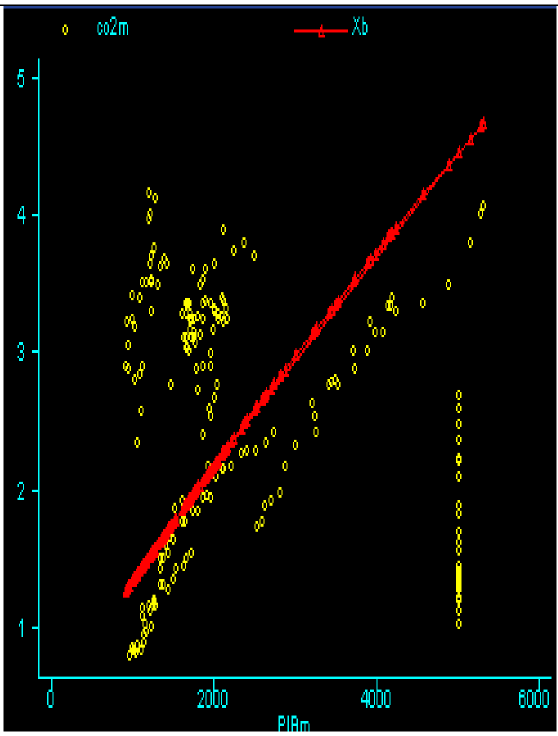
Table 3: Estimation results for MEDA countries

	Linear model	Semi-log-linear model	Log-linear model
GDP	*0.0009028*	*-7.874823*	*-.1907165*
	*(0.000)****	*(0.004)***	*(0.83)*
GDP2	*-2.03*	*0.6359645*	*.066567*
	(0.72)	*(0.000)****	*(0.406)*
Constant	*.4520125*	*25.33553*	*-1.630947*
	*(0.084)**	*(0.014)***	*(0.726)*
R	***0.4659***	***0.4587***	***0.4377***
F	***84.60***	***82.20***	***75.50***
Fixe effect	*240.37*	*238.72*	*250.18*
Turning point	-	-	-
Observation	203	203	203

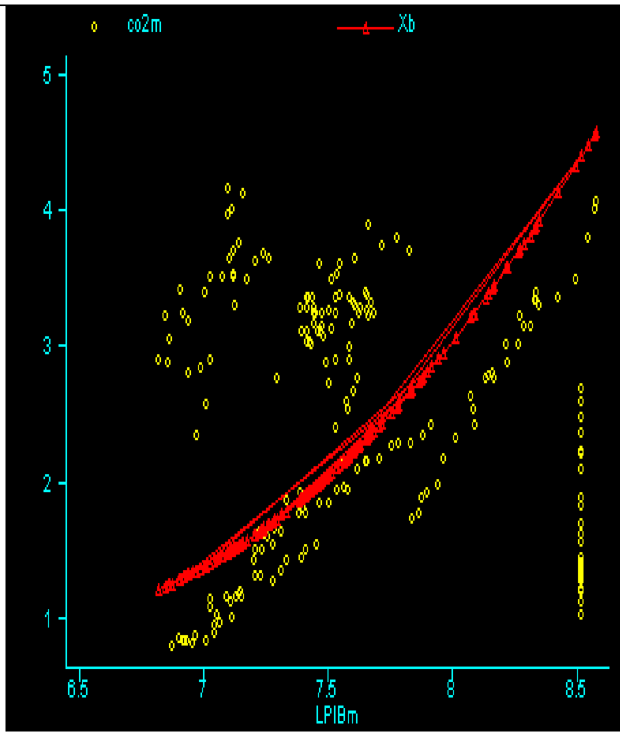
Source: developed by the author

In the semi-log-linear and log-linear models, the signs of the coefficients associated with the explanatory variables are found to be consistent with concave curves (negative linear term and positive quadratic term), an increasing relationship is observed between CO2 emissions and GDP per capita levels. Indeed, this result is expected for three reasons: First, the quadratic term that characterizes the concavity of the relationship is negative but not statistically significant. Second, the estimation results for the European Union group give an idea of the range of turning point values that can be calculated for the CO2 case; but the MEDA countries are characterized by very low GDP per capita compared to the European Union turning points. Finally, previous EKC studies have not put forward any evidence of the existence of an inverted-U relationship for developing countries such as the MEDA countries. The increasing curves observed for MEDA countries show that CO2 emission levels continue to increase as economic growth increases. Indeed, MEDA countries, like all developing countries, are accelerating their economic growth. In fact, a large number of these countries have a satisfactory capacity to assimilate their environment, which is far from saturation, and they share a potential comparative advantage. Consequently, the industrialization that characterizes several MEDA economies and the overuse of polluting technologies certainly contribute to the increase of CO2 emissions.

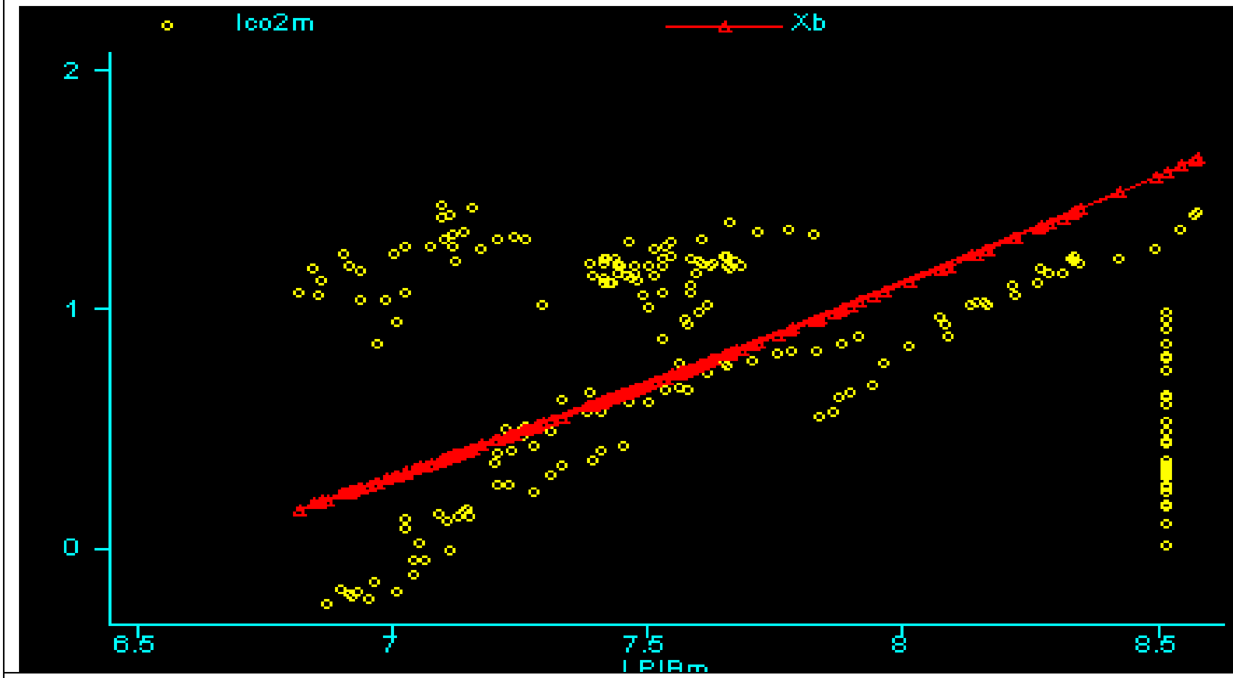
Figure 2: Environmental Kuznets curve for the group of countries
MEDA



Linear model



Semi-log-linear model



Log-linear model

Source: developed by the author

Union for the Mediterranean Countries

The UfM is the main framework that encompasses both EU and MEDA countries. Among the projects of the UfM is the de-pollution of the Mediterranean. This objective seems to be difficult to achieve, given the economic, political, social and cultural differences between the two Mediterranean shores. The estimation results for this sample of countries are shown in Table 4:

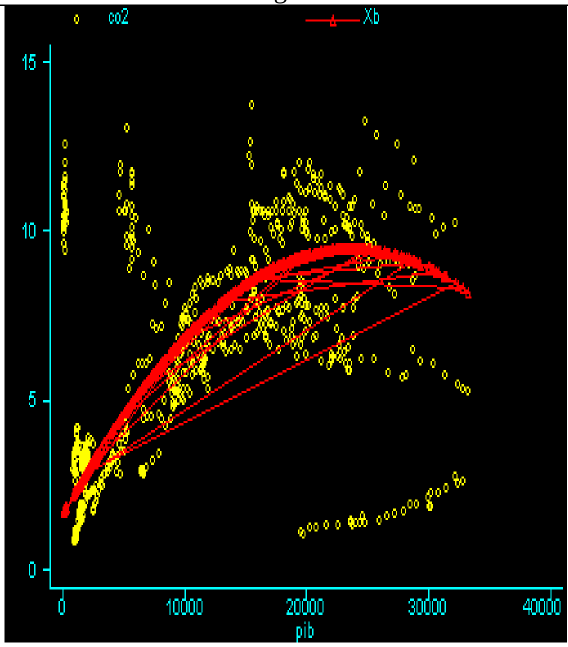
Table 4: Estimating Results

	Linear model	Semi-log-linear model	Log-linear model
GDP	0.0006658	0 .8331857	0.39
	17.76	0.83	4.46
GDP2	$-1.59e^{-08}$	.035	-0.0186413
	-15.60	1.24	-1.87
Constant	1.599954	-6.484741	-3.931954
	6.15	-1.43	-4.85
R	0.3603	0.2435	0.3411
F	180.79	103.31	166.14
Fixed Effect	479.19	357.06	507.03
Turning point	20950	147657	34914
Observation	667	667	667

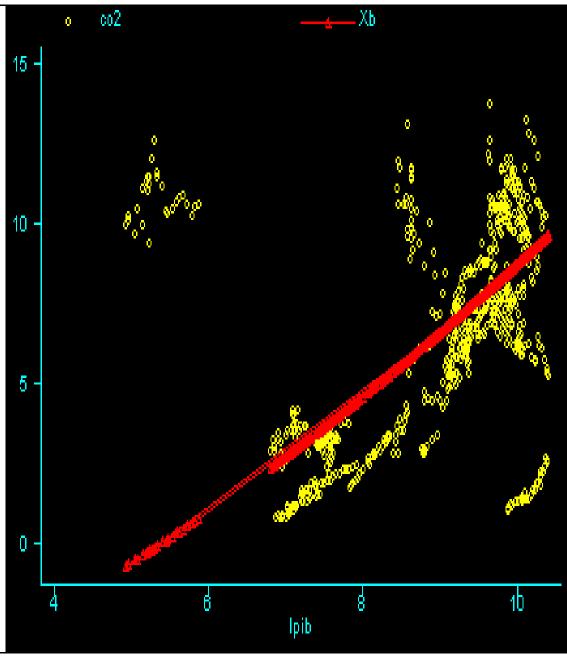
Source: developed by the author

The first finding from the estimation table is that the adjustment quality of the three models is acceptable. The estimated parameters reflect the concave shape of the curve. By the linear model, the relationship between CO2 emission levels and economic growth corresponds to an inverted U-shaped curve with a turning point estimated at 20950 (US$2000) which is very close to the turning point calculated for EU countries (21084 US$2000). This level of GDP per capita is reached only by European countries, so the shape of the curve obtained seems to be dictated by the choice of the sample. As for the semi-log linear model, the curve obtained is practically increasing because the calculated value of the turning point is so high (147657 US$2000) that no country can reach it. CO2 emissions will then continue to increase in the Mediterranean area. For the log-linear model, Figure 3 shows that the curve is rather concave but the resulting turning point is still outside the sample (34914 US$2000).

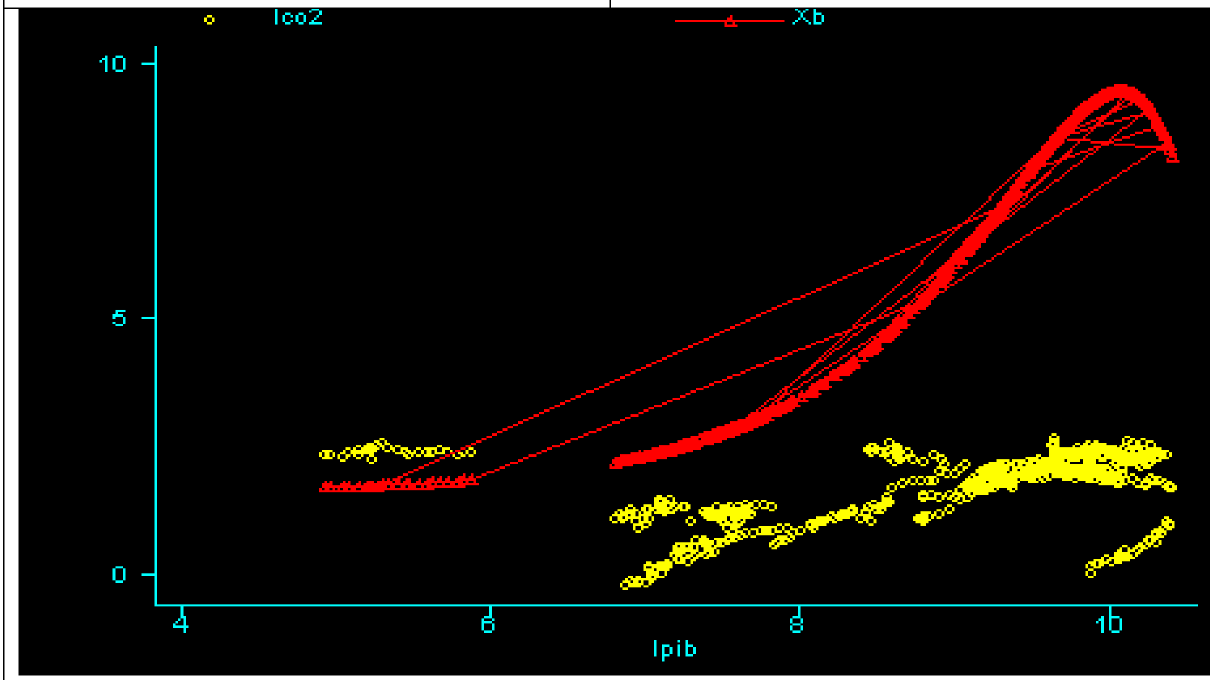
Figure 3: Environmental Kuznets curve for the UPM countries



Linear model



Semi-log-linear model



Log-linear model

Source: developed by the author

V. Conclusion

The large number of publications is the best evidence of the interest of the problem of environmental protection, which is the focus of economists' attention. More recent analyses are interested in the influence of economic growth on the evolution of CO2 emission levels. The present study has sought to enrich this debate by empirically analyzing this relationship for the countries of the Union for the Mediterranean. We have explained Kuznets' thesis. After testing the impact of economic growth on the level of CO2 emissions, we have found an inverted U-shaped evolution of CO2 emissions in European countries. If growth produces degradation, we can ask if it can be a source of environmental protection. The economic literature that studies this direction of causality is still too limited. Therefore, we will work to enrich this line of research which is at the center of a new debate about the effects of green and blue growth on the evolution of environmental quality.

The unstable relationship between changes in GDP and air quality is very difficult to imagine and conceive, the emissions-income relationship most often adopts an inverted U shape. But inverted U-shaped curves seem to be the most common shape when linking GDP per capita and pollutant emissions. Sometimes economic growth for some countries initially has a negative impact on the environment, and later becomes favorable. For some authors the phenomenon is explained by a compensation effect. At the beginning of the industrialization and development process, the increase in the scale of production (scale effect) results in an increase in air pollution, due to the intensive use of natural resources and polluting production technologies. Over time there will be a tendency to favorable changes in the structure (composition effect) and production techniques (technical effect). The question is whether the latter two effects can compensate for the former? One is entitled to ask whether, beyond GDP, certain political and economic factors do not have a strong influence on polluting emissions?

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[i] The Euro-Mediterranean Partnership, also known as the Barcelona Process, was established in 1995 in Barcelona, on the initiative of the European Union (EU) and ten other states bordering the Mediterranean Sea (Algeria, Palestinian Authority, Egypt, Israel, Jordan, Lebanon, Morocco, Syria, Tunisia and Turkey) Libya has had observer status since 1999

[ii] Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Malta, Netherlands, Portugal, Spain, Sweden and United Kingdom.

[iii] The MEDA program was the financial framework of a Euro-Mediterranean partnership. The program finances the cooperation of the European Union with the Mediterranean countries to accompany the economic transition of the Mediterranean countries, with the prospect of building a free trade area in 2010.

MEDA Group: Algeria, Egypt, Jordan, Morocco, Syria, Tunisia and Turkey

[iv] Fisher's test affirmed the presence of fixed effects. it suggests that within performs better than the OLS estimator.

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F test that all u_i=0:     F(15, 446) =    217.96          Prob > F = 0.0000
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[v] The Breush and Pagan (1980) test rejected the hypothesis of inter-individual independence for a confidence level of 1%.

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