

**The effects of commercial openness and fossil fuel energy consumption
In the manufacturing sector on environmental quality in Algeria
Standard study using ARDL model during 1990-2022**

تأثير الانفتاح التجاري واستهلاك طاقة الوقود الأحفوري

في قطاع الصناعات التحويلية على الجودة البيئية في الجزائر

دراسة قياسية باستخدام نموذج ARDL خلال الفترة 1990-2022

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Received on:27/12/2024

Accepted on:14/12/2025

published on: 15/12/2025

Abstract:

This study aims to measure the impact of both trade openness and fossil fuel energy consumption on environmental quality by applying to Algeria's manufacturing sector during the period 1990-2022.

By characterizing a standard model, its independent variables are both fossil fuel energy consumption, EC commercial openness, TO net inflows of FDI, FDII, GDP growth rate and dependent variable in environmental quality expressed

About CO2 emission indicator CO2e and using the autoregressive Bounds Analysis methodology by applying border analysis procedure Distributed lags (ARDL) Procedure and Joint Integration Test, Cointegration Test, the results of the study confirmed that long-term fossil fuel consumption in manufacturing contributed significantly and positively to Algeria's CO2 emissions and that per capita GDP has a significant positive impact on CO2 emissions, In addition, a significant reverse correlation was obtained between CO2 emissions, FDI and open trade in the long term.

Keywords: fossil fuel energy consumption; FDI; Commercial openness; environmental quality; ARDL ;GDP growth rate

JEL classification codes: C19 ; Q19; O49

ملخص: تهدف هذه الدراسة إلى قياس أثر كل من الانفتاح التجاري واستهلاك طاقة الوقود الأحفوري على الجودة البيئية بالتطبيق على قطاع الصناعة التحويلية في الجزائر خلال الفترة 1990-2022،

وبتوصيف نموذج قياسي تتمثل متغيراته المستقلة في كل من استهلاك طاقة الوقود الأحفوري، EC الانفتاح التجاري، TO صافي التدفقات الداخلة للاستثمار الأجنبي المباشر، FDI معدل النمو في الناتج المحلي الإجمالي، GDP والمتغير التابع في الجودة البيئية التي تم التعبير عنها بمؤشر انبعاثات غاز ثاني أكسيد الكربون CO2E. وباستخدام منهجية autoregressive Bounds Analysis من خلال تطبيق إجراء تحليل الحدود distributed lags (ARDL) Procedure واختبار التكامل المشترك Cointegration Test ، وأكدت نتائج الدراسة أن استهلاك الوقود الأحفوري في الصناعة التحويلية على المدى الطويل

ساهم بشكل كبير وإيجابي في انبعاثات ثاني أكسيد الكربون في الجزائر، كما أن الناتج المحلي الإجمالي للفرد له تأثير إيجابي كبير على انبعاثات ثاني أكسيد الكربون، بالإضافة إلى ذلك، تم الحصول على ارتباط عكسي كبير بين انبعاثات ثاني أكسيد الكربون والاستثمار الأجنبي المباشر والتجارة المفتوحة في المدى الطويل.

الكلمات المفتاحية: استهلاك طاقة الوقود الأحفوري؛ الانفتاح التجاري؛ الاستثمار الأجنبي المباشر؛ جودة البيئة؛ ARDL؛ معدل النمو في الناتج المحلي الإجمالي

تصنيف JEL: C19 ; Q19; O49

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1-Introduction

Environmental issues and climate challenges are at the top of the global dialogue agenda. s environment ", where evidence is growing that human activity is the main cause of major environmental changes in the Earth, One of the most significant factors behind this change is carbon dioxide emission. pollution ", resulting from industrial activities and burning fossil fuels, which is considered to be one of the most harmful and harmful air pollutants affecting the environment and human health.

The world's energy supply, according to global energy balance figures, increased from 6.098 million equivalent tonnes of oil in 1973 to 14.282 million tonnes of thermal oil in 2018, mainly due to high demand for consumption in economic activities. Because non-renewable energy sources (fossil fuels) account for 80% of total energy demand. The energy sector is the main source of green house gas emissions, GHG and especially carbon dioxide emissions, accounting for about two thirds of the world's total emissions. Environment under the Sustainable Development Goals (SDG-7) Environmental degradation is a critical concern to ensure sustainable economic growth, SEGG especially in developing economies.

Many CO2 emitters affecting global environmental quality and climate change are among the most important fossil fuel energy consumption and commercial openness.

FDI has become an increasingly important source of capital that transfers management and technology skills, generates employment and gradually contributes to export activities, thereby improving the standard of living of millions of people in the region. However, FDI also leads to environmental degradation of host countries. Host countries have considered the trade-off between environmental degradation and growth so that they can attract FDI to their countries. (Muhammad, Nasrullah, 2021)

Increased consumption of fossil fuel energy has led to a deterioration in the quality of the global environment due to increased CO2 emissions due to production processes in various industrial sectors, especially chemical and mining industries. For example, in the cement industry the production of one

kilogram of cement contributes to the emission of one metric ton of carbon dioxide gas into the air.

Some see commercial openness as one of the most important factors explaining environmental quality. and, assuming the stability of all other factors, international trade increases the volume of production, which in turn means an increase in consumption especially of fossil fuel energy and thus an increase in carbon dioxide emissions - that is, commercial openness is the main cause of environmental degradation -, On the other hand, commercial openness can lead to lower environmental pollution by directing part of the increase in national income caused by international trade to implement environmental regulations and regulations and environmental supervision.

Energy consumption is critical to employment potential and an important factor for economic growth, yet it can also have a long-term negative impact on global warming and climate change caused by increasing greenhouse gas levels. Based on the need for sustainable development, while CO₂ emissions achieve relatively high levels in Algeria's environment, the impact of both fossil fuel energy consumption and commercial openness on Algeria's environmental quality can be examined by applying to the manufacturing sector during the period 1990-2022.

1-1-Study Problem :

Oil is a strategic commodity that plays an effective role at the contemporary economic and political levels. It is the primary source of primary energy on which people rely significantly, being the cheapest to secure the different heavy and transformative industries, the lowest-priced commodity needed for heating and transportation, making controlling its production and distribution to consumption areas and determining its price very difficult.

At present, fossil fuels remain the leading source of energy worldwide, with total global primary energy production coming in about 81% of energy from fossil fuels with oil accounting for 32.5%, coal 26.9% and natural gas 22.8%. In this context, energy can be likened to water or air as necessary, its necessity has caused it to be considered a strategic commodity.

Today the final energy consumption is 442 exajoules divided between industry (167 exajoule), buildings (133 exajoule), transport (116 exajoule), industry is the sector that uses most energy, with the iron and steel industry, chemicals, non-ferrous metals and paper accounting for nearly 90% of coal demand, over 70% for oil, and about 55% for natural gas,

The expected increase in demand for natural gas for industrial purposes demonstrates a deliberate strategic effort to increase the utilization of Algeria's domestic natural gas resources and promote the promotion of new industrial projects. 80% of the energy sources currently used by the industry come from natural gas. Where industry relies heavily on natural gas supplies, on the other hand, Sonatrak is developing fertilizers and other petrochemical products as a way to "add more value" to Algeria's hydrocarbon resources in its new 2030

plan in the industry, the primary uses of natural gas (methane) are the manufacture of methanol and nitrogen fertilizer. Other petrochemical companies use natural gas liquids. On the other hand, expanding production puts pressure on environmental resources, overexploiting them and increasing energy consumption especially from fossil fuels, that is, affecting environmental quality.

Hence the problem of the study is to measure the impact of both fossil fuel energy consumption and commercial openness on Algeria's environmental quality by applying to the manufacturing sector during the period 1990-2022.

1-2-Study assumptions :

This study assumes that:

The consumption of fossil fuel energy adversely affects Algeria's environmental quality due to increased greenhouse gas emissions (GHG), especially from CO₂. Commercial openness adversely affects the quality of Algeria's environment and climate due to the resulting industrial production and transportation processes, i.e. consumption of fossil fuel energy, thereby increasing GHG emissions, the most important of which is gas. CO₂

1-3-Objective of the study :

This study aims to test the previous two hypotheses using the standard method by applying to the Algerian manufacturing sector during the period (2022-19900). The reason for this sector's choice is that it ranked first for its consumption of fossil fuel energy sources since the beginning of the period under consideration.

Algeria's policy of economic reform was chosen at the beginning of the period and the resulting policies of liberalization of foreign trade, thereby increasing the openness of the State to trade with the outside world, and the period ended in 2022 as a result of inadequate data on some of the economic variables under consideration.

1-4-Study methodology :

The study uses the methodology to identify the most important aspects of energy consumption, foreign investment, trade openness and the environment, as well as quantifying the impact of fossil fuel energy consumption and commercial openness on Algeria's environmental quality by applying to the manufacturing sector during the period 2022-1990, drawing on the data contained in the World Bank database.

1-5-Study Plan :

The study can be divided into two parts other than findings and recommendations :

- * Theoretical framework and the most important economic literature of the past.

- *Quantifying the impact of both fossil fuel energy consumption and commercial openness on Algeria's environmental quality

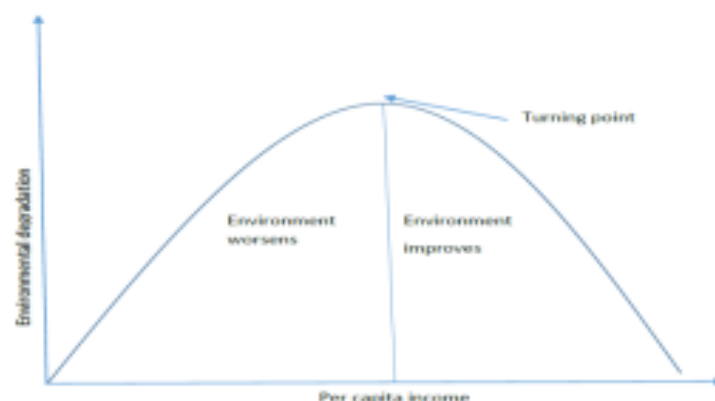
2-Theoretical framework and most important past economic literature

This section reviews the theoretical framework and the most important previous economic literature on the topic of the study as follows :

2-1-Theoretical framework of the study

Many studies suggest that raising the rate of economic growth and improving environmental quality are opposing goals. This is indicated by the Environmental Kuznets Curve (EKC) curve hypothesis, which illustrates the relationship between average per capita income and the level of environmental degradation, and can be explained in chart No. (01) as follows :

Figure No (01) Kuznets Environmental Curve.



Source: Nnyeneime. U., 2018, " Environmental Kuznets Curve (EKC): Review of Theoretical and Empirical Literature", MPRA, No.85024

From chart No. (01) it is clear that EKC takes the form of a UCP and this can be interpreted as follows:

A correlation between average per capita income and the level of environmental degradation. That is, as economic progress increases, and thus the average per capita income increases, environmental degradation increases. This is because the country that is growing economically in the early stages of development is doing its utmost to employ the natural resources at its disposal, putting pressure on the environment and increasing environmental pollution. **(Zubair, 2020)**

An inverse relationship between average per capita income and the level of environmental degradation. This can be explained by the fact that with high levels of economic progress, and thus high average per capita income, there is structural change in the State's economy and the shift towards the production of services and industries less polluting to the environment, the use of cleaner technology, the development and maintenance of environmental regulations and regulations, which ultimately leads to a low level of environmental degradation. **(Fotio, Nkengfack, 2019)**

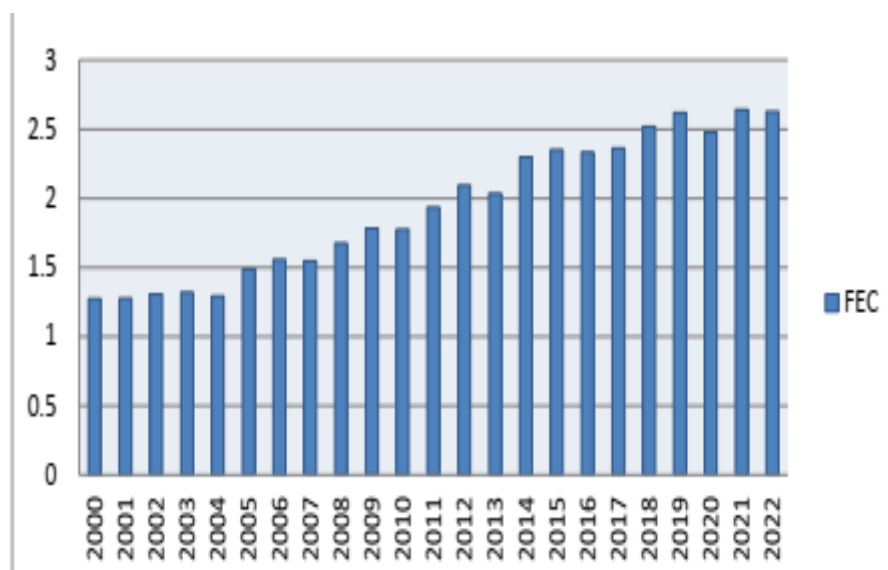
Fossil fuel energy production and consumption are among the most important déterminants of environmental degradation. As the International Energy Agency (IEA) decides that the energy sector is responsible for about 68% of GHG emissions worldwide, coal and petroleum only contribute about 40% of CO₂ emissions. (Anna, Anna, 2021)

Developed countries' pollution and environmental degradation increase due to their dependence on the production of manufactured goods, as they have a relative abundance of capital, called the Factor Endowment Hypo. (Badri Narayan, thai-Ha seema, 2022)

From FEH's premise, trade openness makes developed countries the primary responsibility for global environmental degradation, but because of developing countries' desire to attract FDI and transnational corporations, they are lenient in implementing environmental requirements and regulations, increasing pollution in those countries, the so-called pollution haven hypothesis.(Naranpanawa,2011)

Algeria's economy, like most developing countries that are commercially open to the outside world, suffers from low environmental quality and high pollution, especially as the level of fossil fuel energy use increases.

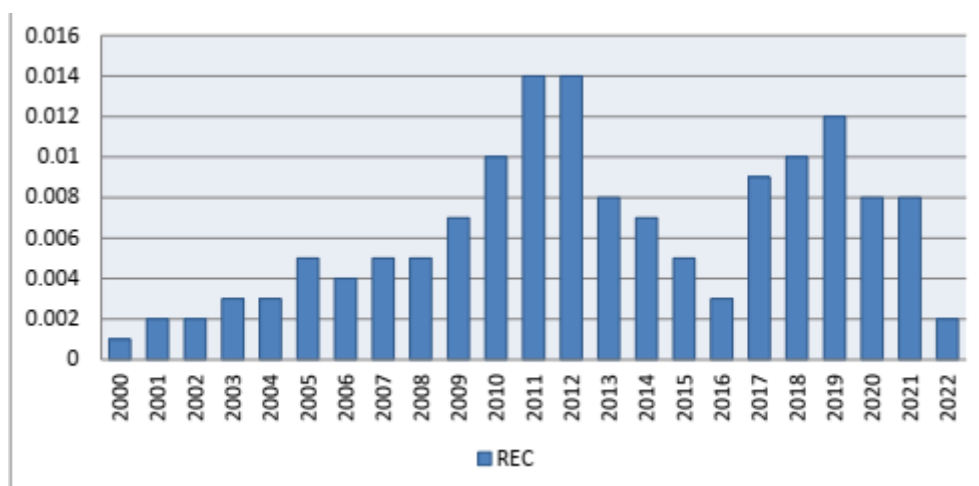
**Figure 02 : Fossil fuel energy consumption in Algeria for 2000-2022
British thermal unit.**



Source : Prepared by researchers based on EIA 2024

From the figure, the domestic consumption of fossil fuels has increased since 2005, estimated at 1.487 British thermal units, after a decline in 2004, so that the increase will continue at a subdued pace until 2014, but 2019 was the highest consumption capacity and continued to increase.

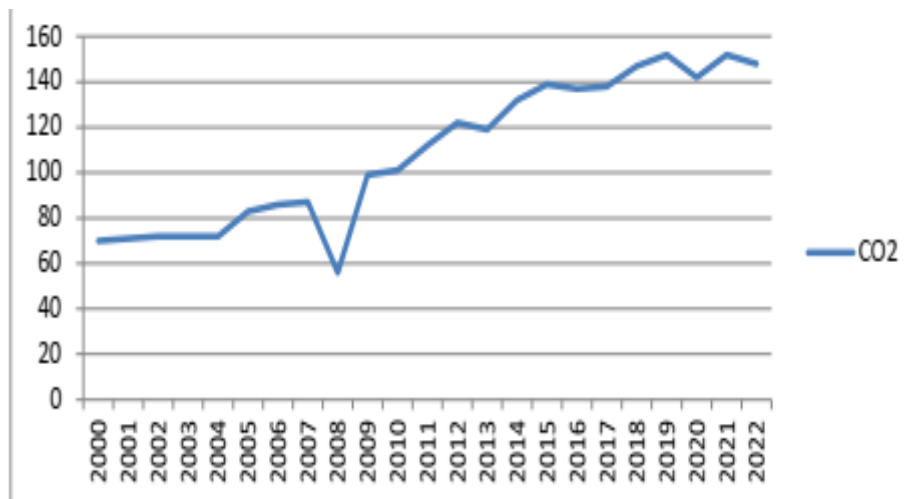
Figure 03 : Renewable energy consumption in Algeria for 2000-2022 British thermal unit.



Source : Prepared by researchers based on EIA 2024

We note from the figure the high levels of national consumption of renewable energy during 2011 and 2012 and the development of the renewable energy sector, where consumption peaked at 0.014 (British Thermal Unit), but by 2013 consumption had decreased by 0.008 (British thermal unit), the decline continued until 2016, and by analysing the two forms we note that Algeria relies heavily on traditional energy sources compared to renewable energy sources.

Figure 04 : Algeria's CO2 emissions.

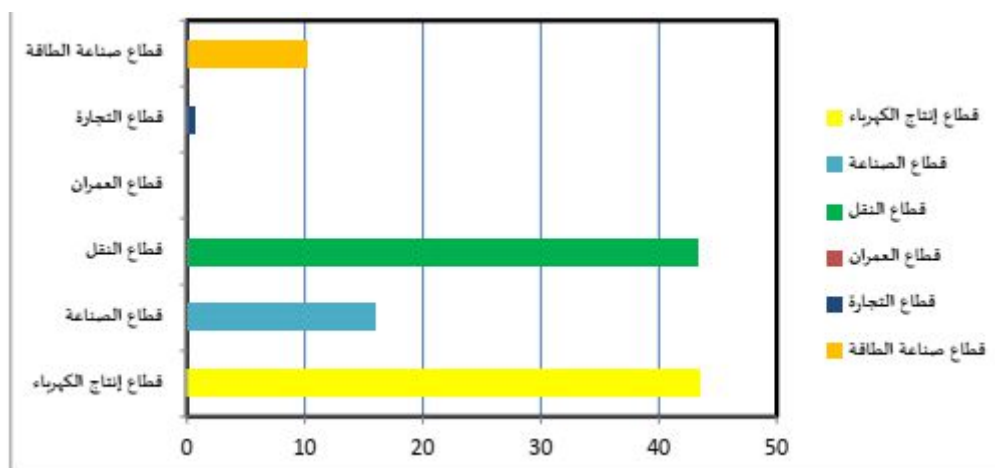


Source: From the researchers' preparation based on
<https://data.albankaldawli.org/indicator/EN.ATM.CO2E.KT>

Carbon dioxide continued to rise gradually until 2019, with a high emission value of 152 kilotonnes. In 2020, carbon dioxide decreased slightly by 142 kilotonnes to continue to rise in 2021 at 152 kilotonnes and in 2022 the capacity of 08 kilotonnes decreased considerably.

Through the next format, we note that gas emissions are not only limited to the energy sector, but also result from other energy-consuming sectors, the same human activity as global warming and environmental pollution. (Dauda, 2021)

Figure No 05 : Algeria's carbon emissions by sector for 2022.

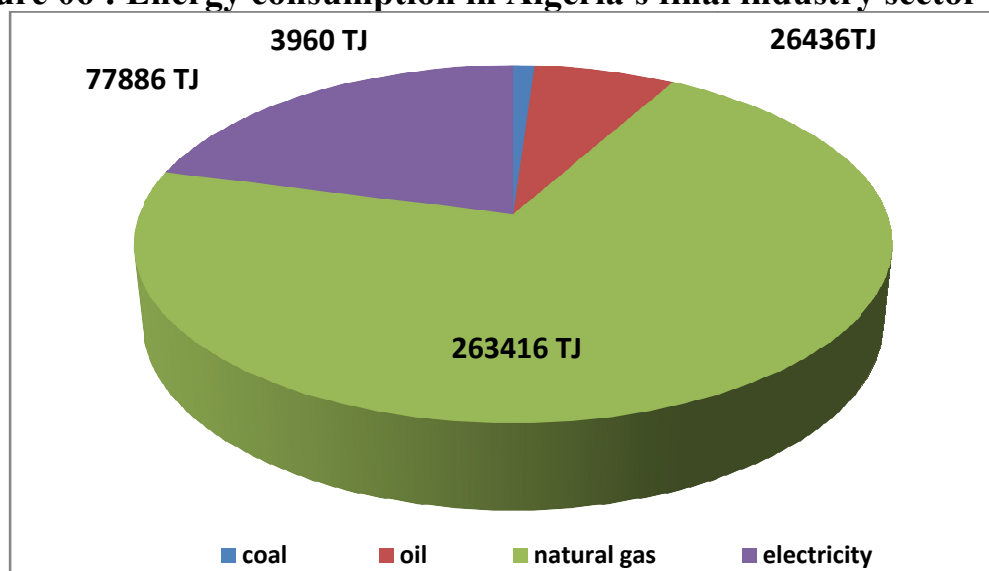


Source : Prepared by researchers :

<https://www.iea.org/countries/algeria/emissions>

Figure No. 06 shows the average percentage of energy consumption of the manufacturing sector in Algeria's total fossil fuel capacity during the period Examined as follows:

Figure 06 : Energy consumption in Algeria's final industry sector 2022.



Source : Prepared by researchers.

-2-2-The most important economic literature of the past:

*Khan et al study. (2020) Ascertaining the relationship between energy consumption, economic growth and CO2 emissions in Pakistan using annual

time chain data and ARDL methodology during the period. The findings indicated that primary energy consumption and economic growth cause the country's high CO₂ emissions in both the short and long term. The study recommends that decision makers adopt the replacement of traditional non-renewable energy sources such as coal, petroleum and natural gas with renewable energy sources so that CO₂ emissions can be reduced and sustainable development achieved.

* Leyton Chandra Fumeck and Mohamed Rizwan (2023) examined the impact of population growth, FDI, manufacturing and education on the environment using the ARDL model of the national economy for 1972-2021. The results of the study showed that industrialization and population have a strong impact on long-term CO₂ emissions and that the impact of FDI is irrelevant. In addition, a significant reverse correlation was obtained between CO₂ emissions and short-term education expenditures, and the results of Granger's causation show a one-way causation among the population, CO₂ emissions, manufacturing, CO₂ emissions, FDI, CO₂ emissions, CO₂ emissions and education.

* Haider et al. In its study on the relationship between exports and imports, FDI and CO₂ emissions, it identifies the impact of trade, energy consumption and FDI on CO₂ emissions in five North African countries in the period, 2014 -1990. This research investigates any applicability of the Kuznets curve's environmental hypothesis to those countries. The study found that commercial openness and energy consumption had a positive impact on gas emissions, CO₂ while it was not clear that FDI affected gas emissions.

* Thuy & Nguyen, 2022 Karedla et al. In studying the impact of commercial openness on the environmental quality of 64 developing countries during the period 2017-2003, commercial openness does not lead to environmental degradation, and financial openness and renewable energy consumption as key determinants of environmental quality reduce CO₂ emissions.

* Arab study, Noir (2022) The impact of FDI and commercial openness on environmental quality in Brazil during the period (1990-2020) using ARDL methodology. The study found that the increase in both TR and FDI will lead to more atmospheric carbon emissions, i.e. more pollution and lower environmental quality, which is consistent with the studies of Ajayi .akin (2016) Jadei (Idadin).

* The Yao Li Yogang Hee (2024) study examined the impact of CO₂ and energy emissions on Korea's economic growth from 1980 to 2022, using a non-linear automatic distributed delay model, and concluded that there was a positive correlation between CO₂ emissions and economic growth, similarly primary energy consumption is positively associated with economic growth. The study illustrates the roles played by net FDI, gross fixed capital creation and the labour force in promoting economic growth **(Yao and Yugang, 2024).**

* (Al - Mulali (2012) researched the main factors affecting CO₂ emissions in 12 Middle East countries: Bahrain, Egypt, Iran, Jordan, Kuwait, Lebanon, Oman,

Qatar, Saudi Arabia, Syria, UAE and Yemen during the period (2009 -1990). The study found that both total primary energy consumption, net FDI inflows, growth rate, GDP and total international trade were the most significant factors causing high CO₂ emissions in the countries under consideration. The study recommends that foreign companies should implement those States' environmental requirements and policies, transfer non-polluting technology and adopt trade policies capable of protecting the environment.

* Mattheus Belushio et al. (2022) study examining the impact of natural gas on the CO₂ emissions of 16 European countries from 1993 to 2018, used CO₂ as a subordinate variable while the autonomous variables are natural gas, oil, GDP, renewable energy consumption and hydropower, and used the distributed self-degradation model (ARDL), the result highlights that in the short term natural gas has little impact on CO₂ emissions than oil consumption, while renewable energy and hydropower consumption do not cause CO₂ emissions in the short and long term. (Matheus ,Renato و , José Alberto ,2022).

2-3-Research Gap :

The current study differs from previous studies applied to the Algerian economy in that the former attempts to look in the opposite direction by examining the impact of both fossil fuel energy consumption and commercial openness (as independent variables) on environmental quality (as a subordinate variable) by applying to Algeria's manufacturing sector.

Despite many applied studies on the impact of fossil fuel energy consumption and commercial openness on the environment and climate changes in many economies of the developed and developing world environmental quality in Algeria's economy ", but there is a dearth of applied studies that have addressed the impact of previous independent variables on environmental quality, The latter's focus has increased on studying the impact of energy consumption, commercial openness, Climate changes in Algeria's economic growth rate, as well as several studies examined the impact of environmental policies on foreign trade also in Algeria's economy.

3-Quantifying the impact of both fossil fuel energy consumption and commercial openness on Algeria's environmental quality.

This segment aims to measure the impact of all fossil fuel energy consumption and commercial openness on environmental quality. The environmental quality of the CO₂ emissions index generated from Algeria's manufacturing sector was expressed by application to the manufacturing sector during the period 1990-2022.

The study relied on the ARDL model for determining the short and long-term relationship between CO₂ emissions and consumption of Algeria's fossil fuel industry with an annual data set from 1990 to 2022. The study explores the impact of fossil fuel consumption on manufacturing, GDP, trade openness and FDI respectively as separate variables on CO₂ emissions, which are dependent

on variables. The choice of study period and country is due to the availability of data and Algeria is a State that relies heavily on fossil fuels.

Table 01 variable descriptions and sources.

	Variables	Variables symbol	Musuring unit	Source
Dependent	Carbon dioxide emissions	CO2	T/J	The global economic
Independent	Fo fuel energy consumption	EC	Thousands of tonne	International energy agency
	Gross domestic product p/c	GDPPC	Constant 2010 dollars	World bank
	Trade openness	TOP	% of GDP	World bank
	Foreign direct investment	FDI	%of GDP	World bank

Source: Authors' compilations

3-1-Model formulation:

To analyse the relationship between co2 and fossil fuel consumption in the manufacturing sector, commercial openness and FDI, GDPPC has been installed as follows:

$$\text{CO2} = f(\text{EC}, \text{GDPPC}, \text{TOP}, \text{FDI})$$

3-1-1-Result and discussion :

The ARDL model is the most effective economic standard method when compared to other methods, and is suitable for determining the impact of .affiliate variables on the independent variable.

3-1-2-Unit root tests results :

Before applying the ARDL boundary test to any variable, the root of its unit must be checked all variables must be fixed in I (0), I (1), or both in order to determine the associated statistical test F, relying on Dickey and Fuller enhanced test (ADF) and Phillips-Peron test (PP), the static test determines the sequencing results.

Table -2 result of the augmented dickey fuller(ADF) and Phillips Peron (PP) unit root tests.

	ADF			PP			
	T-statistic	p-value	Critical value	T-statistic	p-value	Critical value	
CO2	5.545263	0.0005	3.552361	5.552365	0.0005	3.525896	I(1)
EC	4.220640	0.0116	3.562882	4.552524	0.0116	3.523651	I(1)
GDPPC	4.132589	0.0028	2.962543	4.099256	0.0154	3.562882	I(1)
TOP	5.042364	0.0003	2.962564	4.875621	0.0024	3.562354	I(1)
FDI	5.672564	0.0002	2.962562	11.92541	0.0000	3.565963	I(1)

Source : Authors' computations using EvIEWS 12 software.

The result of the ADF test in table 2 shows that all five variables are stable at the first difference I (1) so the boundary test method is applicable in this research and the ARDL model is the most suitable option.

3-1-3-Lag Order Selection Criteria :

After confirming that all variables were fixed in the same order, we determined in this step the optimal delays order according to six selection criteria for delays from 0 to 2 and did not exceed this due to the low number of notes.

Table 03 : Lag Order Selection Criteria Results

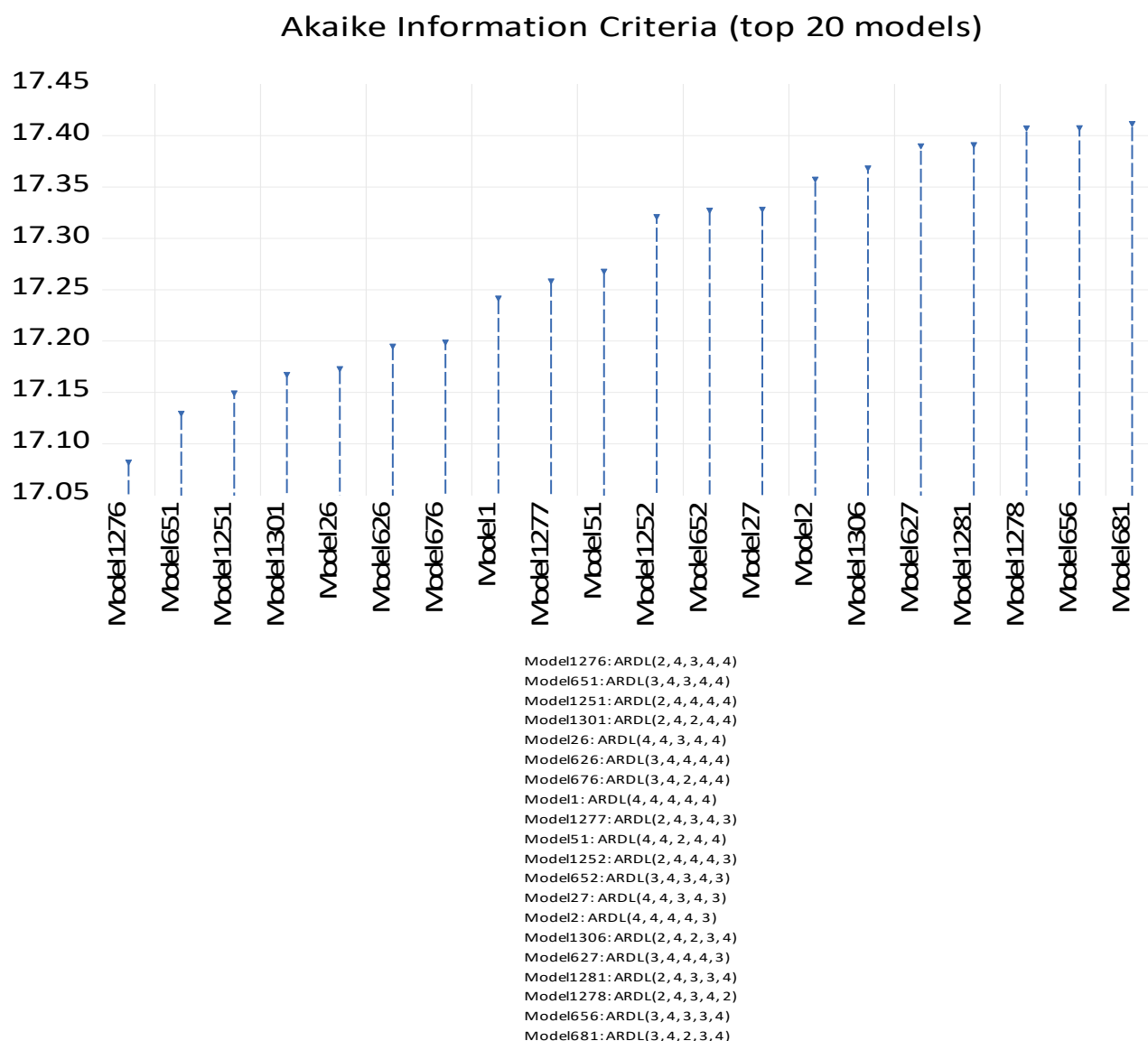
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1036.129	NA	1.02e+23	67.1696467.40093		67.24503
1	-880.7965	250.5369*	2.33e+19*	58.76106*	60.14879*	59.21343*
2	-858.4563	28.82606	3.18e+19	58.93267	61.47684	59.76200

Source : Authors' computations using Eviews 12 software.

According to LR, FPE, AIC and SC standards, the specific delay was 1. We were then able to move to the Bounds test after selecting the ARDL model and diagnosing the ARDL model, followed by ECM.

By applying Automatic Distributor Delay Limit Test (ARDL) after choosing appropriate delay length, we used Akaike information standards to determine optimal delay length, Figure 2 shows the ARDL model estimation process with automatic delay selection using E-views 12 version. Model selected (2, 4,3, 4,4) based on lowest AIC.

Figure 7 : Akaike Information Criteria.



Source: Authors' computations using Eviews 12 software

Through figure 07 it is clear to us that ARDL (2, 4, 3, 4,4) is our appropriate model.

3-2-Estimation of the ARDL model.

3-2-1-ARDL Bounds Test for Cointegration.

The boundary test shows whether the variables in the ARDL model have a common integration link. Under the zero hypothesis of non-co-integration, if the estimated F statistic is below the minimum critical value, this indicates a lack of co-integration. However, if they are greater than the higher critical value, this indicates a common integration link.

Table-4result of ARDL bound test

Test statistic	14.54833					
f-statistic						
	10%		5%		1%	
Sample size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	2.47	3.49	3.05	4.23	4.29	5.85
asymptotic	2.53	3.58	2.58	3.45	3.29	4.38

Source: Authors' computations using EvIEWS 12 software

Table 04 shows that the calculated F count of 14.54,833 is greater than the critical value of the I (0) and I (1) boundaries at an indicative level of 1%, 5% and 10%; Thus, there is a common complementarity between the variables in the laboratory model, which indicates the feasibility of estimating the error correction model to explore the short- and long-term effects of industrial fossil fuel consumption, GDP per individual share, open trade and FDI on CO2 emissions.

3-2-2-Cointegrating ARDL Model Estimate.

The distributed self-decelerating model (ARDL) has been applied to examine the long-lasting and short-lasting relationship between all variables. After confirming the stability and complementarity of the variables,

The Empirical Results of ARDL Estimation

Table - 5: Error Correction Model (ECM), Short-Run, and Long-Run Regression Results

ECM Regression, short-run				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(EC	-0.136225	0.031306	-4.355751	0.0032
D(GDPPC)	40.26523	2.755254	14.61442	0.0000
D(FDI)	1302.154	480.3245	2.710542	0.0301
D(TOP)	-130.4449	53.27220	-2.448553	0.0443
CointEq(-1)*	-1.449900	0.118552	-12.25213	0.0000
R-squared	0.982516	Mean dependent var	3756.172	
Adjusted R-squared	0.958757	S.D. dependent var	4450.646	
S.E. of regression	902.0356	Akaike info criterion	16.75722	
Sum squared resid	9764583.	Schwarz criterion	17.55873	
Log likelihood	-225.6596	Hannan-Quinn criter.	16.98824	
Durbin-Watson stat	2.644969			

* p-value incompatible with t-Bounds distribution

Long -run				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GAZINDUS	0.463090	0.022445	20.63195	0.0000
GDPPC	37.73752	2.358651	15.99962	0.0000
FDI	-4726.993	1044.407	-4.526006	0.0027
TO	-300.6969	94.11650	-3.194944	0.0152
C	-48100.53	3921.506	-12.26583	0.0000

$$EC = CO_2 - (0.4631 * EC + 37.7375 * GDPPC - 4726.9932 * FDI - 300.6969 * OPT - 48100.5314)$$

Source: Authors' computations using Eviews 12 software

-Through this study ECM assessment is negative as CointEq (-1) = -1.449 at a moral level below 1% confirming a long-term balance between the independent variables and the CO₂ variant This result shows that the long-term balance is achieved once short-term errors are adjusted by 144.9%, Furthermore, the R² and R²-adjusted long-term evaluation is 0.9823 and 0.9587, indicating that the proposed regression model fits the data very well. This suggests that approximately 98% of the variance in the component of the independent factors can be explained.

-In the short term: ARDL estimates results show that fossil fuel consumption in industry and commercial openness has a significant negative impact on CO₂, and GDP per capita and FDI has a significant positive impact on CO₂.

-In the long run: fossil fuel consumption in the industry has a significant positive impact on CO₂ emissions, per capita GDP has a significant positive impact on CO₂ emissions, FDI has a significant negative impact on long-term CO₂ emissions, and for commercial openness and CO₂ emissions they have a negative relationship.

3-3-Arch test:

Engel (1982) created the ARCH model to model police variability. Its variation and average equations are conditional. The ARMA procedure (p, q) follows the conditional average formula, which explains how to create return chain data. Although the parity of parity describes the method of obtaining parity data, the variance depends on the square delay of the remaining term.

Table 6: Arch test

Heteroskedasticity Test: ARCH		
F-statistic	0.547522 Prob. F(21,7)	0.8653
	Prob. Chi-	
Obs*R-squared	0.056733 Square(1)	0.8113

Source: Authors' computations using Eviews 12 software

Table 6 shows that the f value associated with the arc test is 0.54 with a probability versus 0.86, this probability is greater than the 5% indicative level, and we accept the zero hypothesis that confirms the stability of the variability of the error terminology series.

Table 07 Breusch-Godfrey Serial Correlation LM Test:

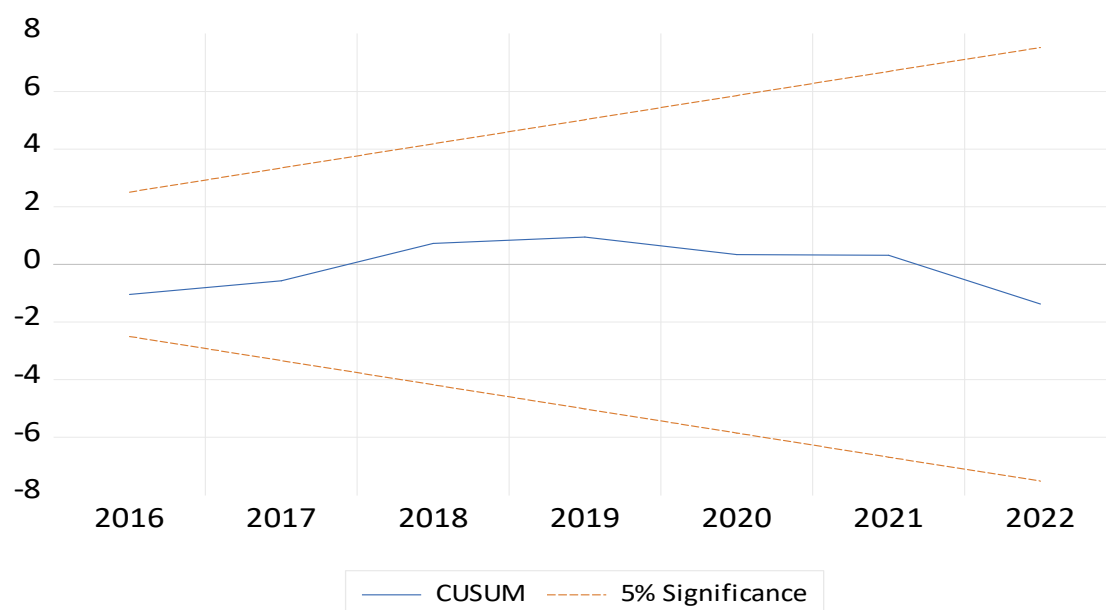
F-statistic	0.547516	Prob. F(21,7)	0.8652
Obs*R-squared	18.02574	Prob. Chi-Square(21)	0.6474
Scaled explained SS	1.095831	Prob. Chi-Square(21)	1.0000

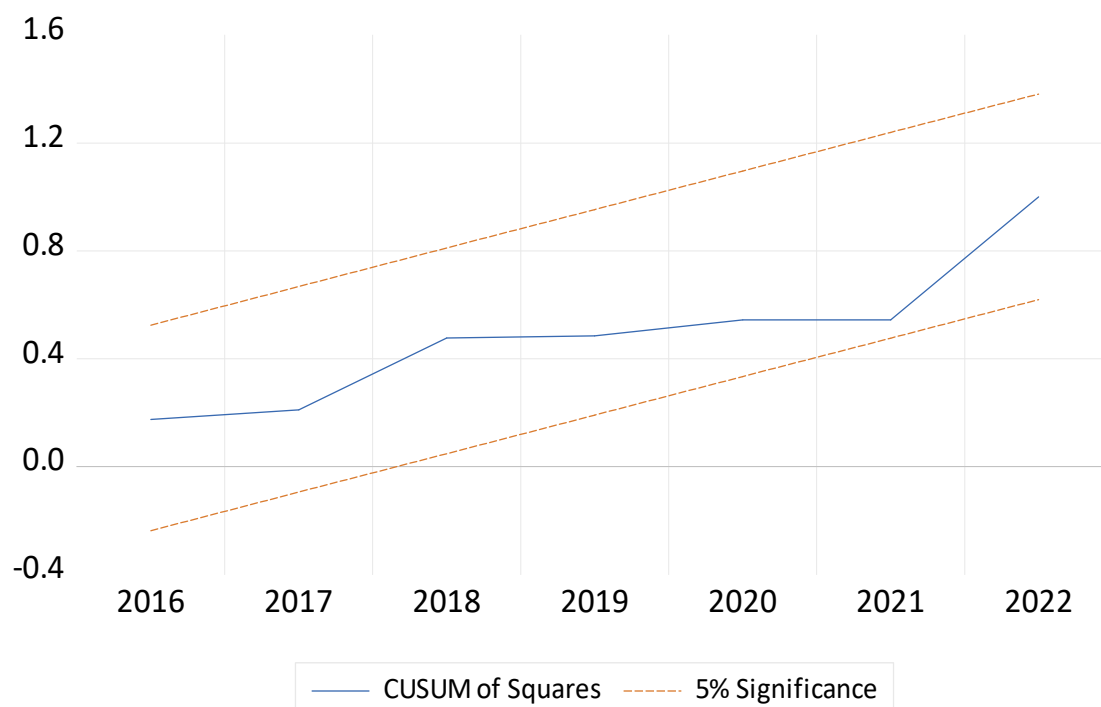
Source: Authors' computations using Eviews 12 software

From Table 7 the value of f is 0.54, in addition the associated probability (0.86) exceeds 5%. We therefore accept the zero hypothesis, suggesting that there is no automatic chain link between errors. In this study we used two statistical tests : CUSUM and CUSUM SQ.

-Also running the CUSUM and CUSUM box test to verify the model's stability, modularity and structural stability, it was first introduced in standard statistical and economic literature by Brown et al. As shown in figure 08, it shows the stability of the model by placing blue lines between red lines. Indicates the level of importance and stability of all transactions in the error correction form.

Figure08: the cusum and cosum of Squares.

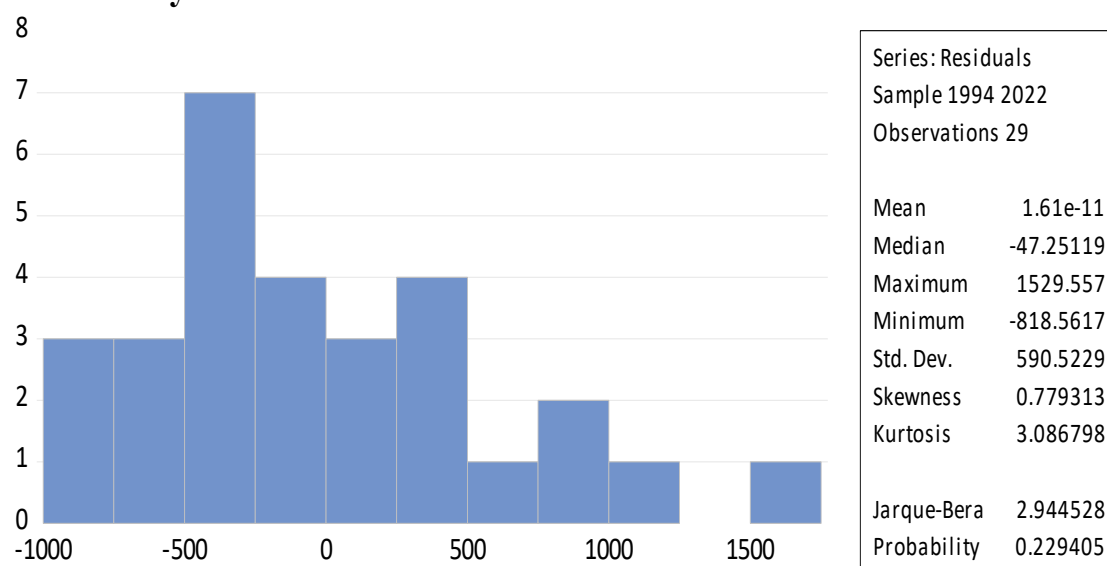




Source: Authors' computations using Eviews 12 software

Respectively displays the formats, the results of the CUSUM and CUSUM calculations of the boxes made. Both graphs illustrate the fact that blue lines may be found within red lines. This indicates that the variables used in the model were stable over the course of the investigation.

3-4-Normality test:



Source: Authors' computations using Eviews 12 software

Natural testing as shown in Your Neighbour Pera's statistical figure confirms that errors are naturally distributed because the statistical probability value is 2.94 and is greater than 0.05

4-Conclusion:

There is still debate about the impact of energy consumption and commercial openness on the quality of the environment in many developed and developing countries alike. Applying ARDL's distributed time gap self-decline methodology to verify a long-term relationship between each of the following independent variables, Ec, GDP, FDI, TOI and the dependent variable of environmental quality expressed by CO2 emissions from the manufacturing sector of the Algerian economy during 1990-2022

The pilot result revealed that fossil fuel consumption in manufacturing, per capita GDP and FDI caused long-term CO2 emissions, while commercial openness had a negative impact on CO2 emissions, with the result that fossil fuel consumption in industry had a negative impact on the environment in the short term.

The Algerian Government must accelerate the implementation of actions that reduce carbon emissions and to reflect on environmental sustainability and the transition from conventional to cleaner sources of energy and the use of renewable energies that have the potential to reduce carbon dioxide emissions, They must build partnerships with other leading countries in the area of clean energy and the Government needs to review its energy policies and implement a strict environmental policy, Breaking oil dependence, promoting a green economy and promoting clean foreign investment, Environmental taxation as corrective taxes, incentives to reduce pollution emissions and green fiscal policies to reduce carbon emissions, helping to achieve sustainable social and economic development.

5-Reference;

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