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Cómo afecta el consumo de gas natural en la industria, la inversión extranjera directa y la apertura comercial a la calidad ambiental: Un estudio de caso de Argelia (enfoque ARDL)

How do consumption of natural gas in industry, foreign direct investment and trade openness affect on environmental quality: A case study of Algeria (ARDL approach)

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RESUMEN

El medio ambiente es la base y el soporte de la existencia y la supervivencia humanas y la garantía del desarrollo humano sostenible; La protección del medio ambiente se ha convertido sin duda en un entendimiento común y la estrategia de desarrollo de todos los países del mundo, la energía no renovable es un factor importante en la contaminación del medio ambiente y el cambio climático, el estudio explora las influencias del consumo de gas natural en la industria de la inversión extranjera directa, el comercio abierto y el producto interno bruto per cápita en las emisiones de dióxido de carbono de Argelia país para el período 1990-2022, Los resultados del estudio confirman que, a largo plazo, el consumo de gas natural en la industria contribuye significativa y positivamente a las emisiones de dióxido de carbono en Argelia, y que el producto interior bruto per cápita tiene un impacto positivo significativo en las emisiones de CO2. Además, se obtuvo una asociación inversa significativa entre las emisiones de CO2 y la inversión extranjera directa y el comercio abierto a largo plazo.

PALABRAS CLAVE

Medio ambiente; comercio internacional; desarrollo; recursos de hidrocarburos.

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ABSTRACT

Environment is the foundation and support of human existence and survival and the guarantee of sustainable human development; environmental protection has undoubtedly become a common understanding and development strategy of all countries of the world, non-renewable energy is a significant factor in environmental pollution and climate change, the study explores the influences of natural gas consumption in industry foreign direct investment, open trade and gross domestic product per capita on Carbon dioxide emissions of Algeria country for the period 1990-2022, Using the autoregressive distributed lags (ARDL), The findings of the study confirm that in the long-run consumption natural gas in industry significantly and positively contributed to the Carbon dioxide emissions in Algeria,also gross domestic product per capita has a significant positive impact on CO2 emissions, In addition, a significant inverse association was obtained between CO2 emissions and foreign direct investment and open trade in the long run.

KEYWORDS

Environment; International Trade; development; Hydrocarbon Resources.

Clasificación JEL: F64, P33, G28, Q35.

MSC2010: 91B76, 62P25, 91B84, 91B69, 93C55, 62M10.

1. INTRODUCCIÓN

Energy is an essential of economic development and social life among the various energy sources available including; coal, oil, naturel gas electricity, solar power, (Narayan et al., 2019) at present fossil fuels remain the primary source of energy worldwide the global total primary energy production approximately 81 % of energy comes from fossil fuels with oil representing 32.5 %,coal 26.9 %and natural gas 22.8 % (Komarnicka and Murawska, 2021), in this context energy can be likened to water or air in terms of their necessity,its necessity caused that it is perceived as a strategic good (Dorota, 2019), have contributed significantly to climate change,, through the high rates of CO2 emissions in the world, which is considered the main cause of global warming, as it represents more than 75 % of the total greenhouse gas emissions in the world.

Today the final energy consumption is 442 EJ divided between industry (167 EJ) buildings(133EJ) transport (116EJ), industry is the sector that uses the most energy iron and steel, chemical non-ferrous metal and paper account for almost 90 % of demand for coal more than 70 %for oil and almost 55 %for natural gas, (Outlook, 2023).

Algeria is a member of the organization of the petroleum exporting countries (opec) and it is one of the major players in the Africa energy market producer of crude oil and natural gas, hydrocarbons are a vital component of Algeria economy accounting in general 30 % percent of global domestic product,60percent of budget revenues and nearly 95 per-cent of export earnings, the total primary energy consumption almost it source natural gas and oil (REPORT, 2020).

The anticipated increase in demand for natural gas for industrial purposes signifies a deliberate strategic effort to further capitalize on Algeria's domestic natural gas resources and foster the advancement of new industrial ventures. It should be mentioned that 80 % of the energy sources used by industry currently come from natural gas. As a result industry is highly reliant on natural gas supplies that are subsidized Sonatrach emphasizes the development of fertilizers and other petrochemical products as a means of "adding more value" to Algeria's hydrocarbon resources in its new 2030 plan. In this industry, the primary uses of natural gas (methane) are in the manufacturing of methanol and nitrogenous fertilizers. Natural gas liquids are used by other petrochemical companies (Institute Oxford, 2019).

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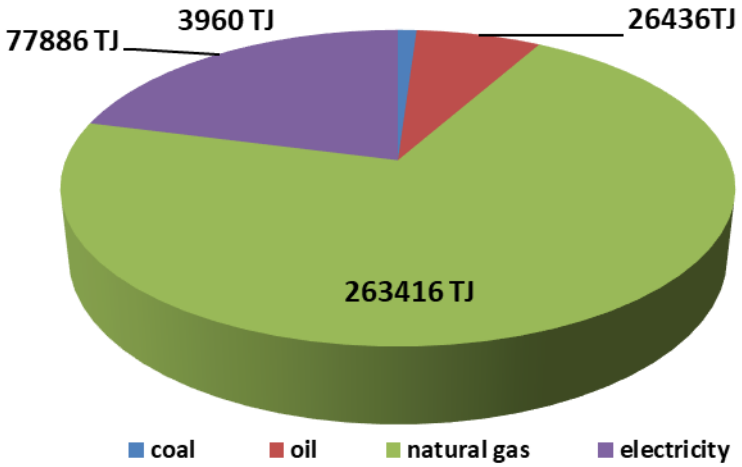
Figure 1: final consumption energy industry in Algeria 2021



Energy consumption is critical to job possibilities and important factor of economic growth, however it can also have long-term negative effect on global warming and climate change induced by growing levels of greenhouse gases.

The purpose of this paper is explore the correlation between consumption of natural gas in industry and gross domestic product and trade openness and foreign direct investment on the Carbon dioxide emissions in Algeria. Additionally the paper to identifying policies that the Algerian government can implement in order to minimise damage to the environment.

2. LITERATURE REVIEW

There is relation between different indicators of environmental degradation and income per capita According to Environmental Kuznets curve, industrialization and urbanization significantly deplete natural resources and produce industrial and urban waste during the early phases of economic growth. At this point, pollution and economic growth are related in that environmental pollution rises in tandem with economic expansion. affirm this opinion by claiming that pollution is increasing quickly in the early phases of industrialization since the primary objective is to boost material output and individuals are more concerned with running their businesses and making money than with maintaining clean air and water. Fast economic expansion means more use of natural resources and pollution emissions, which puts more strain on the environment's quality. (Mitić et al.,2019). An inverted U-shaped relationship exists between economic development and environmental quality depicts the environmental Kuznets curve (EKC) (Alola et al., 2023).

International trade plays a pivotal role in driving economic growth and development. When countries participate in open trade, there are numerous benefits. Consumers can access diverse goods and services, businesses can take advantage of innovative technologies from various parts of the world, producers can expand their reach to bigger markets, and resources can be utilized more efficiently. The comparative advantage theory of trade predicts substantial gains from trade liberalization, emphasizing the benefits of specialization based on comparative advantage. However, it is crucial to recognize that trade liberalization can have significant environmental implications, particularly in developing countries (Malik and Aziz, 2024).

Global warming is a significant factor contributing to climate change, and therefore it is essential to limit anthropogenic greenhouse gas (GHG) emissions from different sources particularly from industries related to electricity generation, transportation, and heating, (Atieh Fahimi et al., 2024). The built environment is the largest source of greenhouse gas (GHG) emissions among human activities, contributing at least 37% of global GHG emissions, (Elliot et al., 2024). Also, one

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of the challenges facing the environment The widespread use and unethical disposal of plastics result in plastics polluting the terrestrial and aquatic systems, (Dokl et al., 2024).

In this section we review theoretical concerns and empirical studies that have to do with relationship between non-renewable energies, foreign direct investment, gross domestic product, trade openness and environment.

Thi Van Trang Do and Hong Linh Dinh (2020) this paper investigated the impact of economic growth on the environmental pollution in Vietnam during the period 1980-2014 using the regression model, the result demonstrate that a negative correlation in the long run with GDP growth and CO2 emission,and positive relationship of the foreign direct investment as the percentage of GDP with CO2 emission in a long time, in the short run GDP per capita impact CO2 emission with two year lags, similarly energy consumption impact CO2 emission with a one year lag, the result finding that the energy consumption increasing CO2 emission (Trang Do and Dinh, 2020).

Yaswanth Karedla et al (2021) The purpose of this study is to examine the impact of economic growth, trade openness and manufacturing on CO2 emissions in India The study employed autoregressive distributive lag (ARDL) during the period 1971 to 2016, the result founded that Trade openness has a negative association with CO2 emissions, Manufacturing and GDP have a significant and positive relationship with CO2 emissions in the long run (Karedla et al., 2021).

Unraveling the nexus the impact of economic globalization on the environment in Asian economies a study conducted by Nazia latif et al (2023) on Asian economies, this study aim to examines the impact of institutional quality and economic globalization on environmental performance of Asian economies, the result of research indicate a positive correlation between economic globalization, institutional quality index on environmental performance in 48 Asian countries.

Ojonugwa Usman and al (2020) this study investigated the dynamic effect of renewable energy consumption, economic growth, biocapacity and trade policy on environmental degradation in the United States from 1985to2014 used d an autoregressive distributed lag (ARDL) model, the result founded that divulged that a decline in environmental degradation can be attributed to an increase in renewable energy consumption through its negative effects on ecological footprint, The ecological footprint was shown to be under increasing pressure from biocapacity and economic expansion, but under downward pressure from trade policy (Usman et al., 2020).

Ebrima K at al (2022) concentrated to analysis the influence of climate change on food security and economic growth in Gambia for the period 1971-2020 using vector autoregressive approach (VAR) granger causality approach and auto regressive distributed lag mode approach, the result of study found a positive correlation between agriculture and food security and a negative correlation with average annual rainfall and the GDP per capita and population growth on food security.

Winny Perwithisuci et al (2020) the study was conducted in five developing countries in Asian in the period 1985-2017for investigated the influence of population, GDP, oil consumption and foreign direct investment to CO2 emissions, the research revealed that population, GDP,oil consumption are three major cause of CO2 emissions and foreign direct investment shares a negative relationship with CO2 emissions (Perwithosuci et al., 2020).

Matheus Belucio et al (2022) inspected the influence of natural gas on CO2 emissions for sixteen countries European in the period 1993 to 2018, this study utilised CO2 as a dependent variable while the independent variables are natural gas,oil, gross domestic product renewables consumption and hydroelectric, used the autoregressive distributed lag (ARDL) model, the result highlight that in the short term natural gas has a little impact on CO2 emissions when compared to oil consumption, while the consumption of renewable energy and hydroelectric don't causes CO2 emissions both in the short and long run. (Belucio et al., 2022).

Yao Li,and Yugang He (2024) examined the impact of carbon dioxide emissions energy on economic growth in korea from 1980to 2022,using the non-linear autoregressive distributed lag model, the result founded that o positive link between carbon dioxide emissions and economic growth similary primary energy consumption is positively by economic growth The study clari-

fies the roles that net-flow foreign direct investment, gross fixed capital creation, and the labor force have in promoting economic growth (Li and He 2024).

Phoumyxay Sitthivanh, Khaysy Srithilat (2022) the study investigated at how FDI changed environmental quality in ASEAN nations between 2005 and 2018, they used GHG emissions and CO2 emissions measured as environmental quality indexes, the result showed that FDI and GDP growth have a substantial negative impact on carbon dioxide emissions that is as FDI and GDP increase ASEAN's envi ronmental quality improves (Sitthivanh and Srithilat, 2022).

Liton Chandra Voumik, Mohammad Ridwan(2023) examined the influence of population growth, foreign direct investment, industrialization and education on environment using an ARDL model for the Argentina economy from the period 1972-2021, the study result demonstrate that industrialization and population effect strongly on CO2 emissions in the long run, the impact of FDI is insignificant impact.in addition, a significant inverse association was obtained between CO2 emissions and educational expenditures in the short run, and the finding of Granger's causality show that a one-way causality between population and CO2 emissions, industrialization and CO2 emissions, FDI and CO2 emissions, and CO2 emissions and education (Chandra and Mohammad, 2023).

3. METHODOLOGY AND DATA

The study utilised a Autoregressive Distributed Lags (ARDL) to determine the short-run and long-run relationship between Carbon dioxide emissions and Consumption Natural gas industry in Algeria with an annual dataset spanning from 1990 to 2022, the study explore the impact of consumption natural gas in industry and gross domestic product and trade openness and foreign direct investment are respectively considered as independent variables on CO2 emissions which is the dependent variable, the choice of study period and country are due to data availability and Algeria is a highly natural gas-dependent country.

Table 1. Variable descriptions and sources

	Variables	Variables symbol	Musuring unit	Source
Dependent	Carbon dioxide emissions	CO2	T/J	The global economic
Independent	Consumption Natural gas industry	NGINDUS	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

4. FORMULATION OF MODEL

In order to analyse the relationship between co2 and natural gas industry,GDPPC, OP and fdi, the model that follows is fitted as:

CO2 = f(NGINDUS, GDPPC,TOP,FDI)

Building upon the previous methodology, we specify the Autoregressive Distributed Lag (ARDL) version of our model as:

$$C02 = B_0 + B_1 NGINDUS_{t-1} + B_2 GDPPC_{t-1} + B_3 TOP_{t-1} + B_4 FDI_{t-1} + \sum_{i=1}^{p} y_1 \Delta NGINDUS_{t-p} + \sum_{i=1}^{p} y_2 \Delta GDPCC_{t-p} + \sum_{i=1}^{p} y_3 \Delta TOP_{t-p} + \sum_{i=1}^{p} y_4 \Delta FDI_{t-p} + \varepsilon i$$

5. RESULT AND DISCUSSION

The study applies autoregressive distributed lag (ARDL) approach it developed by Pesaran et al (2001), When the variables are either integrated of order I(1) or stationary at I(0), the ARDL model is regarded as the most effective econometric technique when compared to other approaches, it is suitable for determining the effect of the dependent variables on the independent variable (Muhammad et al., 2021).

5.1 Unit root tests results

Before applying the ARDL boundary test to any variable, it is necessary to check its unit root All of the variables must be stationary at I(0), I(1), or both in order to determine the bound F-statistic test, Relying on the augmented Dickey and Fuller (ADF) test and the Phillips–Peron (PP) test, The stationary test determines the sequence of variable's integration to avoid spurious regression results in the econometric analysis (Mu et al., 2022).

Table 2 Results 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	5.526745	0.0005	3.562882	5.526203	0.0005	3.562882	I(1)
NGINDUS	4.220640	0.0116	3.562882	4.550640	0.0116	3.562882	I(1)
GDPPC	4.134975	0.0028	2.960411	4.099810	0.0154	3.562882	I(1)
TOP	5.040039	0.0003	2.960411	4.876663	0.0024	3.562882	I(1)
FDI	5.677157	0.0002	2.963972	11.92172	0.0000	3.562882	I(1)

Source: Authors' computations using Eviews 12 software

The empirical result of ADF test in table 2 shows that all five variables are stationary at the first difference I(1), Consequently, the bounds test method is applicable in this research the ARDL model is the most suitable choice.

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5.2. Lag Order Selection Criteria

Having established that all variables were stationary to the same order, in this step we determined the optimal lag order according to six selection criteria for delays of 0 to 2 we did not go beyond that due to the low number of observations.

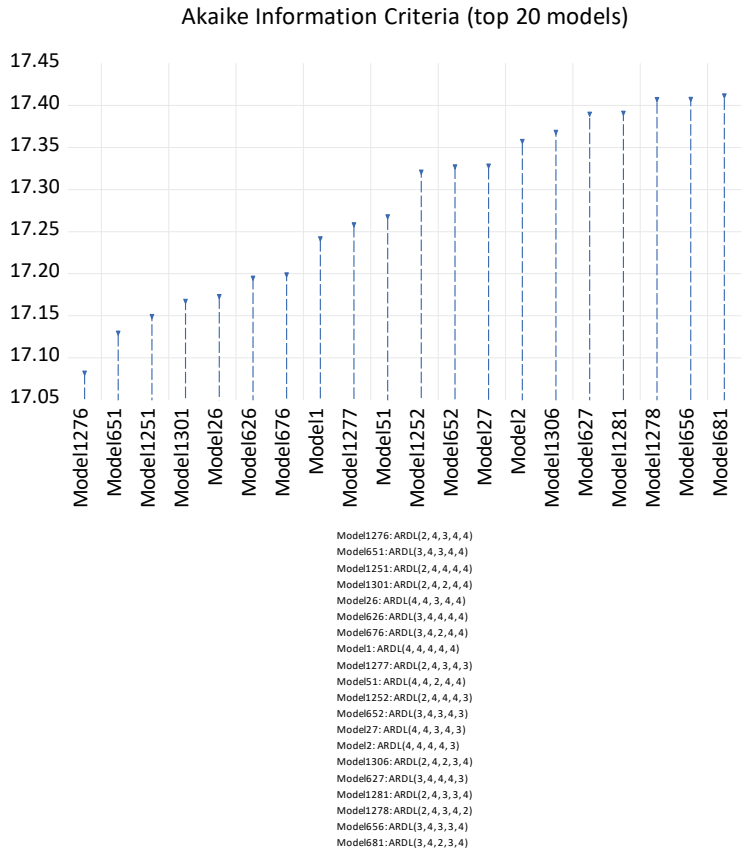
Table 3. Lag Order Selection Criteria Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1036.129	NA	1.02e+23	67.16964	67.40093	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

According to the LR, FPE, AIC, and SC criteria, the selected delay was 1. We were then able to proceed to the Bounds test after ARDL Model Selection and ARDL MODEL Diagnostics, followed by ECM.

The next step is to apply the Autoregressive Distributed Lag (ARDL) bounds test after choosing an appropriate lag length we used Akaike Information Criteria to decide the optimum lag length, Figure 2 illustrates the ARDL model estimation process with automatic lag selection using E-views version 12. The model (2,4,3,4,4) was chosen based on the lowest AIC

Figure 2: Akaike Information Criteria



Source: Authors' computations using Eviews 12 software

The Figure 2 depict that ARDL(2,4,3,4,4) model is our appropriate model.

5.3 Estimation of the ARDL model

5.3.1 ARDL Bounds Test for Cointegration

The Bounds Test determines if the variables in the ARDL model have a cointegration correlation. Under the null hypothesis of no cointegration, if the estimated F-statistic is less than the lower critical value, it suggests no cointegration. However, if it is more than the upper critical value, it shows that a cointegration correlation exists. (Djihad and M'hamed, 2024).

Table 4 Result of ARDL bound test

Test statistic 14.54924 f-statistic						
	10 %		5 %		1 %	
Sample size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
30	2.46	3.46	3.05	4.22	4.28	5.84
asymptotic	2.52	3.56	2.56	3.49	3.29	4.37

Source: Authors' computations using Eviews 12 software

As seen from Table 3 the calculated F-statistic 14.54924 is greater than the critical value of Bound I(0) and I(1) at the level of significance of 1 %, 5 %, 10 %. Thus, there is a co-integration relationship between the variables in the tested model, This suggests the feasibility of estimating an error correction model to explore the short- and long-term effects of the consumption natural gas industrial and GDPPPC and open trade (OPT) and Foreign direct investment (FDI) on dioxide carbon emissions (CO2).

5.3.2 Cointegrating ARDL Model Estimate

After establishing the stationarity of the variables and that they are cointegrated, the Auto-Regressive Distributed Lag (ARDL) was then applied to examine the long run and short run relationship among all the variables.

5.4. 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(GAZINDUS	−0.136361	0.031306	−4.355751	0.0033
D(GDPPC)	40.26483	2.755635	14.61182	0.0000
D(FDI)	1302.103	480.3606	2.710679	0.0302
D(TOP)	−130.4579	53.27110	−2.448943	0.0442

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CointEq(-1)*	–1.449900	0.118522	–12.23313	0.0000
R-squared	0.982316	Mean dependent var	3736.172	
Adjusted R-squared	0.958737	S.D. dependent var	4440.646	
S.E. of regression	902.0386	Akaike info criterion	16.73722	
Sum squared resid	9764083.	Schwarz criterion	17.53873	
Log likelihood	–225.6896	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 = CO2 - (0.4631*GAZINDUS + 37.7375*GDPPC -4726.9932*FDI
–300.6969*OPT - 48100.5314)

Source: Authors' computations using Eviews 12 software

The ECM results reveal the speed at which the system returns to equilibrium after a short-term disturbance, which is crucial for understanding short-term dynamics. Including a straightforward explanation of the ECM coefficient, The evaluation of ECM by this study is negative reached CointEq(-1) =-1.449 at a significant level of less than 1%, which confirms the existence of a long-run equilibrium relationship between the independent variables and the dependent variable CO2, This result demonstrates that the long-run equilibrium is reached once short-run errors are adjusted by 144.9 percent, Furthermore, the long-run evaluation R2 and adjusted R2 are 0.9823 and 0.9587, correspondingly, demonstrating that the proposed regression model fits the data remarkably well. This indicates that approximately 98% of the variability in the dependent component can be explained by the independent factors.

in the short run the result of the ARDL estimates show that natural gas consumption in industry and trade openness has a significant negative effect on CO2, and gross domestic product per capita and foreign direct investment a positive significant effect on CO2, This result demonstrates that the coefficient of -1.449 suggests that approximately 144.9% of the short-run disequilibrium is corrected annually.

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In the long run natural gas consumption in industry has a significant positive impact on carbon dioxide emissions in, and gross domestic product per capita has a significant positive impact on carbon dioxide emissions, foreign direct investment has a significant negative effect on carbon dioxide emissions in the long run, as for trade openness and carbon dioxide emissions has a negative relationship.

6. DISCUSSION

The positive relationship between natural gas consumption in industry and carbon dioxide emissions As India is an emerging country, its growing economic activity necessitates a higher energy demand that is more reliant on fossil fuels, resulting in a rise in CO2 emissions. This result is consistent with Winny Perwithisuci et al (2020), Matheus Belucio et al (2022), degradation suggests the need for Algeria to improve on the share of renewables from the clean sources in their energy mix as emphasized by the Intergovernmental Panel on Climate Change (IPCC) and other international treaties on the environment and climate change.

The positive impact gross domestic product per capita on carbon dioxide emissions of findings show that one of the main causes of environmental deterioration is GDP. This can be linked to the businesses' heavy reliance on fossil fuel energy sources for their manufacturing processes in Algeria. Economic activity in the transportation, agricultural, and other greenhouse gas-emitting sectors rises with economic development, This result is consistent with Yao Li, and Yugang He (2024) and Yao Li, and Yugang He (2024).

The negative correlation between foreign direct investment and environmental, can be justified The relationship between FDI and environmental emissions is still a contentious issue in the discussion of globalization and the environment, This controversy is centered around whether increased globalization through the movement of international capital from one country to another is good or bad for the environment, Each side of the issue is supported by conflicting hypotheses that have been produced by this debate. According to the PHH, more foreign direct investment would be detrimental for the environment, particularly in emerging nations. Proponents of this viewpoint argue that through environmental exploitation and the loss of natural resources, increasing FDI may encourage increased output and consumption; conversely, the pollution halo hypothesis contends that FDI may benefit the environment by transferring green or ecologically benign energy. (Demena. and Afesorgbor, 2020).

Trade openness and carbon dioxide emissions has a negative relationship, This result is consistent with Yaswanth Karedla et al (2021) Theoretically, there are two main schools of thought that can be applied to the discussion of the connection between trade openness and environmental quality namely emissions levels. Environmental economists adhere to a school of thinking that has its roots in the neoclassical trade perspective. The other viewpoint is grounded in ecological economics. The former advances the gains-from-trade theory and supports the idea that trade openness can help address environmental degradation. The latter is against and in doubt of the environmental benefits of trade on account of race-to-the-bottom hypothesis The former holds an opinion that trade openness itself is a great benefit to the improvement of environmental quality thanks to its long-term growth-promoting effect that results in better environmental conservation with the assumption of environment being a normal good whose demand rises with income The argument basically starts from the popular Heckscher-Ohlin-Samuelson theory of trade in which a country increases production of goods for which it enjoys the comparative advantage. With trade facilitation and boosted exports, any participants gain a win-win position as it leads to more efficient movements and transfers of environmentally-friendly production techniques (Dung, 2018).

6.1 Arch test

Engle (1982) created the ARCH model for modeling conditional variance. Its variance and mean equations are conditional. The ARMA (p, q) procedure is followed by the conditional mean equation, which explains how return series data is generated. Although the conditional variance equation describes the method of obtaining conditional variance data, where variance is dependent on the square lag of the residual term (Ghulam et al., 2019).

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Table 6 Arch test

Heteroskedasticity Test: ARCH			
F-statistic	0.547516	Prob. F(21,7)	0.8652
Obs*R-squared	0.056731	Prob. Chi-Square(1)	0.8117

Source: Authors' computations using Eviews 12 software

From the Table 6 show the f value linked to the arch test is 0.54 with a corresponding probability of 0.86, this probability greater the 5 % significance level, we accept the null hypothesis affirming the stability of the variance of the error term series.

Table 7 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 the Table 6 show the f value is 0.54, additionally, the associated probability (0.86) exceeds 5 %. Consequently, we accept the null hypothesis, indicating no sequential autocorrelation between errors.

In this study we employed two statistical tests: the Cumulative Sum (CUSUM) test and the Cumulative Sum of Squares (CUSUM SQ) test.

A CUSUM and CUSUM of the squares test is also run to verify the stability, endogeneity, and structural invariance of the model, it for parameter stability were first introduced into the statistics and econometrics literatures by Brown et al. (Turner, 2010) as seen from figure1 demonstrate the stability of the model by placing the blue lines between the red lines It suggests the significance level and the stability of all the coefficients in the error correction model.

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Figure 3 The cusum and cosum of Squares

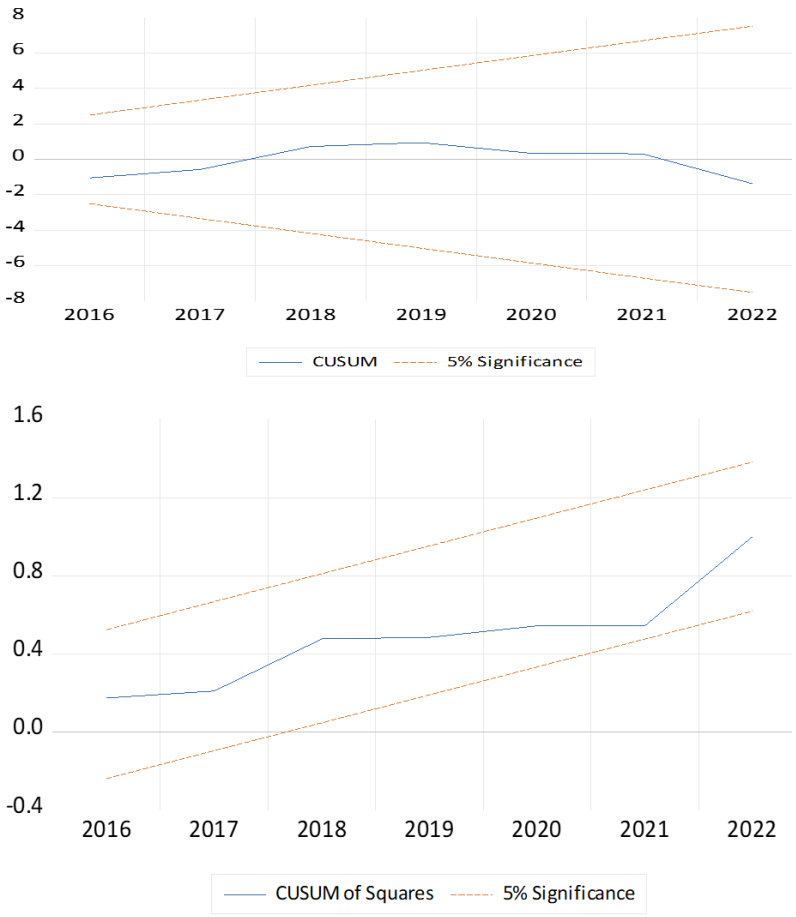
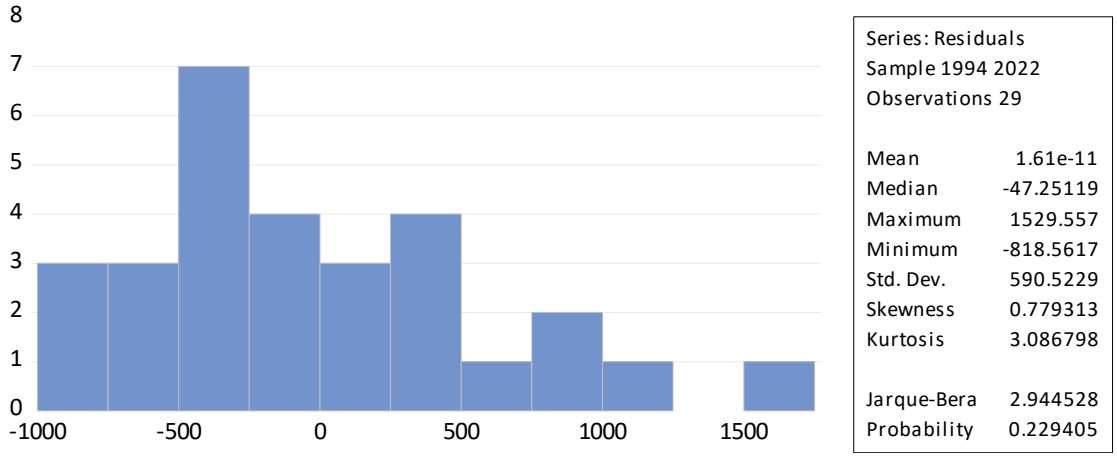


Figure 3 displays the results of the CUSUM and CUSUM of squares calculations that were performed. Both plots illustrated the fact that the blue lines may be found inside the red lines. This suggests that the variables that were used in the model were stable over the course of the investigation.

6.2. Normality test

Figure 4 Normality test



The normality test as shown in figure Jarque-Bera's statistic confirms that errors are normal distributed because the statistical probability value is 2.94 which is greater than 0.05.

7. CONCLUSIONS

Realisation the objectives of sustainable economic growth and minimizing environmental effect is one of the fundamental issues confronting the modern world, global warming become increasingly urgent concerns in the world because economic development depend on natural resources in production energies, Algeria is an important player in the global energy market as it is one of Africa's biggest producers and exporters of natural gas and oil, economic growth driven by hydrocarbon has consumed an enormous amount of fossil energy, resulting in varying levels of air pollution in Algeria.

This paper examined the effect of natural gas consumption in industry, gross domestic product, foreign direct investment and trade openness on co2 emissions in Algeria from 1990 to 2022,the research applied the ARDL method, the empirical result revealed that a consumption of natural gas in industry, gross domestic product per capita caused co2 emissions in the long run, while a negative impact of foreign direct investment and trade openness on co2 emissions, the result existed a negative impact of consumption natural gas in industry on the environment in the short run, The policy implications of the findings include:

The development of renewable energy is a significant global factor in the achievement of a green economic recovery like solar power and hydro power,and to enhance sustainable social development in the future, Algeria should be profoundly aware of the significant role of renewable energy in low-carbon development should encourage investments, research and development in renewables and enhance their policy support for it as well as establishing and improving the policy system for renewable energy development and reducing reliance on fossil fuels.

Algeria could adopt policies that encourage "green FDI" by incentivizing investments in sectors such as renewable energy or cleaner industrial technologies. For example, offering tax incentives for sustainable investments or establishing special economic zones dedicated to green industries could be effective measures. The government could leverage this by strengthening emission standards and environmental regulations related to international trade. Implementing stricter CO_2 emission requirements for imported goods would not only reduce overall emissions but also encourage domestic firms to adopt cleaner technologies to remain competitive in the global market

The significant impact of natural gas consumption on CO_2 emissions suggests that implementing carbon taxes could be an effective policy tool. Proposing a gradual introduction of carbon taxes on industrial natural gas usage would incentivize industries to reduce emissions. This approach aligns with measures taken in other countries that promote a shift toward cleaner production technologies by making higher emissions financially disadvantageous.

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