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DETERMINANTS OF ALGERIA NATURAL GAS EXPORTS: USING A VECTOR ERROR CORRECTION MODEL (VECM)

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Abstract

The present research tries to determine the cause and variables influencing Algeria's natural gas exports between 1980 and 2022. The Granger causality test was performed to ascertain whether there were causal linkages between the variable, and the vector error correction model (VECM) was used to assess whether there were long-and short-term relationships between the variables. According to the study's findings, the factors have just one cointegrating line. Natural gas production, internal gas consumption, and their effect on Algeria's natural gas exports were all statistically related, according to our research using the least squares method.

Keywords*: Natural gas; Cointegration; VECM; Granger causality; Algeria.*
JEL Codes : *C4, Q32, Q43*

Introduction

Algeria is one of the most prominent countries with a rentier economy, which depends mainly and heavily on depleted natural resources such as oil and natural gas, as hydrocarbon exports constitute more than 90% of total exports. In addition to that, Algeria is one of the largest producing and exporting countries of natural gas, as Algeria ranked tenth among the top 10 natural gas producers in the world during the year 2021, with a production capacity estimated at 100.8 billion M^3 (about 2.5% of global natural gas production). As for natural gas exports, Algeria ranked ninth in the world with a value of 39 billion M^3 and first in Africa. Natural gas exports in Algeria increased to 56 billion M^3 in 2022.

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This is due to factors determining natural gas exports, including production capacity, domestic consumption of gas, and total reserves of natural gas, in addition to other factors represented in the geopolitical factors the world is going through (Khelifa, Mezouaghi, & Bachouche, 2020).

At the end of 2022, Algeria's estimated natural gas resource value was 450 trillion cube meters (Tm^3), which places it 7th in the world. Additionally, domestic natural gas consumption rose by 6,5% in 2021 to a total of 17,9 million tons.

The volume of natural gas exports is determined by a set of factors. This research paper addresses the problem of identifying these factors and measuring their impact on natural gas exports.

In this context, the problem of our study revolves around the following question:

What elements influence Algeria's exports of natural gas?

The following theories were put up in an effort to provide an answer to the study's main question:

H1: Each production has a statistically significant correlation with each other;

H2: There is a cointegration relationship between the study variables in the long run.

Literature review

Concept of Natural Gas

Specialists define natural gas as a mixture of gaseous hydrocarbons that are found underground. It can exist with oil (called "associated gas") or in its fields (called "non-associated gas, and methane gas is considered one of the most essential and abundant components of natural gas, in addition to other components in the lowest percentage represented in ethane, propane, and butane. (Aktemur, 2017).

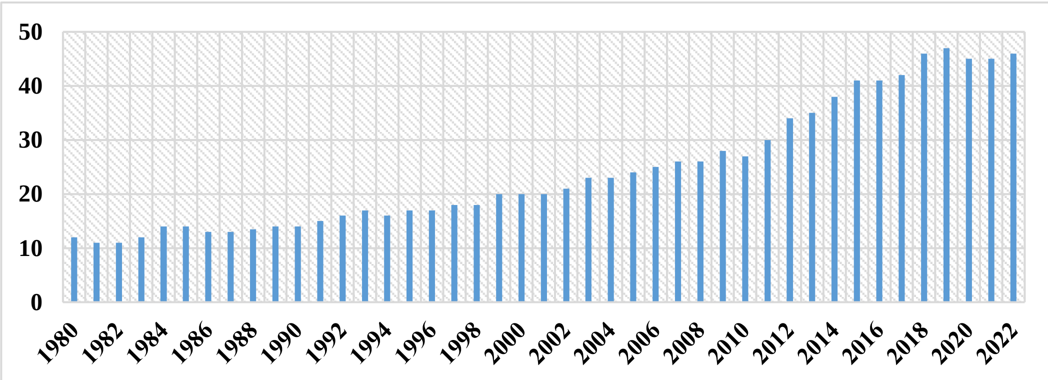
A descriptive study of the determinants of natural gas in Algeria during the period: 1980-2022

The following tables show the annual time series data for natural gas determinants in Algeria represented by: natural gas exports, natural gas production, natural gas consumption, and natural gas reserves in Algeria during the period 1980-2022, as follows:

Evolution of Natural Gas consumption in Algeria

Natural gas consumption in Algeria was estimated to be approximately 45.8 billion cubic meters (bcm) in 2021, or 1.1% of global consumption. The figure below shows the evolution of natural gas consumption in Algeria from 1980 to 2022.

Figure no. 1 Natural gas consumption in Algeria from 1980-2022.



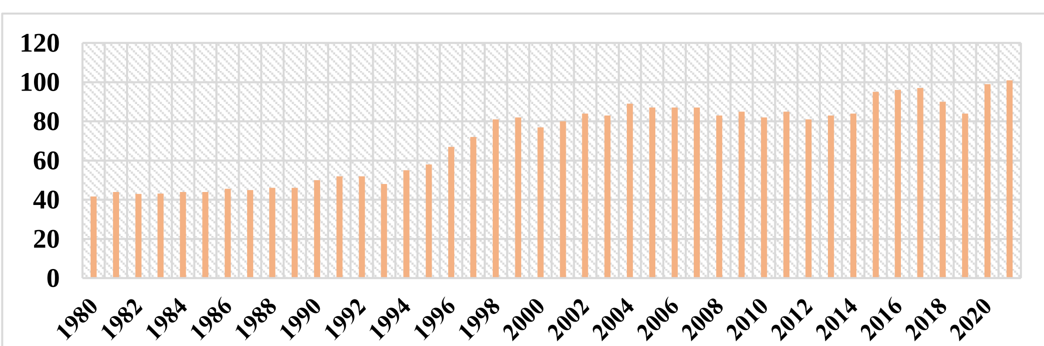
Source : Energy Institue, 2023

The figure shows that natural gas consumption in Algeria has been increasing steadily since 1980, from 12 billion cubic meters (bcm) to 46 bcm in 2022. This increase can be attributed to the parallel increase in natural gas production during this period.

Evolution of Natural Gas production in Algeria

The national company, Sonatrach, is considered among the most significant international companies exporting natural gas, as the latter expanded its gas facilities (Yekhtar & Abderrahmane, 2013) and thus increased production capacity, which amounted to approximately 100.80 billion M^3 in 2021, i.e., contributing 2 % to 5% of the global production of natural gas. The graph below shows the evolution of the quantities of natural gas produced in Algeria between 1980 and 2022.

Figure no. 2 Natural gas production in Algeria from 1980-2022.



Source : Energy Institue, 2023

The figure above shows that the production of natural gas in Algeria has been increasing steadily since 1980, when it was about 40.9 billion M^3, to reach 2022 approximately 100.8 billion M^3.

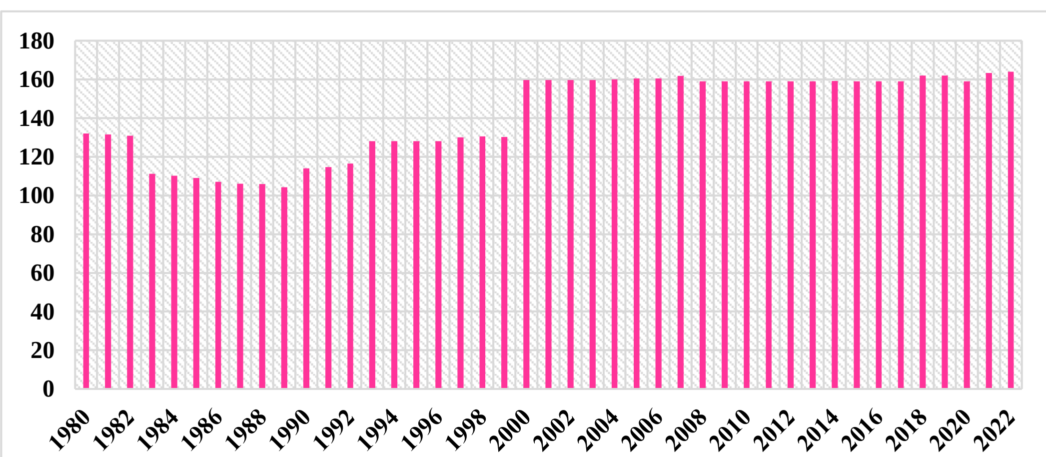
The legislation and laws reflected in the protective measures implemented in the year 2009, which specified the percentage of foreign investors' participation in the capital of significant projects, are what account for the slight decline in natural gas production that we observed between 2004 and 2014.

Production began to rise continuously and rapidly, especially since 2015, this is mainly due to the pace of intensive gas production pursued by the Ministry of Energy to value and exploit all discovered fields, and this is done according to two strategies: the first depends on exporting large quantities of natural gas to the European market through pipelines, and to other markets in the form of liquefied gas, and the second depends on the intensification of internal use and an increase in its consumption in the local market as an energy source. (Boulasal & Soufan, 2021).

Evolution of Natural Gas reserves in Algeria

Algeria's natural gas reserves amounted to about (4.5 trillion M^3) by the end of 2022. With the beginning of the current year of 2023, Algeria has made considerable investments in searching and exploring new fields to raise production and increase its reserves of natural gas. The graph below shows Algeria's natural gas reserves' evolution between 1980 and 2022.

Figure no. 3 Natural gas reserves in Algeria from 1980-2022.



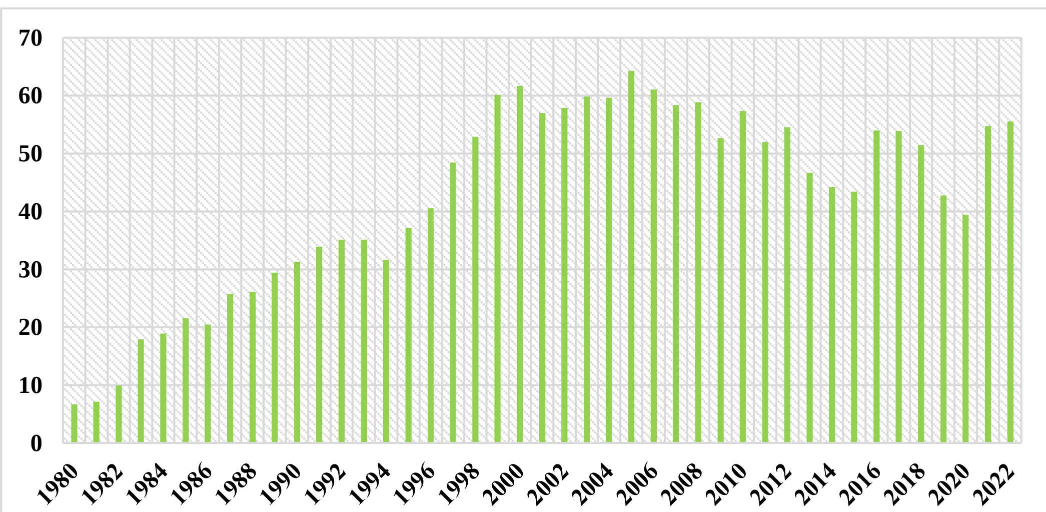
Source : Energy Institue, 2023

The graph shows that Algeria's natural gas reserves have remained relatively stable over the past four decades. From 2005 to 2019, the reserves stayed at around 4.3 (Tcm). There was also no significant change in the reserves during the period from 2001 to 2004, when they were estimated at 4.4 Tcm. In 2021, Algeria's natural gas reserves were estimated at 4.5 Tcm.

Evolution of natural Gas exports in Algeria

The critical position Algeria currently holds, and the gas reserves it owns significantly contributed to the development of Algeria's natural gas exports to the largest global market for gas. As a result, Algeria is currently regarded as one of the most significant natural gas suppliers to the European market. Actually, Algeria achieved a record in its natural gas exports during the year 2022, with natural gas exports totalling about 56 billion M^3. The graph below illustrates the growth of Algeria's natural gas exports between 1980 and 2022.

Figure no. 4 Natural gas exports in Algeria from 1980-2022.



Source : Energy Institue, 2023

The above chart shows that natural gas exports in Algeria fluctuated significantly between 2000 and 2020. This was due to several factors, including geopolitical factors and the decline in production between 2004 and 2014, caused by the protective measures, legislation, and laws approved by the Algerian government in 2009.

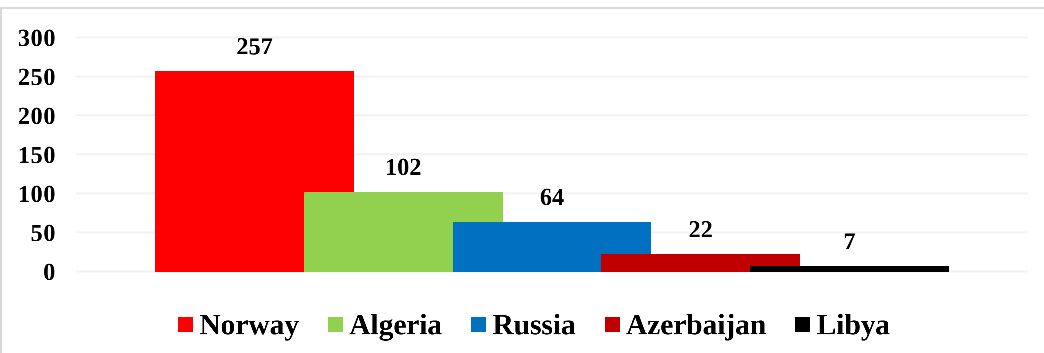
Recently, Algerian liquefied gas exports recorded a qualitative leap, especially during the first quarter of 2023, and this is due to the increase in shipments to the European market, as exports rose to about 2.8 million tons during the first quarter of 2023. Gas exports also recorded that Algerian liqueurs decreased in 2022 by 12.8% compared to 2021, from 11.48 million tons to 10.2 million tons.

It is also mentioned that Algeria ranked fourth among the list of the largest exporters of liquefied natural gas to the European market, with a total value estimated at 10.2 million tons in 2021, behind Russia, Qatar, and the United States of America, which came on top of the list.

Algerian Natural Gas exports through pipelines

Algerian natural gas exports exceeded the barrier of 100 million M^3 per day during the first quarter of 2023, supported by Italian demand for energy supplies from Algeria. The graph below shows a map of natural gas orders through pipelines to European Union countries.

Figure no. 5 Algeria's ranking of natural gas exports through pipelines (million M3 per day)



Source : www.attaqa.com, Consultation Date : 04/08/2023

From the above figure, it is clear that: Algerian gas exports exceeded the exports of 3 major countries, Russia, Azerbaijan, (Hamidova, 2018), and Libya, and only Norway preceded them in the list, with total exports amounting to about 257 million M^3 of gas per day, as Algerian gas exports came by approximately 102 million M^3 per day, and ranked second.

Research methodology

A time series dataset of 42 years (from 1980 to 2022) was used for the independent and dependent variables to achieve the study's objectives. The data was collected from the World Energy Statistics reports (IEA, 2023; OPEC, 2023), the Worldometer, and previous studies.

This study employed a unit root test, cointegration test (Engle & Granger, 1987), VECM approach to lead the stationarity test to examine the short-run and long-run linearity relationship among the variable, and Granger Causality test (1969). (Meyer & Sanusi, 2019)

Results and discussion

Before discussing the results, we decided to build a standard model that shows the determinants of gas exports in Algeria: gas production, gas consumption, and gas reserves. Therefore, the model form would be:

$$\boldsymbol{EXGAS = f(CGAS; PGAS; RGAS)} \ldots\ldots\ldots (\mathbf{1})$$

Where:

EXGAS: represents Natural gas exports.

CGAS: Domestic consumption of natural gas.

PGAS: Natural Gas production.

RGAS: Natural Gas Reserves.

Stationarity Tests

We use the Augmented Dickey-Fuller Test and Philips-Perron Test (ADF & PP) (Amassoma, Sunday, & Onyedikachi, 2018) (Dickey & Fuller, 1981) (Philips & Perron, 1988), the results of these tests are shown in Table 1 and Table 2:

Table no. 1 – Augmented Dickey-fuller (ADF) Test findings

Variable code	Level				First Difference			
	Constant		Constant, linear trend		Constant		Constant, linear trend	
	t-Statistics	P	t-Statistics	P	t-Statistics	P	t-Statistics	P
EXGAS	-2,1569	0,2245	-1,6887	0,7387	-6,1974	**0,0000**	-6,4310	**0,0000**
CGAS	1,3546	0,9985	-1,6517	0,7547	-5,7821	**0,0000**	-6,0652	**0,0000**
PGAS	-0,6250	0,8540	-2,1059	0,5276	-6,5006	**0,0000**	-6,4172	**0,0000**
RGAS	-1,1628	0,6816	-0,7030	0,9663	-6,8953	**0,0000**	-7,1575	**0,0000**

Source: The outputs Eviews.12

Table no. 2 – Phillips-Perron (PP) Test findings

Variable code	Level				First Difference			
	Constant		Constant, linear trend		Constant		Constant, linear trend	
	t-Statistics	P	t-Statistics	P	t-Statistics	P	t-Statistics	P
EXGAS	-2,2952	0,1782	-1,6141	0,7704	-6,1959	**0,0000**	-8,1866	**0,0000**

CGAS	1,3546	0,9985	-1,6676	0,7479	-5,7674	**0,0000**	-6,0652	**0,0000**
PGAS	-0,5089	0,8793	-2,2016	0,4764	-6,5870	**0,0000**	-6,4880	**0,0000**
RGAS	-0,7190	0,8309	-2,4041	0,3723	-6,2249	**0,0000**	-6,1931	**0,0000**

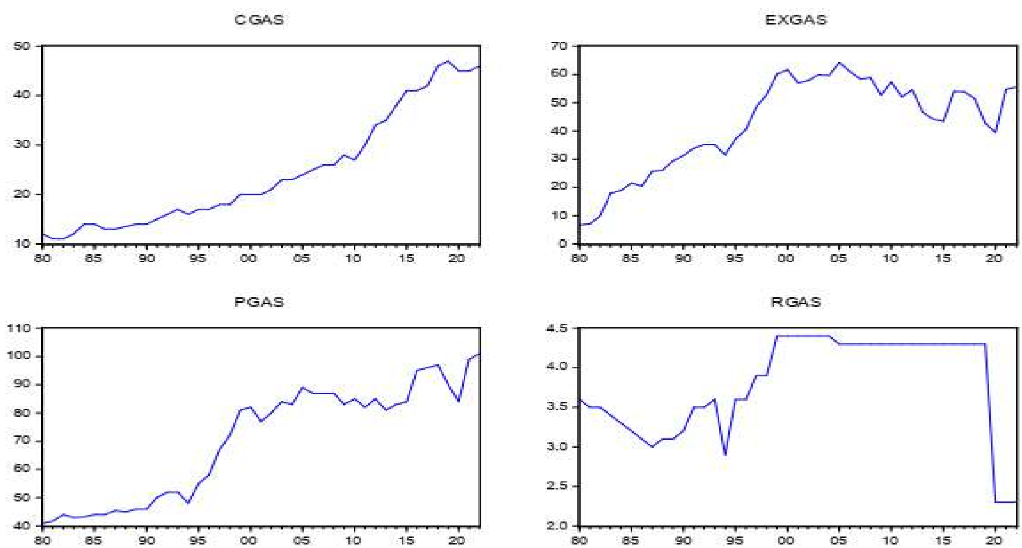
Source: The outputs Eviews.12

Is can be seen from the results of the unit root for all-time series that it is unstable at the level, meaning stable at the first difference, and this indicates the presence of the unit root.

After making the first differences on the time series after entering the logarithm and re-testing the stability, we noticed that the series does not have a unit root, and it stabilized after we made the first difference.

It was possible to draw observations of the variables to know their general trend, as the chart below shows some of the characteristics of the studied time series. It can be seen from Figure.6 that it suffers from the problem of the general trend, which indicates the instability of the analyzed time series.

Figure no. 6 shows the trend of the study variables in time.



Source: The outputs of Eviews.12

Studying the association between the study variables

After testing the stability of the time series of the study variables, we will try in this step to test the degree of correlation between the study variables. The obtained results are shown in Table 3.

Table no. 3 – The degree of correlation between the study variables

	CGAS	EXGAS	PGAS	RGAS
CGAS	1	0,54537423508	0,84853664491	0,76657436701
EXGAS	0,54537423508	1	0,87652068502	0,75608161867
PGAS	0,84853664491	0,87652068502	1	0,91529843554
RGAS	0,76657436701	0,75608161867	0,91529843554	1

Source: The outputs of Eviews.12

From the results of the above table, it is clear that:

- There is a medium positive relationship between the consumption and exports of natural gas in Algeria, with a value of (0.5453).
- There is a strong direct relationship between the production and exports of natural gas in Algeria, with a value of (0.8765).
- There is a strong direct relationship between natural gas reserves and exports in Algeria, with a value of (0.7560).

Cointegration Test- Johansen-Juselius

After verifying the first condition, the stability of variables of the same degree, we estimate the long-term relationships using the ordinary least squares method— Here, we use the Johansen-Juselius Cointégration test to study the relationship in the long run because time series are unstable over time (Ferdousi & Qamruzzaman, 2017) or using the (Johansen (Johansen & Juselius, 1990) eigenvalue test and the most significant plausibility ratio test (the most excellent probability) to find out the order of simultaneous integration.

Determine the number of rays of co-integration

In the following, we aim to determine the number of rays of co-integration between the study variables using the Johansen test, which is based on the effect test, and the maximum eigenvalue test.

Table no. 4 – Johansen-Juselius Cointegration tests results

Trace Test			
Null	**Trace Statistic**	**5% critical value**	**Prob.**
$r = 0$	**60,959338**	**47,85613**	**0,0019**
$r \leq 1$	26,75980	29,79707	0,1076
$r \leq 2$	5,922826	15,49471	0,7046
$r \leq 3$	0,056322	3,841466	0,8124
Maximum eigenvalue Test			
Null	**Max-Eigen Statistic**	**5% critical value**	**Prob.**
$r = 0$	**34,19958**	**27,58434**	**0,0061**

$r \leq 1$	20,83697	21,13162	0,0549
$r \leq 2$	5,866503	14,26460	0,6304
$r \leq 3$	0,056322	3,841466	0,8124

Source: The outputs of Eviews.12

Because the Maximum Eigenvalue and trace statistic value are greater than the Critical Value at 5% $(60{,}959338 > 47{,}85613)$; $(34{,}19958 > 27{,}58434)$ and are significant$(0{,}0019 < 0{,}05\,;\ 0{,}0061 < 0{,}05)$. Since the variables are co-integrated, we proceed to model the chosen variables using the Restricted VAR Model (VECM) rather than the Unrestricted VAR model.

Model estimation

Choosing the optimum Lag

The first step in VECM model validation, which is essential for time series data analysis, is to select the optimal lag by comparing each lag to the chosen criterion. The results in Table 4 show that the optimal lag is 1 according to the LR, FPE, AIC, SC, and HQ selection criteria. (Akaike, 1974). The maximum values from each of the information criteria are marked with an asterisk (*), which indicates that these are the preferred models. We carried out additional tests using a delay of 1 and one cointegration between the variables to verify the VECM model.

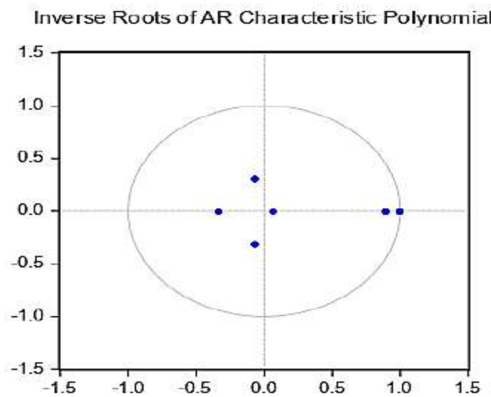
Table no. 5 – Results of LB (Q-statistics)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-413,3310	NA	23158,77	21,40159	21,57221	21,46281
1	**-233,4873**	**313,5738***	**5,225311***	**12,99935***	**13,85246***	**13,30544***
2	-222,0582	17,58324	6,794439	13,23375	14,76935	13,78471
3	-207,0439	20,01897	7,680757	13,28430	15,50239	14,08013
4	-188,4562	20,97080	7,769052	13,15160	16,05217	14,19230

Source: The outputs of Eviews.12

The Roots of characteristic Polynomial Stability Conditions Tests for Model stability, the Breusch-Godfrey Serial correlation LM, the Breusch-Pagan-Godfrey Heteroscedasicity Test, and the Jaque-Bera Test for Normality Tests were used to evaluate the sufficiency of the VECM model. The Roots of the characteristic Polynomial Stability Conditions analysis results (Figure 7) show that the VECM model satisfies stability conditions because all of the roots are situated in the unit circle.

Figure no. 7 Stability graph for VECM



Source: The outputs of Eviews.12

Granger Causality Test

After performing the co-integration Test, which reveals a relationship between the variable over the long term, we will us the Granger-Causality test to determine the direction of this relationship. (Patonov, 2020) This is illustrated in Table 6.

Table no. 6 – Results of Granger-Causality examination

	EXGAS	**CGAS**	**PGAS**	**RGAS**
EXGAS	-----	0.64808 (0.5290)	0.01200 (0.9881)	1.72076 (0.1933)
CGAS	1.80108 (0.1797)	-----	2.29974 (0.1148)	2.25638 (0.1193)
PGAS	0.01650 (0.9836)	0.75518 (0.4772)	-----	3.96723 **(0.0277)***
RGAS	3.75539 **(0.0330)***	0.81353 (0.4513)	5.43980 **(0.0086)***	-----

Source: The outputs of Eviews.12

Given the above Granger causality test results for the short term, which show that there a bilateral relationship (in both directions) between natural Gas production and natural gas reserves, the null hypothesis can be rejected and the alternative hypothesis can be accepted ($Prob = 0{,}0277 < 0{,}05$) and ($Prob = 0{,}0086 < 0{,}05$). Therfore, it may be claimed that natural gas reseves cause gas production and vice-versa. Additionally, there is a one-way relationship ($Prob = 0{,}0330 < 0{,}05$) between natural gas reserves and natural gas exports, i.e., natural gas reserves cause natural gas exports.

Table no. 7 – Results of the Least Square Method

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-15.60446	4.840060	-3.224023	0.0026
CGAS	-1.039736	0.149424	-6.958313	0.0000
PGAS	1.230109	0.095303	12.90733	0.0000
RGAS	-0.749007	1.607578	-0.465923	0.6439
R-squared	0.909361	Mean dependent var		42.58949
Adjusted R-squared	0.902388	S.D. dependent var		16.41334
S.E. of regression	5.127999	Akaike info criterion		6.195716
Sum squared resid	1025.559	Schwarz criterion		6.359549
Log likelihood	-129.2079	Hannan-Quinn criter.		6.256133
F-statistic	130.4254	Durbin-Watson stat		0.209653
Prob(F-statistic)	0.000000			

Source: The outputs of Eviews.12

The results of the table show that natural gas reserves are not a significant factor affecting gas exports in Algeria, as the p-value is 0.6439, which is greater than the significance level of 0.05. However, natural gas consumption is a significant factor affecting gas exports, as the p-value is 0.000, which is less than the significance level of 0.05. This means that an increase in natural gas consumption in Algeria by one unit is associated with a decrease in the volume of gas exports by 1.03 units.

The study also found that natural gas production is a significant factor affecting gas exports, as the p-value for natural gas production is statistically significant, with a value of 0.0000, which is less than the significance level of 0.05. This indicates that there is a positive relationship between increasing natural gas production and exports.

The correlation coefficient between the variables in the model is also strong, as confirmed by the results of the correlation test and the simultaneous integration test. The adjusted R-squared value indicates that the relationship between the independent variables (natural gas consumption, natural gas production, and natural gas reserves) and the dependent variable (natural gas exports) is estimated to be 90.23%. This means that only 9.77% of the variation in natural gas exports is due to variables outside the model.

Conclusion

Our study found that natural gas exports in Algeria are primarily influenced by three factors: production, consumption, and natural gas reserves. These factors account for 90% of the variation in natural gas exports, with the remaining 10% due to other factors.

The study also found that there is a statistically significant positive correlation between natural gas production and exports, and between natural gas consumption and exports. This confirms the first and second hypotheses of the study.

The study did not find a statistically significant correlation between natural gas reserves and exports, which negates the third hypothesis.

Finally, the study found that there is an inverse relationship between domestic consumption of natural gas and natural gas exports. This means that an increase in consumption of natural gas in Algeria is likely to be followed by a decrease in the volume of exports of natural gas.

REFERENCES

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, *19*(6), 716-723. doi:10.1109/TAC.1974.1100705

Aktemur, C. (2017). An Overview of Natural Gas as an energy Source for Various purposes. *International Journal of engineering technologies- IJET*, *3*(3), 91-104. doi:10.19072/ijet.300750

Amassoma, A. D., Sunday, K., & Onyedikachi, E. E. (2018). The infuence of money supply on inflation in Nigeria. *Journal of Economics and Management*, *31*(1), 5-13. doi:10.22367/jem.2018.31.01

Boulasal, M., & Soufan, E. (2021). Algeria's Natural Gas exports to the European Union countries in light of current economic transformations. *Albashaer Economic Journal*, *7*(2), 351-365.

Dickey, D., & Fuller, W. (1981). Likelihood ratio statistics for Autoregressive time series with a Unit Root. *Econometrica*, *49*(4), 1057-1072. doi:10.2307/1912517

Engle, R. F., & Granger, C. W. (1987). Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica*(55), 251-276. doi:http://dx.doi.org/10.2307/1913236

Ferdousi, F., & Qamruzzaman, M. (2017). Export, import, Economic Growth, and Carbon Emissions in Bangladesh: A Granger Causality Test under VAR (Restricted). *Environment Management of Cities and Region*. doi:10.5772/intechopen.70782

Hamidova, L. (2018). Diversification of the economy of Azerbaijan: How to Overcome resource dependence? *Economics and Management*, *XIV*(I), 2-13.

Energy Institue. (2023). *Statistical Review of World Energy.* KEARNEY. Consulté le Auguest 01, 2023, ed. 72, from: https://www.energyinst.org/__data/assets/pdf_file/0004/1055542/EI_Stat_Review_PDF_single_3.pdf

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and interference on cointegration with application to the demand for money. *Oxford bull. Econ.statis*(52), 169-210.

Khelifa, h., Mezouaghi, D., & Bachouche, H. (2020). The Relationship between the Use of Renewable Energies and the Dimensions of Sustainable Development in Algeria during the Period 1990-2014. *Advanced Research in Economics and Business Strategy Journal*, *1*(1), 23-39. doi:https://doi.org/10.52919/arebus.v1i01.8

Meyer, D., & Sanusi, K. A. (2019). A Causality Analysis of the Relationships between Gross Fixed Capital Formation, Economic Growth and Employment in South Africa. *Studia Universitatis Babeș-Bolyai Oeconomica*, *64*(1), 33-44. doi:doi: 10.2478/subboec-2019-00

Patonov, N. (2020). Gold price and bitcoin exchange rate: Is there a correlation? *Entrepreneurship*, *VIII*(I), 119-124.

Philips, P., Perron, P. (1988). Testing for a unit Root in time series regression. *Biométrika, 75*(2), 335-346. doi:10.1093/biomet/75.2.335

Yekhtar, A., & Abderrahmane, A. (2013). The impact of security developments in the Sahel region on Natural Gas production in Algeria, the terrorist attack on the Tiguentourine Gas production complex Economic. *Journal of Economic*, *4*(1), 239-258.