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MACROECONOMIC DETERMINANTS OF CARBON DIOXIDE EMISSIONS IN ALGERIA DURING THE PERIOD 1970-2019

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ABSTRACT: Algeria is one of the most important carbon dioxide emissions (CO2) emitters among developing countries, which has led to the deterioration of its environmental quality constantly, which necessitates the reduction of carbon emissions. for this reason, our study aims to show the macroeconomic determinants of CO2 over the period 1970-2019. In order to complete our research, Descriptive and analytical approaches are used to form the background by reviewing literature and analyzing existing information about CO2, and also the quantitative approach will be employed to determine its macroeconomic determinants. The study found that the most significant carbon dioxide emissions determinants are economic growth, financial sector development, domestic investment and trade openness. The study also found a positive impact of these determinants on the carbon dioxide emissions, with the exception of financial sector development and trade openness.

Keywords: Carbon dioxide emissions, Macroeconomic determinants, ARDL approach, Cointegration, Algeria.

JEL Classification : C51, M50, Q56.

1. INTRODUCTION:

Within the framework of the increasing interest in preserving the components of the environment that surround us, and in the context of the modern twenty-first century systems that are based on the principles of governance and globalization, various countries of the world have become afraid of the manifestations and results of environmental pollution on the one hand, and are becoming more cautious and cautious of various industries and Activities that threaten the ozone layers and increase global warming on the other hand, and in this context we will be interested in highlighting the danger of carbon dioxide (CO2), which represents a major component of greenhouse gases (GHG) associated with human activities as one of the most important causes of increased global warming and climate change, as it remains in the atmosphere longer than other major greenhouse gases.

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As mentioned and discussed after the activities of the United Nations Conference on the Human Environment (1972) by urging countries to reduce greenhouse gas emissions.

And because Algeria today has become considered one of the most important countries that emit carbon dioxide, its government has become increasingly interested in improving the current environmental situation through the implementation of appropriate policies, without harming economic development, especially since the Algerian economy is characterized by its heavy dependence on oil and gas exports, as it leads to enhancing Economic growth has led to the consumption of large amounts of energy obtained mainly from oil and gas.

Following these rapid changes and the different environmental requirements, we cannot help but pay attention to the macroeconomic factors that determine carbon dioxide emissions**. So what are the most important macroeconomic determinants of carbon dioxide emissions in Algeria during the period 1970-2019?**

The problematic of the Study is sub-divided into the following two questions:

- What are the trends in carbon dioxide emissions in Algeria?
- What is the nature of the relationship between carbon dioxide emissions and its macroeconomic determinants in Algeria?

Based on the problematic of this Study and secondary questions, the following hypotheses can be formulated:

- The most important macroeconomic determinants of carbon dioxide emissions in Algeria are: economic growth, domestic investment, foreign investment, financial sector development and trade openness.
- Emissions of carbon dioxide continue to increase in Algeria
- The existence of a long-term relationship between carbon dioxide emissions and its determinants in Algeria, where economic growth, domestic investment, foreign investment, financial sector development and trade openness affect positively on carbon dioxide emissions.

The significance of this study comes from the great importance and attention given by the whole world to the environmental pollution, global warming and its causes, in addition to determining of macroeconomic determinants of carbon dioxide emissions in Algeria, which is one of the most important causes of climate change.

Through this study, we seek to find the macroeconomic determinants of carbon dioxide emissions in Algeria, through an econometric model that determines the relationship between carbon dioxide emissions as a dependent variable and its determining factors as independent variables, based on the available data during the study period.

The descriptive and analytical approaches are used in this study to describe the trends of carbon dioxide emissions in Algeria based on the historical data, and also the quantitative approach will be employed to determine the macroeconomic determinants of carbon dioxide emissions, where autoregressive distributed lag approach (ARDL) bound testing approach, which proposed by Pesaran et al. (2001). This approach has several advantages over alternatives. For instance, this method can be applied whether variables are stationary or integrated in different order. Hence, it overcomes problem of integration order related to Johansen (1995). This approach redresses heterogeneity and mitigates serial correlation problems through accurate order augmentation of the repressor and appropriate lag selection. (Lacheheb, Rahim, & Sirag, 2015, p. 1127). To build the study model we include the following variables: CO2 emissions per capita as indicator of CO2 emissions, real GDP per capita growth as indicator of economic growth, Domestic credit to private sector and money supply as indicator of financial sector development, domestic investment (constant LCU), foreign investment (net outflows in current US$) and trade openness (the ratio of exports plus imports over GDP)

2. LITERATURE REVIEW:

- **Economic development** as a determinant One of the implied factors of increasing greenhouse gas concentration by previous research is the economic development of a certain country. A common framework that connects the economic development (in most cases, measured by GDP per capita) and the amount of $CO2$ emissions is the Environmental Kuznets curve (EKC), developed by Grossman and Krueger (1995). It states that environmental deterioration occurs during the early stages of economic development, but after a certain degree of growth has been achieved, the benefits of economic growth are used to protect the ecosystem. It is referred to as the Environmental Kuznets curve due to its similarity to Kuznets Inverted-U relationship between income inequality and income per capita. The EKC theory implies that when an economy is in an early stage of development, usually because of being abundant in labour and natural resources. The heavy industries, which usually are pollution-intensive, are promoted by accepting foreign direct investment of developed countries. Consumers benefit from economic growth because they can get credit at a lower rate to buy items that increase energy consumption, which as a result raise $CO2$ emission.
- **Financial development** as a determinant Another aspect to take into consideration when analysing the financial implications on greenhouse gas emissions is the financial development of the economies. The popular debate of whether to finance operations by increasing equity or debt reaches beyond just financial or managerial outcomes. for given levels of economic and financial development, carbon emissions per capita are significantly lower in economies where equity financing is more important relative to bank lending.
- **Trade** as a determinant an important aspect to consider is the effect of trade on greenhouse gas emissions. First, trade is accompanied by transport of goods, and the transport industry accounts for Considerable percentage of global greenhouse gas emissions. Second, trade openness eases foreign direct investment and capital inflows/outflows which directly correspond to the relationship between economic development and carbon emissions. And third, it is believed international economic relations between countries result in a mutual dependence in the environmental policy and carbon efficiency. Not always the reduction of carbon emissions is a result of the introduction of new, environment-friendly technology or the shift to green innovation. In some cases, to lower the domestic greenhouse gas pollution, companies move the carbon-heavy manufacturing to countries where the regulation is not so restricting.
- **foreign direct investment**: the effects of foreign direct investment on ecosystem have recently begun to take place in the literature. There are two important hypotheses on this issue, namely Pollution Halo Hypothesis and Pollution Haven Hypothesis. Eskeland & Harrison (1997:1) states that according to pollution haven hypothesis (PHH), “environmental regulations will move polluting activities to poorer countries”. As environmental consciousness globally raises, countries settle down to improve new environmental regulations and policies with severe sanctions. The fact that developed countries can manage to implement these leads to that dirty investment run away from developed countries. On the other hand, developing countries generally tend to slur over environment problems by weak

environmental regulation. In this way, they get free from the monitoring and controlling expense of these regulations, and also they attract the profit-driven companies willing to get rid of costly regulatory observance in their countries. Therewith multinational corporations involved in FDI have a tendency to transfer its clean technology to the ones in the host country.

In this contest, there are a number of studies that have examined the macroeconomic determinants of carbon dioxide emissions. These studies varied in terms of treatment methods and asymmetric results. A review of these studies is given below.

Ayad Hicham and Chenini Moussa (2019) studied the relationships between energy consumption, economic growth and CO2 emissions in Algeria for the period 1970-2017, using structural VAR approach. The findings of this study revealed that a positive shock in CO2 emissions increases both of economic growth and energy consumption, and it find that a positive shock in energy consumption has a very small positive impact on economic growth and a high negative impact on CO2 emissions. (Ayad & Chenini, 2019, pp. 101-114)

Rambeli Norimah and all (2018) investigated the relationship between gross domestic product, net trade and electricity consumption on carbon dioxide emission in Malaysia. Thus, it uses the Ordinary Least Square method in structuring the model estimation, by utilizing yearly time series data from 1980 to 2017. The findings of the study suggested that gross domestic product, net trade and energy consumption affect carbon dioxides positively. Furthermore, the results in statistical criteria conclude that the gross domestic product and energy consumption are the dominant factors that influence carbon dioxides combustion in the long run in Malaysia. (Rambeli, Abdul Jalil, Hashim, Mahdinezhad, Hashim, & Mohd Bakri, 2018, pp. 204-208)

Ombwori Kongo Yabesh (2018) examined the macroeconomic determinants of CO2 emissions such as; gross domestic product, population growth and trade openness on carbon emissions in Kenya during the period 1970-2015. The study also analyzed the effect of energy mix such as; Energy generated from renewable sources, fossil fuel sources, Alternative and Nuclear Energy sources and Imported Energy on carbon emissions in Kenya. The results established that in the long run, changes in population growth, gross domestic product and trade openness have significant effect on CO2 emissions. Further, results indicated that except renewable energy, fossil fuel, alternative and nuclear energy, imported energy have significant effect on CO2 emissions. Except for trade openness with a negative coefficient all other variables had positive coefficient hence contribute to increase in carbon emissions. (OmbworiKongo, 2018, pp. 1-22)

Kajally Jawara and Adedeji Abiodun Liadi (2016) studied the socio-economic variables that are responsible for the production of carbon dioxide emissions in The Gambia. This study, in particular, looked at the relationship between CO2 emissions and gross domestic product per capita, population density and trade balance. The study employed the Vector Error Correction Model to determine the dynamic relationship between CO2 emissions and the variables such as GDP per capita, population density and trade balance. The findings of this study revealed that there is a long run relationship between CO2 emissions and the variables. In other words, GDP per capita and population density positively impacts on the growth of CO2 emissions in The Gambia, while the influence of trade balance was negatively associated. (Jawara & Adedeji Abiodun, 2016, pp. 43-52)

Hamisu Sadi Ali and all (2016) examined the dynamic impact of urbanization, economic growth, energy consumption, and trade openness on CO2 emissions in Nigeria based on autoregressive distributed lags (ARDL) approach for the period of 1971–2011. The result shows that variables were cointegrated as null hypothesis was rejected at 1 % level of significance. The coefficients of long-run result reveal that urbanization does not have any significant impact on CO2 emissions in Nigeria, economic growth, and energy consumption has a positive and significant impact on CO2 emissions. However, trade openness has negative and significant impact on CO2 emissions. (Law, Siong Hook, & Talha Ibrahim, 2016, p. 1)

In general, the literature shows that determinants of CO2 emissions vary depending on the period studied, the econometric methods used, and the country.

3. TRENDS OF CARBON DIOXIDE EMISSIONS IN ALGERIA:

Algeria is one of the most important carbon dioxide emitters among African and developing countries, because of the ever increasing of carbon dioxide emissions in recent decades.

3.1. Evolution of carbon dioxide emissions in Algeria:

Emissions of carbon dioxide (CO2) continue to rise in Algeria, Which is shown through the evolution of carbon dioxide emissions per capita in Algeria in the period 1970-2019.

Table N° 1: CO2 emissions per capita in Algeria in the period 1970-2019

Metric tons per capita

year	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**
Co2 emissions	1.04	1.26	1.85	2.44	1.98	1.93	2.29	2.38	3.45	2.45
year	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**
Co2 emissions	3.46	2.34	1.92	2.49	3.27	3.24	3.30	3.54	3.43	3.19
year	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Co2 emissions	2.99	2.99	2.96	2.97	3.06	3.31	3.32	2.94	3.54	3.01
year	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Co2 emissions	2.83	2.68	2.82	2.84	2.71	3.24	3	3.20	3.17	3.44
year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Co2 emissions	3.31	3.31	3.48	3.53	3.74	3.85	3.70	3.87	4.08	4.23

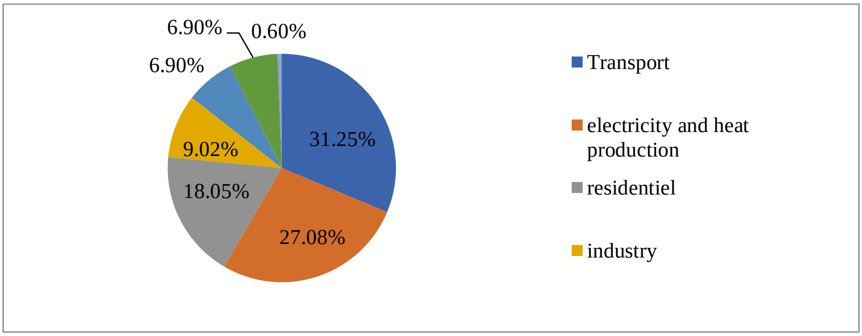
Source: prepared by the author from: World Bank data and BP's Statistical Review of World Energy.

The statistical data in the previous table show that CO2 emissions per capita for Algeria have seen a rise between the period of 1970 and 2019. In 1970, Co2 emissions registered in Algeria was 1.04 metric tons. The emissions of CO2 has being increasing since 1970 to reach 3.48 metric tons in 2012 and continuing to growth, in which reached a high value of 4.23 metric tons in 2019 growing at an average annual rate of 3.06, because Algerian economy is characterized by its high dependence on fossil fuel, in addion to the socio-economic development -for several years generates in Algeria a high demand for electricity and natural gas- and other factors can be affecting CO2 emissions in Algeria.

3.2. Sectoral distribution of carbon dioxide emissions in Algeria:

Carbon dioxide emissions can also be broken down by the economic activities that lead to their production, which is shown in the figure below.

Figure N°1: Quantity of CO2 emitted by sectors in Algeria in 2018



Source: prepared by the author from: International Energy Agency

The figure shows that the transportation sector and Electricity production combined dominate current global CO2 emissions, accounting for about 58% of total CO2 emissions, as the transportation sector generates the largest share of CO2 emissions, which primarily come from burning fossil fuel. A large percentage of the fuel used for transportation is petroleum based, which includes primarily gasoline and diesel, and electricity production generates the second largest share of CO2 emissions. Approximately 99.33 % of our electricity comes from burning fossil fuels, mostly natural gas (www.iea.org). The figure shows also that residential sector generates 18.05% of CO2 emission followed by industrial sector with 9.02% and both commercial and public services and other energy industries by 6.90%.

In general, the growth of energy consumption of different sectors is due to the dependence on fossil fuels (oil and natural gas), because Algeria owns the largest crude oil reserves, in addition to subsidizing energy prices, which are an important determinant of energy consumption.

4. METHODS AND MATERIALS:

4.1. Sample and data:

The data employed in this study are annual data covering the period 1970-2019. The main types of data are taken from World Bank data, United Nations Conference on Trade and Development (UNCTAD) and BP's Statistical Review of World Energy.

4.2. Variables of the study:

The Variables with their symbols are given in table 2.

Table N° 2: Variables of study

Variables	symbol	type
CO2 emissions per capita	(CO2PC)	Dependent
real GDP per capita	(GDPPC)	Independent
Domestic credit to private sector	(DCP)	Independent
money supply	(M2)	Independent
domestic investment	(DI)	Independent
direct foreign investment	(FDI)	Independent
trade openness	(TO)	Independent

Source: prepared by the author

5. RESULTS AND ANALYSIS:

5.1. Order of Integration and Stationary of Serial:

A chronological serial is stationary if not contain no trend and intercepts, so we must establish the order of variables integration, we say that variables are integrate in order p if her deference's in order p is stationary so we shall be checking are this variable got unit root or not. That means her deference's in order p is null growth. There are many tests permit to put on evidence the stationary of serial. In this study we use augmented Dickey-Fuller test (ADF), in order to ensure that the variables are not I(2). The ADF test results for both level and first difference tests with their significance levels are presented in Table 3 below.

Table N° 3: Augmented Dickey Fuller (ADF) Test Results

		ADF test results		
		With Intercept	**With Intercept &**	**With Out Intercept &**
CCO2PC	**At Level**	-3.05 (0.036)	-4.25 (0.0076)	1.55 (0.96)
	1st Difference	-5.87 (0)	-5.79 (0.0001)	-5.69 (0)
GGDPPC	**At Level**	-2.26 (0.18)	-2.07 (0.54)	2.37 (0.99)
	1st Difference	-7.86 (0)	-7.95 (0)	-6.87 (0)
DI	**At Level**	-1.36 (0)	-1.43 (0)	0.08 (0)
	1st Difference	-6.81 (0.59)	-6.79 (0.83)	-6.86 (0.70)
FDI	**At Level**	-3.80 (0.004)	-4.26 (0.0075)	-2.67 (0.0084)
	1st Difference			
TO	**At Level**	-1.86 (0.34)	-1.75 (0.71)	-0.30 (0.57)
	1st Difference	-5.20 (0.0001)	-5.21 (0.0005)	-5.25 (0)
DCP	**At Level**	-1.37 (0.58)	-1.82 (0.67)	-0.94 (0.30)
	1st Difference	-5.16 (0.0001)	-5.10 (0.0007)	-5.22 (0)
M2	**At Level**	-1.71 (0.41)	-1.49 (0.81)	0.33 (0.77)
	1st Difference	-5.71 (0)	-5.68 (0.0001)	-5.74 (0)

Source: Author computation using Eviews10

The results depicted in table (3) revealed that FDI is stationary in level while others variables are stationary in first difference. On the based ADF test results, we select to use the ARDL technique to perform the long term and short-run analysis. The ARDL approach is preferable when variables have mixture of results at stationary in level I(0) and stationary in I(1). It is intimate that among the variables; no one is integrated of order two. Thus, our result is free of spurious regression.

5.2. ARDL Model Estimation

In recent times, an emerging body of work led by (Pesaran & Shin, 1999) and further extended by (Pesaran et al, 2001), has introduced an alternative cointegration technique recognized as the 'Autoregressive Distributed Lag' or ARDL bound test (Benanaya & Bakdi, 2017, p. 24). According to Nkoro & Uko (2016) some of the advantages of the approach above the Ordinary Least Squares (OLS) Estimator and other dynamic lag models are its ability to handle the possible endogeniety problems that usually arise as a result of residual correlation since all underlying variables stand as single models. Furthermore, they stated that, the major advantage of this approach lies in its identification of the cointegrating vectors where there are multiple cointegrating vectors. Again, another major advantage of the approach is that it gives results both short run (Error Correction Model) and long run cointegration among variables under study (Adzugbele, Afamefuna Angus, Ejimofor, & Nnebuihe Ihechi, 2020, p. 54). Table (4) provides if there is a short run relationship among variables or not.

Table N° 4: ARDL Model Estimation:

Dependent Variable: CO2PC				
Maximum dependent lags: 1 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (2 lags, automatic): GDPPC FDI DCP M2 DI TO				
Fixed regressors: C				
Selected Model: ARDL(1, 1, 0, 0, 0, 0, 0)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CO2PC(-1)	0.283671	0.130060	2.181075	0.0351
GDPPC	0.000652	0.000408	1.596870	0.1182
GDPPC(-1)	0.000185	0.000405	0.455768	0.6510
FDI	0.123494	0.104326	1.183731	0.2435
DCP	0.001711	0.003868	0.442494	0.6605
M2	-0.019059	0.010244	-1.860534	0.0702
TO	-0.032365	0.008661	-3.736707	0.0006
DI	0.019968	0.009289	2.149616	0.0377
C	1.205397	0.431857	2.791192	0.0080
R-squared	0.774751	Mean dependent var		3.027143
Adjusted R-squared	0.729701	S.D. dependent var		0.612485
S.E. of regression	0.318433	Akaike info criterion		0.713595
Sum squared resid	4.055975	Schwarz criterion		1.061072
Log likelihood	-8.483071	Hannan-Quinn criter.		0.845427
F-statistic	17.19762	Durbin-Watson stat		2.256820
Prob(F-statistic)	0.000000			

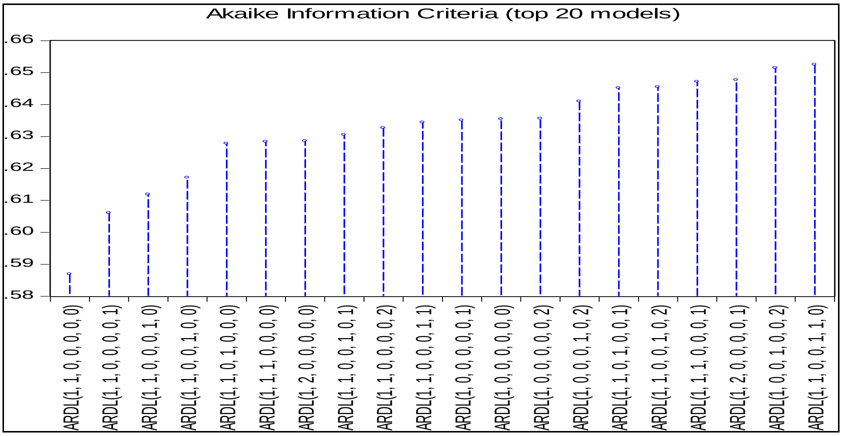
Source: Author computation using Eviews10.

The results of the model estimation show that some of CO 2 emissions macroeconomic determinants affect it in different lag, which are CO2PC (-1), TO, DI in addition to the constant and the variable AL, which mean that there is a short run from the independent variables to the dependent variable. The statistical tests of the regression equation indicate that the estimated model is good, as the coefficient of determination is equal to 0.7747, meaning that the model interprets 77.47% of the changes in the rate of CO2 emissions. Furthermore, the results indicate that the relationship between the dependent variable and the explanatory variables is not false; the value of F-statistics has a significant value of 17.19.

5.3. Optimal Lag Length Selection:

Before estimating the ARDL model, we must determine the optimum degrees delays for the model. For this purpose, the Akaike Information Criterion (AIC) was used to select the number of lags required in the cointegration test. The lag length chosen are showed in graph (2) below.

Figure N°2: optimal lags Optimal Lag Length Selection



Source: Author using Eviews10

The lag order of model based on Akaike Information Criterion (AIC) is: ARDL(1, 1, 0, 0, 0, 0, 0); The ARDL model can be specified as:

$$\Delta CO2PC = C + \alpha_1 CO2PC_{t-1} + \alpha_2 GDPPCF_{t-1} + \alpha_3 FDI_{t-1} + \alpha_4 DCP_{t-1} + \alpha_5 M2_{t-1} + \alpha_6 DI_{t-1} + \alpha_7 OPE_{t-1} + \beta_{1i} \Delta CO2PC_{t-1} + \beta_{2i} \Delta TGDPPC_{t-1}$$

Where :

Δ : the first-difference operator.

β_1, β_2: The coefficients of short–run relationship.

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6, \alpha_7$: The coefficients of long- run dynamic relationship.

5.4. Bound Test for Cointegration:

To determine the existence of long run relationship among the variables of the study, the (Pesaran, M. H., Shin, Y, & Smith, R. J, 2001) Bound test procedure was used. Narayan, 2004 tabulated two sets of critical values, the upper bound critical values refers to the I(1) series, meaning that there is cointegration among the variables and the lower bound critical values to the I(0) series, meaning that there is no cointegration relationship between variables . For some significance level, if the F-statistics falls outside the critical bound, a conclusive inference can be made without considering the order of integration of the explanatory variables (Rahmatullah, Haqbin, Samoon, Zahid, & Mywanwal, 2020, p. 8235). The bound test results were presented in Table (5) below.

Table N° 5: ARDL bounds Test

ARDL Bounds Test				
Test Statistic	Value	k		
F-statistic	4.328679	6		
Critical Value Bounds				
Significance	I0 Bound	I1 Bound		
10%	2.12	3.23		
5%	2.45	3.61		
2.5%	2.75	3.99		

Note: k is the number of regressor for dependent variable in ARDL model.

Source: Author computation using Eviews10

The bound test results indicate that the F-statistic value is 4.32, which is more than the upper bound critical value at all levels of significance. The bounds test results support the presence of cointegration relationship among the variables running from the independent variables to dependent variable.

5.5. Cointegration of long run relationship:

The two popular co-integration tests in applied time series modeling are the (Engel & Granger, 1999) cointegration test and the (Johansen & Juselius, 1990) cointegration test. The (Engel & Granger) cointegration test is adopted in cases of single equation models, while, the (Johansen & Juselius) co-integration test is used for system equation models. The autoregressive distributed lag (ARDL) model is based on single equation modeling (Pesaran & al, 2001). For the purpose of our study we chose the Autoregressive Distributed Lag (Benanaya & Bakdi, 2017, p. 25). The long-run regression results are presented in table (6).

Table N° 6: ARDL Cointegrating and Long Run Form

ARDL Cointegrating And Long Run Form Dependent Variable: CO2PC Selected Model: ARDL(1, 1, 0, 0, 0, 0, 0) Sample: 1970 2019				
Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDPPC)	0.000652	0.000408	1.596870	0.1182
D(FDI)	0.123494	0.104326	1.183731	0.2435
D(DCP)	0.001711	0.003868	0.442494	0.6605
D(M2)	-0.019059	0.010244	-1.860534	0.0702
D(TO)	-0.032365	0.008661	-3.736707	0.0006
D(DI)	0.019968	0.009289	2.149616	0.0377
CointEq(-1)	-0.716329	0.130060	-5.507681	0.0000
Cointeq = CO2PC - (0.0012*GDPPC + 0.1724*FDI + 0.0024*DCP -0.0266 *M2 -0.0452*TO + 0.0279*DI + 1.6827)				
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDPPC	0.001168	0.000246	4.748351	0.0000
FDI	0.172399	0.147019	1.172625	0.2479
DCP	0.002389	0.005341	0.447304	0.6571
M2	-0.026607	0.013138	-2.025214	0.0496
TO	-0.045182	0.011545	-3.913392	0.0003
DI	0.027875	0.013850	2.012630	0.0500
C	1.682742	0.585953	2.871805	0.0065

Source: Author computation using Eviews10

As show the results in table above table (6), the error correction estimator is significant at 1%, which support the presence of long run relationship between variables (ECT =-0.7163), this means that when CO2 emissions (Measuring with CO2 emissions per capita) deviate from his equilibrium value in the short period (t-1), it corrects which was equivalent to 71.63% of this deviation in the period (t). This ratio reflects the speed of return to the equilibrium position after the impact of any shock on the model as a result of the change in the determinants of CO2 emissions. Furthermore, all variables GDPPC, M2, TO and DI were statistically significant determinants of CO2 emissions in Algeria, whereas FDI and DCP do not have any significant effect on CO2 emission.

The long-term coefficients for the model show that trade openness has a very significant effect co2 emissions, as 1 % increase in this variable will reduce co2 emissions by 0.04 metric tons. This result can be explained by offsetting forces (the technical effect), Therefore, the significant trend of increasing exports of gross fuels in Algeria, instead of oil products and manufacturing, may explain the negative sign of the estimated coefficient of trade openness in the long-run and short-run. This finding therefore reconfirmed the findings of Kajally Jawara and Adedeji Abiodun Liadi (2016) and Hamisu Sadi Ali and all (2016).

Other than that, real gross domestic product per capita growth has a positive impact on CO2 emissions; an increase of real GDP per capita growth by 1 USD (constant 2010 USD) will increase co2 emissions by 0.001 metric tons, because Algerian economy remains highly dependent on the oil and gas sector, in addition to economic expansion and the implementation of many huge investment projects. The result reconfirmed the findings of Rambeli Norimah and all (2018), Ombwori Kongo Yabesh (2018), Kajally Jawara and Adedeji Abiodun Liadi (2016) and other studies.

Additionally, the findings in Table 6 show that financial development measuring with money supply improves air quality in the long run. Accordingly, a 1% increase in financial development reduces CO2 emissions by 0.02 metric tons, because The level of development of the financial sector creates less demand for energy. Then, lower energy consumption gives rise to less $CO2$ emissions, as well as The financial services provided don't Allow people to purchase more durable consumer goods, which will give rise to energy demand and consumption. These results contradict the findings by Duy Tung Bui (2020) and Chun Jiang and Xiaoxin Ma (2019) due to the different level of financial development in countries, whereas the impact of domestic investment (% of GDP) found to be positive and statistically significant at 5% level; an increase of domestic investment by 1% will increase Co2 emissions by 0.02 metric tons, because investments are the engine of economic expansion in Algeria, and a high investment rate leads to high physical capital stock in steady state and increases carbon dioxide emissions per capita. This outcome corroborates the results of Bernard Boamah Bekoe and all (2022), who also found a positive impact of domestic investment on Co2 emissions in Ghana.

5.6. Diagnostic tests:

Now, we perform some diagnostic tests to ensure that the model is best fit and the stability of the model.

- **Serial Correlation LM Test**: the serial correlation problems in the data were examined through the Breusch Godfrey serial correlation LM test. The examined results (table 7) indicated that there is no serial correlation in the study data because the calculated P value is higher than 0.05.

Table N° 7: Breusch-Godfrey Serial Correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.356229	Prob. F(2,38)	0.2698
Obs*R-squared	3.264613	Prob. Chi-Square(2)	0.1955

Source: Author computation using Eviews10

- **Heteroskedasticity Test**: The Breusch Pagan-Godfrey test was applied to examine the problem of heteroskedasticity in the residuals. The examined results of heteroskedasticity indicate that no problem of heteroskedasticity exists in our data based on the calculated P-value of chi-square.

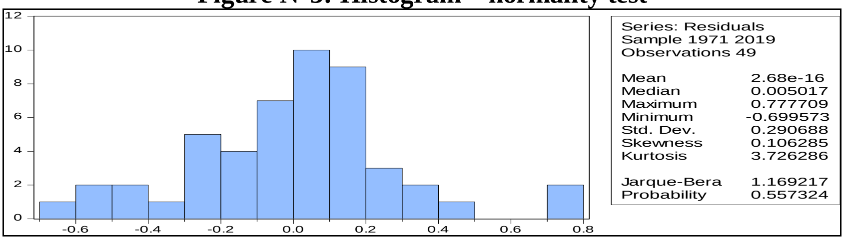
Table N° 8: Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.948178	Prob. F(8,40)	0.0791
Obs*R-squared	13.73896	Prob. Chi-Square(8)	0.0888
Scaled explained SS	12.48024	Prob. Chi-Square(8)	0.1310

Source: Author computation using Eviews10

- **The test for normality:** The result of the test for normality in table figure 3 demonstrates that the error term is also proved to be normally distributed.

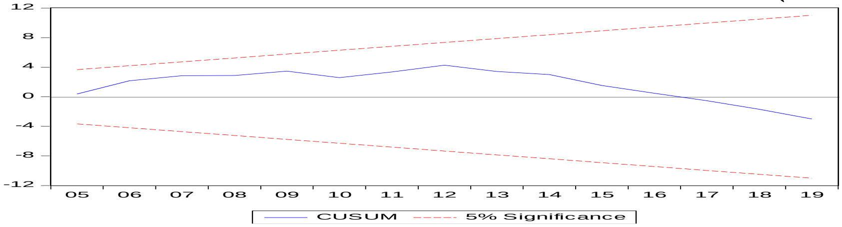
Figure N°3: Histogram – normality test



Source: Author using Eviews10

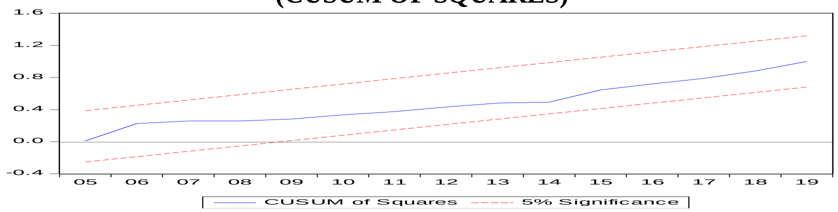
- **Test of parameters stability:** To make sure, that the data used in this study, does not contain any structural changes, we should use one of the appropriate tests CUSUM and CUSUM of squares, which developed in order to clarify the extent of stability and consistency of long-term parameters with short-term parameters. If the plot of CUSUM-SQ and CUSUM statistic stays within 5% significance level, then the estimated coefficients are said to be stable (Tilak & Dhakal, 2020, p. 286). A graphical presentation of this test for our ARDL model is provided in Figures 4, 5 below.

Figure N°4: The cumulative sum of recursive residual test (CUSUM)



Source: Author using Eviews10

Figure N°5: The cumulative sum of recursive squares residual test (CUSUM OF SQUARES)



Source: Author using Eviews10

The results in the graphs show that the curve CUSUM within critical limits is 5%, as well as for the curve CUSUM OF SQUARES located within the critical area, which explains that the model is stable at 5%.

5. CONCLUSION:

This study investigated the macroeconomic determinants of carbon dioxide emissions in Algeria over the period of 1970 - 2019. We have applied ADF and PP unit root tests to test stationarity of the variables. Further, the ARDL bounds testing approach to cointegration was employed to investigate the long and short-run relationships between the variables. The results are:

- Carbon dioxide determinants affect it in different lag, which are CO2PC (-1), TO, DI in addition to the constant and the variable AL, which mean that there is a short run from the independent variables to the dependent variable
- The statistical tests of the regression equation indicate that the estimated model is good, as the coefficient of determination is equal to 0.7747, meaning that the model interprets 77.47% of the changes in the rate of CO2 emissions.
- the error correction estimator is significant at 1%, which support the presence of long run relationship between variables (ECT =-0.7163), this means that when CO2 emissions (Measuring with CO2 emissions per capita) deviate from his equilibrium value in the short period (t-1), it correct which was equivalent to 71.63% of this deviation in the period (t).
- Trade openness has very significant effect co2 emissions, as 1 % increase in this variable will reduce co2 emissions by 0.04 metric tons. The positive relationship between trade openness and Co2 emissions is as result of offsetting forces (the technical effect), Therefore, the significant trend of increasing exports of gross fuels in Algeria, instead of oil products and manufacturing, may explain the negative sign of the estimated coefficient of trade openness in the long-run and short-run.
- Real gross domestic product per capita growth has a positive impact on CO2 emission, because Algerian economy remains highly dependent on the oil and gas sector, in addition to economic expansion and the implementation of many huge investment projects.
- Financial development measuring with money supply improves air quality in the long run. Accordingly, a 1% increase in financial development reduces CO2 emissions by 0.02 metric tons, because liberalization and financial sector development.
- Domestic investment (% of GDP) found to be positive and statistically significant at 5% level; an increase of domestic investment by 1% will increase co2 emissions by 0.02

metric tons, because investments are the engine of economic expansion in Algeria, and a high investment rate leads to high physical capital stock in steady state and increases carbon dioxide emissions per capita.

In view of this, and for reducing CO_2 emissions, we recommend:

- Promoting renewable energies and energy efficiency policies, through developing a specific sustainable energy model and identify the different possible energy scenarios depending on the national and global energy contexts. Once this model is defined, some measures to promote renewable energies and energy efficiency should be considered with the aim of stimulating new renewable installations.
- Decreasing subsides in energy prices to encourage energy efficiency.
- Shifting towards service intensive economy rather than resource intensive, in order to mitigate environmental degradation as well as promote economic development

Finally, this work is not without any limitations. First, the selection of control variables may not be comprehensive, there may be some missing information and future research should increase the number of determinants to obtain more perfect information. Second, only CO_2 emission was tested as dependent variable while other GHG indicators also exist such as sulfur dioxide (SO_2), nitrogen dioxide (NO_2), chlorofluorocarbons (CFC). Third, limited by the availability of data, the sample size of data is relatively small and the result of the model may only reflect the situation from 1990 to 2019. Although the coefficients of variables are as expected, their size may be different from that of a large sample, so the sample size should be expanded in future research. Therefore, Future research may extend the analysis by including other factors such as decomposition of energy consumption with renewable energy, energy prices, other economic and social factors, and other forms of GHG emissions, in order to capture the dynamic changes in carbon emissions. Furthermore, future research could also focus on the other empirical approaches and employing higher frequency dataset to forecast the dynamic levels of carbon emissions.

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