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The Impact of Economic Growth on Pollution in Developed European Countries

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Abstract

In our study, we empirically examine the influence of economic growth on environmental degradation in the developed European economies through the period of study beginning in 1985 to 2015. For the econometric methodology, we employ the Cobb-Douglas production function. From the tests of cointegration (Kao and Fisher tests), we corroborate the existence of a cointegration nexus among the economic growth and pollution. Also, we confirm the hypothesis of basic EKC which assumes the existence of a bidirectional relationship between economic growth and emissions of CO2 in developed European countries during the period of study (1985-2015). In addition, we conclude that there is a two-way causal nexus among energy consumption and pollution in developed European countries.

Keywords: Economic growth, pollution, developed European countries, financial development

1. Introduction

Different countries have withstood the exclusive achieving economic growth while observing an increase in carbon dioxide (CO2). Then there was a growing apprehension about the technique of "low CO2 emissions and green growth." Especially considering whether it is really possible to achieve steady economic growth not including the increase in energy consumption of gas.

The developed and developing countries disagree that some CO2 Energy constraints would slow economic growth and suggested that industrialized countries should augment funding to reduce total warming, which is widely marked because of strong gas emissions from industrial economies. This question is reasonably related to post-Kyoto negotiations on climate vary, and therefore, it is essential to look at the connection between environmental degradation and economic growth with several empirical examination tools.

In this alignment, the causal link among economic growth and energy consumption was considered by many significant academic researchers in recent decades. Several works have focused on different economies, different time, a variety of modeling methodologies and diverse substitution variables that were employed for the link among CO2 emissions, energy utilization and economic development (Baranzini et al, 2013; Ghosh, 2010; Stern, 1993; Wolde-Rufael, 2005; Yuan et al., 2007). However, their results are mixed and failed to unique findings (Chen et al., 2007).

Several investigations have studied the causal relationship between energy consumption, CO2 emissions and economic development. However, these results have find mixed results, calling for further study to explain this link. Several studies have investigated the link among economic development, energy utilization, financial development, openness trade and CO2 emissions by utilizations diverse econometric methodologies.

In this paper, we will empirically study the impact of economic growth on pollution for all developed European economies through the period from 1985 to 2015. We will use the tests of the unit root tests cointegration, estimation by FMOLS and DOLS method and causality test Granger. We conclude the existence of a cointegration nexus among the economic development and pollution. Also, we confirm the hypothesis of basic EKC which assumes the subsistence of a bidirectional link among economic development and emissions of CO2 in developed

European countries through the period of study (1985-2015). In addition, we show the existence of a two-way causal nexus among energy utilization and pollution in developed European countries.

The rest of this paper is planned as follow: in Section 2, we present a review of literature on the link among GDP and pollution. In Section 3, we present the econometric method employed in this study. In section 4, we present the dataset utilized for the empirical validation. Section 5 finds the empirical results. Section 6 concludes.

2. Literature Review

To examine the impact of economic activity indicators of environmental degradation, Omri (2013) use the method of generalized least squares throughout the period 1990-2011 for countries in the MENA region. It uses CO2 as an indicator of pollution and labor, capital, population, financial development, and GDP as an indicator of economic activity. Their results show the presence of a significant positive impact in GDP and the negative impact of financial development and capital on CO2 emissions.

Shahbaz et al. (2013) use the error correction vector model and the GC to study the impact of GDP, energy consumption, foreign direct investment, financial development, and trade openness on pollution environment during the period from 1971 to 2011 in the case of Malaysia. They show that the GDP consumption, energy, foreign direct investment, financial development, and trade openness have a positive effect on CO2 emissions.

Baek and Pride (2014) develop a survey to a sample of countries in the largest nuclear production during the period 1990-2011. Econometrically, these authors use the vector autoregressive model and Johnsen cointegration. They employ CO2 as an indicator of pollution. For economic indicators, they use the GDP and the production of nuclear electricity. Their results showed that economic indicators have a positive impact on the pollution of these countries.

Farhani et al. (2014) exploit by GC errors vectors correction model for the case of Tunisia (1971-2008). They utilize CO2 emissions, GDP, energy use, and trade openness to investigate the indicators of economic activity of the effect on pollution. Their empirical results prove the presence of a positive causality between CO2 emissions and economic indicators.

Charfeddine and Ben Khediri (2016) utilize unit root tests with multiple structural breaks and cointegration techniques switching scheme considering for one and two unknown regime moves to examine the relationship between CO2 emissions, electricity use, economic development, financial development, trade liberalization, and urbanization in the UAE during the period 1975-2011. The empirical results of their study show the existence of Environmental Kuznets Curve (EKC). In addition, Charfeddine and Ben Khediri (2016) explain an inverted U relationship amid financial development and emissions of carbon dioxide. In addition, they find that electricity utilization, urbanization, and openness trade help to improve environmental quality.

The primary goal of any economy is to make the most of economic development to achieve its place in the developed economies of the world, which makes the reply of the environment to the very precise and crucial economic development because economic growth influences 'natural environment. It is known that economic growth at the expenditure of the quality of the environment; but, it is also highlighted that developed economies may introduce environmentally friendly technology, which in turn will make the most excellent environment to live.

After the prediction (Kuznets, 1955) that the changing relationship amid environmental quality and income per capita and income inequality takes the form of an inverted U on the assumption of the EKC. Thus, the quality of the environment is first compounded by the country's economic expansion, but after winning enough growth to a threshold level of economic growth can improve the quality of the environment and is a U-shaped curve reversed between them.

Jamel and Derbali (2016) investigate empirically the effect of energy utilization and economic development on the environmental degradation as measured by CO2 emissions. They employ the cointegration test, the fully modified OLS, and the panel causality to study the causality amid environmental pollution and economic aggregates from a panel data of eight Asian economies through the period 1991–2013. They find that the cointegration tests confirm long run relationship among environmental degradation and energy consumption and economic growth along with financial development, trade openness, capital stocks, and urbanization as control variables. In addition, FMOLS estimation results confirm that economic development and energy utilization have a positive and significant effect on environmental degradation. Besides, panel causality through VECM verifies that bidirectional causal connection is found amid energy utilization and economic development and environmental degradation.

Jamel and Maktouf (2017) explore empirically the causal link amid economic growth (GDP), CO2 emissions (environmental degradation), financial development, and openness trade with the ordinary least squares technique for a yearly panel data of 40 European economies, through the period of study beginning on 1985 to 2014. To examine this fundamental link, they exploit the Cobb–Douglas production function. Their empirical conclusions point to a bidirectional Granger causal linkage amid GDP and pollution, GDP and financial sector development, GDP and openness trade, financial sector development and trade openness, and trade openness and pollution in the case of European economies. From the causal link between GDP and environmental pollutants, they authorize the existence the validity of the environmental Kuznets curve hypothesis. Also, they substantiate out the feedback suggestion of the bidirectional causality amid trade openness and financial sector development. Besides, they discover the neutrality hypothesis linking carbon emissions and financial sector development inflows. They find the occurrence of the bidirectional nexus amid GDP and financial sector development and among GDP and trade openness in the European countries. Finally, Granger causality verifies that bidirectional causal connection is found among economic development, environmental degradation (CO2), financial progress, and trade openness.

Jamel and Maktouf (2017) check the causal link among economic growth (GDP), CO2 emissions (environmental degradation), financial development and trade openness by utilizing the ordinary least squares technique for a yearly panel data of 40 European economies, through the period of study beginning on 1985 to 2014. To examine this causal association, they utilize the Cobb-Douglas production function. Their empirical conclusions point to a bidirectional Granger causal connection among GDP and pollution, GDP and financial sector development, GDP and openness trade, financial sector development and openness trade and trade openness and pollution in the case of European economies. From the fundamental link amid GDP and environmental pollutants, they authorize the continuation of the environmental Kuznets curve hypothesis. Also, they prove the feedback suggestion of the bidirectional causality amid openness trade and financial sector development. Besides, they conclude the neutrality hypothesis linking CO2 emissions and financial sector development inflows. Finally, they show the occurrence of the bidirectional nexus amid GDP and financial sector development and amongst GDP and trade openness in the European economies.

3. Model

In this research, we will study the effect of economic development measured by the growth of gross domestic product (GDP) on pollution. This impact is studied while incorporating other control variables namely trade in goods and services (OC) as a measure of openness trade and domestic credit to the private sector (DF) as a financial development indicator.

In addition, we use in the same category of the control variables; the urban population calculated in thousands of people has also been utilized as an index of urbanization (U).

The integration of these variables is based on the Cobb Douglas production function, in which economic growth is calculated as a function of endogenous and exogenous factors.

Finally, the emission of carbon dioxide (CO2) was used as a measure of pollution. Annual data for all the above mentioned variables will be taken from the World Bank's database for the period through 1985 to 2015.

The study of the effect of economic development on pollution is based on the use of the Cobb-Douglas function, which is a widely employed economics function to represent the liaison between input and output. This function has been proposed and tested econometrically by the American economist Paul Douglas and the American mathematician Charles Cobb in 1928.

As part of a production function of two factors, the most generally used form is of the following form:

$$Y = C.K^{\alpha}.L^{\beta}$$

Where, Y is the level of production, K than the capital L in the workplace, and c, α and β are constants determined by technology.

Under the model of perfect competition, the α and β coefficients correspond to the distribution of income between labor and capital. But the statistical evidence of the consistency of this model, conducted by Cobb and Douglas, also showed that the income distribution key between labor and capital is constant over time in developed countries. However, this constancy, clearly established at the time, is now in doubt.

Subsequently, the model used was as follows (Jamel and Derbali, 2016; Sy et al., 2016)

$$Polution = f\left(PIB, DF, VC\right) \tag{1}$$

Where, GDP refers to the growth rate of gross domestic product of each country and VC are the control variables. The different variables are expressed in natural logarithm. Thus, the econometric model can be presented as follows:

$$LCO_2 = \beta_{i0} + \beta_{i1} LPIB_{it} + \beta_{i2} LDF_{it} + \sum_{j=2}^{p} \beta_{ij} X_{it} + \varepsilon_{it} \quad (2)$$

Where, β_{i0} is the constant, β_{is} indicates the coefficient of each explanatory variable used in our research work with s = 1, ..., p, ε_{it} is the error term and X_{it} is the vector of control variables such as trade openness, the consumption of energy, urbanization rate, foreign direct investment, the capital stock and inflation. i denotes the index of each country (i = 1, ..., 25). t is the index of each year (t = 1, ..., 31).

4. Data

Our paper focuses on the determination of the impact of economic growth on pollution in European countries for the study period between 1985 and 2015. We will use annual panel data for a sample of 25 developed European countries. We summarize in Table 1 the list of developed European countries that will be utilized in this study.

We chose this sample is composed of European countries since this area is the richest in the world. It is composed by the most industrialized area of the world. Thus, Europe is the richest region and developed world, but it is not an economically homogeneous space: all European countries are developed countries: Ukraine and Moldova are the exception and are classified as a means for developing countries with an HDI (human development index) less than 0.8. The Western Europe and very prosperous Northern Europe contrasts with some poorer regions of Central Europe, Eastern Europe (Moldova, Ukraine, parts of Romania, Russia) and Europe South (Albania, Serbia, Macedonia, parts of Bulgaria, southern Italy,

And our choice is justified by the human development index since the majority of European countries have an index greater than 0.85 according to Figure 1 in 2015.

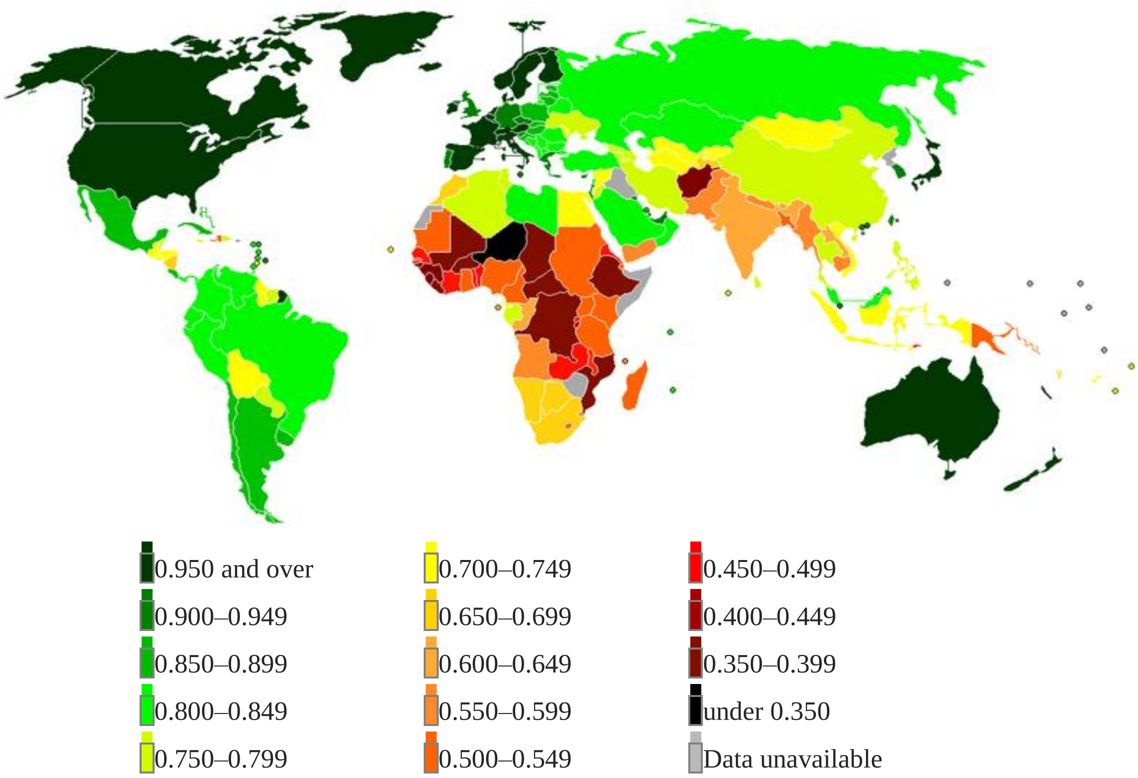

Figure 1. The Human Development Index

Source: United Nations Development Program (2015)

The richest regions belong to the European metropolis, vast triangle between London, Milan and Hamburg, and are the economic heart of Europe. Also, it is known as the "blue banana", the Rhine Axis or “European backbone”.

These regions, which experienced an early industrial revolution, are more urbanized and best equipped in terms of infrastructure (road and rail in particular) 7.8. Despite the crisis affecting certain industrial centers (e.g. parts of Belgium and northern France), the inhabitants of this part of Europe generally benefit from higher incomes.

We usually speak of Central and Eastern Europe to designate the former satellite states of the USSR. The Central European countries that recently joined the European Union have them, an industrial transfer from Western Europe, Germany and North Europe. The Eastern European regions, retraining after leaving the USSR, compared with a low capita income and sometimes high unemployment, but in sharp decline during the years 2009.

In general, European peripheral regions (southern Italy, Portugal, and Greece) are less rich than the center, although northern Europe, prosperous and located on the technological frontier, seems to be an exception.

Table 1. List of developed European countries

	Name of the country	Surface (km2)	Population (2014)	The population density (per km2)	Capital city
1	Austria	83.879	8504850	101.4	Vienna
2	Belgium	30.528	11198638	366.8	Brussels
3	Cyprus	9,251	1117000	120.7	Nicosia
4	Czech republic	78.866	10513209	133.3	Prague
5	Denmark	42.916	5655750	131.8	Copenhagen
6	Estonia	45.227	1315819	29.1	Tallinn
7	Finland	338.424	5470820	16.2	Helsinki
8	la France	551.695	66030000	115.8	Paris
9	germany	357.168	80716000	226.0	Berlin
10	Greece	131.957	10816286	82.0	Athens
11	Hungary	93.030	9877365	106.2	Budapest
12	Iceland	103.001	325.671	3.2	Reykjavík
13	ireland	70.273	4609600	65.6	Dublin
14	Italy	301.338	60782668	201.7	Rome
15	luxembourg	2,586	549.680	212.6	luxembourg
16	Netherlands	41.543	16856620	405.8	Amsterdam
17	Norway	385.178	5136700	13.3	Oslo
18	Poland	312.679	38483957	123.1	Warsaw
19	Portugal	92.212	10427301	113.1	Lisbon
20	Slovakia	49.035	5415949	110.5	Bratislava
21	Slovenia	20.273	2061085	101.7	Ljubljana
22	spain	504.645	46704314	92.6	Madrid
23	Sweden	449,964	9716962	21.6	Stockholm
24	Swiss	41.285	8183800	198.2	Bern
25	UK	243.610	64100000	263.1	London

Source: IMF (2016)

All of the descriptive statistics of the indicators used in our research are summarized in Table 2 for the developed European countries during the period of study.

For the group of European countries and developed according to the results of Table 2, we noticed that the LCO2 variable, which expresses logarithm of CO2 emissions, can reach a maximum value 3.311344. As its minimum value is 1.005861. Its risk is 0.339933.

The LPIB variable, which measures the logarithm of the GDP growth rate may reach a maximum value 11.36358. While its minimum value is 8.391950. Its risk is 0.663097.

The LCE variable, which measures the logarithm of the energy consumption for non developed European countries, may reach a maximum value 9.840280. As its minimum value is 6.997467. Its risk is 0.429237.

The FLA variable, which measures the logarithm of the level of financial development, can reach a maximum value 6.065274. While it's minimum value is -5.696879. It's risk is 1.250932.

LIDE variable, which measures the logarithm of foreign direct investment, can reach a maximum value 5.739996. While it's minimum value is 0.000000. It's risk is measured by the standard deviation is 0.720456.

Both statistics of skewness and kurtosis, we can conclude that all variables used in the present research work are characterized by non-normal distribution. Then, the asymmetry coefficients indicate that all variables are shifted to the left with the negative sign of asymmetry coefficients and is far from symmetrical except for the three indicators LCO2, LOC and LCE that are geared to the right with the positive sign of asymmetry coefficients. In addition, the leptokurtic coefficient shows that for all variables employed in this paper indicate the presence of a high peak or a large tail in their volatilities.

Also, the positive indication of estimation coefficients of Jarque-Bera statistics indicates that we can refuse the null hypothesis of the normal distribution of the variables employed in this study. In fact, the elevated value of the coefficients of the Jarque-Bera statistic reflects that the series are not normally distributed at a threshold of 1%.

The results shown by the three statistics suggest that all variables utilized in this study are not normally distributed in the case of developed European countries throughout the period from 1985 to 2015.

In pursuit of our empirical analysis, we conduct a test of the correlation between the different variables used in the case of developed European countries during the period of study from 1985 to 2015. Table 3 summarizes the results relating to the Pearson correlation test.

Thus, the correlation coefficients used to give a summary measure of the intensity of the liaison between two characters and sense when this relationship is boring.

In addition, the results of correlation that all coefficients between the explanatory variables do not surpass the tolerance limit (0.7), which does not cause problems in the estimation of the model. That is to say, we can integrate the different variables employed in the same model.

A study of the causal link among economic development and pollution in developed European countries requires prior perform stationary tests to conclude the order of integration of each indicators. Before processing a time series, it is necessary to examine the stochastic characteristics. If these characteristics, that is to declare - the expectation and variance - are modified above time, the variable is considered as non-stationary in the case of an invariant stochastic process, the series is then stationary.

The results of the Levin-Lin-Chu test (LLC), Im-Pesaran-Shin test (IPS), Fisher-ADF test and Fisher-PP test applied to the variables are shown in Table 4 for the developed European countries.

Acceptance or refusal of the null hypothesis of the different tests is based on the value of probability and the indicated test statistics. These probabilities are compared by a 10% threshold. If these probabilities are fewer than 10%, then we refuse the null hypothesis and if these probabilities are superior than 10%, then we admit the null hypothesis.

For developed European countries and in Table 4, we observe that only two variables LPIB and LCE are non-stationary in level according to the test of Levin-Lin-Chu but all indicators used in this paper are stationary in first difference according to this test.

According to statistics of the test-Im Pesaran-Shin (IPS) test ADF-Fisher and the test of PP-Fisher, we can conclude that only four variables FLA, LIDE, LINF and LU are stationary in level. But first difference, all variables are stationary according to these three tests. Thereafter, all the variables are integrated of order 1. Thus, we can advance with the cointegration test.

Table 2. Descriptive statistics for developed European countries

	LCO2	LDF	LIDE	LINF	LOC	LPIB	LSK	LU	LCE
Mean	2.127313	0.751679	4.271883	1.048004	4.408486	10.11090	2.375731	-0.395732	8.234923
Median	2.079290	0.711802	4.376396	0.984499	4.361559	10.27027	2.571368	-0.121982	8.195946
Maximum	3.311344	6.065274	5.739996	6.319655	5.917387	11.36358	5.919903	1.205764	9.840280
Minimum	1.005861	-5.696879	0.000000	-28.94033	3.525479	8.391950	-3.793771	-4.614765	6.997467
Std. Dev.	0.339933	1.250932	0.720456	1.553748	0.456544	0.663097	1.819433	0.916152	0.429237
skewness	0.682344	-0.140631	-1.705785	-9.126357	0.504057	-0.629751	-0.637919	-1.445124	0.640854
kurtosis	4.321457	4.206863	10.95208	180.9030	3.111689	2.650659	3.185460	5.977498	4.121064
Jarque-Bera	116.5283	49.58794	2417.817	1032773.	33.22068	55.16660	53.67387	556.0312	93.63164
Probability	0.000000 *	0.000000 *	0.000000 *	0.000000 *	0.000000 *	0.000000 *	0.000000 *	0.000000 *	0.000000 *
Sum	1648.668	582.5514	3310.710	812.2030	3416.576	7835.945	1841.192	-306.6925	6382.066
Sum Sq. Dev.	89.43889	1211.179	401.7497	1868.540	161.3265	340.3257	2562.199	649.6450	142.6053
observations	775	775	775	775	775	775	775	775	775

Note: (*) are significant values at a threshold of 1%.

Table 3. The correlation matrix for developed European countries

	LCO2	LDF	LIDE	LINF	LOC	LPIB	LSK	LU	LCE
LCO2	1.000000	0.278870	-0.099142	-0.021480	0.407358	0.137253	-0.119378	0.032678	0.526315
LDF	0.278870	1.000000	0.109938	-0.151631	0.568514	0.091746	0.115856	0.186582	0.173852
LIDE	-0.099142	0.109938	1.000000	-0.303582	0.076379	0.499680	0.363730	0.177899	0.017187
LINF	-0.021480	-0.151631	-0.303582	1.000000	-0.166768	-0.355833	-0.291696	-0.002415	-0.069892
LOC	0.407358	0.568514	0.076379	-0.166768	1.000000	0.144417	-0.163140	0.249062	0.285672
LPIB	0.137253	0.091746	0.499680	-0.355833	0.144417	1.000000	0.425109	0.132127	0.503731
LSK	-0.119378	0.115856	0.363730	-0.291696	-0.163140	0.425109	1.000000	-0.024049	0.083723
LU	0.032678	0.186582	0.177899	-0.002415	0.249062	0.132127	-0.024049	1.000000	0.075779
LCE	0.526315	0.173852	0.017187	-0.069892	0.285672	0.503731	0.083723	0.075779	1.000000

Table 4. The unit root test for developed European countries

	Levin, Lin and Chu test		*Im Pesaran and Shin test*		*Fisher-ADF test*		*Fisher-PP test*	
	In level	In the first difference	In level	In the first difference	In level	In the first difference	In level	In the first difference
LCO2	-1.99132 **	-10.0135 *	-0.18744	-13.4939 *	62.4743	273 549 *	75.8540 **	576 168 *
LDF	-3.54839 *	-7.95865 *	-2.14304 **	-7.00217 *	72.1094 **	157 951 *	* 96.0630	251 138 *
LIDE	-3.27169 *	-15.0276 *	-4.13400 *	-19.8093 *	* 93.4536	413 149 *	185 031 *	719 988 *
LINF	-1.87740 **	-15.9591 *	-1.4994 ***	-19.2103 *	70.2090 **	400 253 *	116 535 *	671 116 *
LOC	-2.49506 *	-4.85462 *	0.61191	-12.0263 *	32.7873	238 635 *	21.1950	367 802 *
LPIB	-1.05050	-8.78113 *	1.04897	-6.89834 *	27.5561	853 234 *	40.8874	881 724 *
LSK	-3.37852 *	-13.3311 *	-1.06058	-12.3459 *	49.8572	244 379 *	38.5970	371299
LU	-2.62319 *	-11.2996 *	-4.48602 *	-13.9293 *	102 246 *	282 807 *	111 306 *	425 765 *
LCE	4.27379	-6.15483 *	4.79995	-3.19096 *	24.2644	* 82.1370	29.1594	215 571 *

Note: In this test, the p-value is compared to 10%. If the probabilities <10% therefore we reject the null hypothesis and the probabilities> 10% then we accept the null hypothesis. With the null hypothesis all series are non-stationary. (*), (**) and (***) are significant values for the 1%, 5% and 10%, respectively.

5. Empirical Results

5.1 Testing Cointegration

The analytical part is devoted to the presentation of the test results of cointegration. The tests of cointegration of Kao and Fisher are applied to ensure the long-term nexus between the variables employed in this research project to examine the effect of economic development on pollution in the case of developed European countries.

Thus, the long-term link among the development of the economic sphere and the environmental sphere can be easily understood with a cointegration relationship between the two variables. Nevertheless, we must first ensure that the requirements are fulfilled and it is always possible to find a long-term relationship between financial variables and real variables; this can be verified from a co-integration test.

The Kao test is based on the t-ADF statistic. But Fisher's test is based on the Fisher statistical test track and Fisher Statistic of max-eigen test. The empirical results of the cointegration test for developed European countries are presented in Table 5.

In the case of developed European countries, Kao test confirms the long-term link among the different variables utilized in our research mainly between economic development and pollution. Fisher test results corroborate the existence of a long-term nexus between GDP and emissions of CO_2 in developed European countries for the study period from 1985 to 2015.

According to the results of Table 5, we have confirmed the presence of a cointegration nexus between the different series studied. Indeed, the results of the null hypothesis test of no-cointegration was rejected at the 5% threshold, which explains the existence of a cointegration link.

The results are established by the results of eigenvalue. The results of these tests can conclude the exercise of an error correction model. Also, to test the effect of economic development on environmental degradation in developed European countries, we will perform two FMOLS and DOLS estimation.

Table 5. The cointegration test of the impact of economic growth on pollution for developed European countries

Kao Residual Cointegration Test	Fisher Johansen Cointegration Test Panel			
Statistics (Probability)	Fisher Stat. * (From test track)	Prob.	Fisher Stat. * (From max-eigen test)	Prob.
-3.471189 (0.0003) *	645.5	(0.0000) *	1863.	(0.0000) *

Note: (*) are significant values at a threshold of 1%.

5.2 FMOLS Estimates and DOLS

In this part, we perform two estimates by FMOLS and DOLS methods for the case of selected groups of economies in this paper. Tables 6 and 7 summarize the estimation results of the impact of economic development on pollution in the case of developed European countries, respectively the technical FMOLS and DOLS.

The technique FMOLS in panel proposed by Pedroni (1996, 2000) solves problems of heterogeneity in the sense that it allows the use of heterogeneous cointegrating vectors. Also, the FMOLS estimator takes into description the existence of the constant term and the possible presence of correlation among the error term and differences estimators.

Adjustments are complete to this effect on the dependent variable and long-term parameters obtained by estimating the fitted equation. In the case of panels, long term coefficients from the FMOLS art are obtained by the average group of estimators with respect to the sample size (N).

So, one of the problems of the OLS estimator is derived from the correlation between the explanatory variables and endogeneity. One way to correct these problems is to use the DOLS estimator. This method is to integrate the cointegration delays and advances of the explanatory variable taking orthogonalizing difference to the residue of the cointegration relationship; i.e. to eliminate the link among the explanatory variables and the error term.

Then, the coefficients of determination for the two estimates is superior than 0.7 (0.947960 and 0.996949), Therefore, both estimated models are characterized by a good linear fit.

The first is the variable For FMOLS estimate, we notice that four variables are significant, but with different signs for the group of developed European countries.

Indeed, the GDP growth rate has a positive and important effect on emissions of CO_2 at a threshold of 1% in the case of developed countries. This means that, if economic growth increases by one while the CO_2 emissions increase by 0.143860 units at time t for the case of the group of developed European countries.

LEC variable which measures the level of energy utilization is statistically significant and positive at a 1% level. So if energy utilization increases by one then, environmental degradation increases 0.525440 units in developed European countries.

In the same analytical framework, we find that, statistically significant and positive at a 1% level. The LIDE variable measuring foreign direct investment has a negative effect on emissions of CO2 at a 10% threshold. That is to say, if the level of FDI increases by ten units, then the CO2 emissions decrease of0.010375 units.

LOC variable which measures the commercial opening rate is statistically significant and negative to a threshold of 1%. So if trade opening increments so, environmental degradation decreases 0.259711 units.

Table 6. Estimated FMOLS for developed European countries

Variable	Coefficient	Std. error	Does Statistic	Prob.
LIDE	-0.010375	0.005748	-1.805069	0.0715 ***
LDF	0.000500	0.009608	0.051994	0.9585
LINF	-0.004828	0.003620	-1.333594	0.1828
LOC	-0.259711	0.037994	-6.835634	0.0000 *
LPIB	0.143860	0.044864	3.206586	0.0014 *
LSK	-0.005796	0.004813	-1.204150	0.2289
LU	0.002477	0.006650	0.372510	0.7096
LCE	0.525440	0.043556	12.06356	0.0000 *
R-squared	0.947960	Mean dependent var		2.127647
Adjusted R-squared	0.945637	SD dependent var		0.336522
SE of regression	0.078463	Sum squared resid		4.414182
Durbin-Watson stat	0.418460	Long-run variance		0.016528

Note: significant value to a threshold: (*) 1%; (**) 5% (***) 10%.

The first is the variable For the DOLS estimation, we find that there are three variables that are significant, but with different signs for the group of European countries.

Thus, always the GDP growth rate has a positive and important effect on CO2 emissions at a threshold of 1% for the case of non-developed countries. This means that, if economic growth increases by one while the CO2 emissions increase0.227367 units for the case of the group of developed countries.

LCE variable which expresses the level of energy utilization is statistically significant and positive at a 1% level. So if energy consumption in developed European countries increased by one then, environmental degradation increases0.266434 units.

LOC variable which measures the commercial opening rate is statistically significant and negative to a threshold of 1%. So if trade openness increases by one then, pollution decreases 0.384999 units.

Table 7. Estimated DOLS to developed European countries

Variable	Coefficient	Std. error	Does Statistic	Prob.
LIDE	0.001743	0.009400	0.185427	0.8530
LDF	-0.001252	0.015744	-0.079536	0.9367
LINF	0.006846	0.004468	1.532217	0.1266
LOC	-0.384999	0.051133	-7.529318	0.0000 *
LPIB	0.227367	0.057543	3.951277	0.0001 *
LSK	-0.003870	0.005729	-0.675437	0.5000
LU	-0.006529	0.008114	-0.804695	0.4217
LCE	0.266434	0.044867	5.938313	0.0000 *
R-squared	0.996949	Mean dependent var		2.127313
Adjusted R-squared	0.991411	SD dependent var		0.339933
SE of regression	0.031503	Sum squared resid		0.272920
Long-run variance	0.000535			

Note: significant value to a threshold: (*) 1%; (**) 5% (***) 10%.

5.3 The Test of Granger Causality

To investigate the causal link among economic variables in the using model, we employ a causality test of Granger initiated in 1969 that has become above time an interesting conceptual framework than the one for the highlight econometric links.

In general, based on this test, we can prove if there is a close liaison among the variables of economic growth and pollution.

To supply a robust analysis of the relationship between pollution and fluctuations in GDP growth rate, we start to apply some trying Granger causality.

Therefore, we must check whether the cause economic growth the movement of CO2 emissions or pollution due to economic growth.

Acceptance or rejection of the null hypothesis of Granger causality test is based on a threshold of 5%. If the probability of Granger causality test is less than 5% in this case we reject the null hypothesis and if the probability is superior than 5% then we recognize the null hypothesis of no causality.

Table 8 summarizes the results of causality test for the case of developed European countries for the study period of 1985 to 2015.

According to this table, we find that it is growth that causes Granger changes in CO2 emissions (0.0050 <0.05) and not the reverse (0.7151 > 0.05). In this case, we can say that there is a unidirectional link between economic development and pollution in the case of developed European countries.

We observe that there is a bidirectional nexus between energy consumption and pollution Granger (0.0023 <5% and 0.0002 <5%).

We find that it is CO2 emissions that causes Granger variation IDEs (0.0139 <0.05) and not the reverse (0.9858> 0.05). In this case, we can say that there is a unidirectional relationship between IDEs and pollution.

Thus, there is no causal link between financial development and pollution Granger as their probability values are above 0.05 (0.3525 and 0.2604) allow to accept the null hypothesis of the test.

Also, there is no causal link between inflation and CO2 emissions of Granger as their probability values are above 0.05 (0.1187 and 0.9843) allow to accept the null hypothesis test.

Similarly, there is no causal liaison between trade openness and pollution Granger as their probability values are above 0.05 (0.9085 and 0.1784) allow to accept the null hypothesis test.

Moreover, there is no causal link between capital stock and pollution Granger as their probability values are above 0.05 (0.1644 and 0.1246) allow to accept the null hypothesis test.

Similarly, there is no causal liaison between urbanization and pollution Granger as their probability values are above 0.05 (0.9643 and 0.1340) allow to accept the null hypothesis test.

Table 8. Granger causality test for developed European countries

Null hypothesis:	Obs	F-Statistic	Prob.
LIDE does not Cause LCO2	725	0.01426	0.9858
LCO2 does not Cause LIDE		4.30185	0.0139
DFL does not Cause LCO2	725	1.04409	0.3525
LCO2 does not Cause LDF		1.34794	0.2604
The INF does not Cause LCO2	725	2.13767	0.1187
LCO2 does not Cause LINF		0.01583	0.9843
LOC does not Cause LCO2	725	0.09596	0.9085
LCO2 does not Cause LOC		1.72788	0.1784
LPIB does not Cause LCO2	725	3.00621	0.0500
LCO2 does not Cause LPIB		0.33553	0.7151
LSK does not Cause LCO2	725	1.80969	0.1644

LCO2 does not Granger Cause LSK		2.08872	0.1246
LU does not Granger Cause LCO2	725	0.03631	0.9643
LCO2 does not Granger Cause LU		2.01570	0.1340
LCE does not Granger Cause LCO2	725	6.14704	0.0023
LCO2 does not Granger Cause LCE		8.78431	0.0002

6. Conclusion

Our goal in the present paper is to scrutinize empirically the effect of economic development on pollution for all developed European countries through the period of study from 1985 to 2015.

At the descriptive level, we notice that the rate of economic development and CO2 emissions is higher in developed European countries. This was well justified by the different descriptive statistics such as maximum, minimum and the level of risk. Furthermore, we demonstrate that the different series employed do not follow a normal distribution based Skweness statistics, kurtosis and Jarque-Bera.

In addition, we find that all variables used in this paper are stationary in first differences according to the used tests in our empirical framework. Thereafter, all the variables employed are integrated of order 1. And then, we progress to the cointegration test.

We use the cointegration tests of Kao and Fisher to examine the long-term relationship linking the variables used to test the effect of economic development on pollution in the case of developed European countries. According to the results of the two tests, we confirm the subsistence of a cointegration relationship among the different indicators studied.

Then, we utilize the methods FMOLS and DOLS and the Granger causality test to empirically test the effect of changes in economic development on environmental degradation in developed European countries. The results find by these two techniques have confirmed the hypothesis of basic ECK which assumes the presence of a bidirectional nexus among economic development and CO2 emissions in developed European countries. In addition, we find that there is a two-way causal link among energy utilization and pollution in developed European countries.

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