The impact of natural gas sustainability on the economic stability of countries during the Period 2000–2022

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Abstract :
Natural gas sustainability is a decisive factor in shaping the economic stability of producing and consuming countries. As one of the most widely used energy sources worldwide, natural gas supports key sectors such as electricity generation, heating, transportation, and the chemical industry. This paper investigates the extent to which natural gas sustainability—measured through the ecological footprint, domestic production, and investment in the energy sector—affects economic stability, proxied by per capita income. Using panel data for five major gas-producing countries (the United States, Australia, Russia, Qatar, and Algeria) over the period 2000–2022, the study combines a descriptive analysis with an econometric approach. The results suggest that while sustainable natural gas practices can contribute to growth and energy security, their impact is uneven across countries and often undermined by price volatility, high capital requirements, and growing competition from renewables. The study highlights the need for coherent policies that integrate environmental and economic dimensions to ensure that natural gas remains a stabilizing factor in the context of global energy transitions.

Key Words: Natural gas; Sustainability; Economic stability; Ecological footprint; Panel data

JEL Classifications: Q34, Q02, Q01

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Introduction

Sustainable development and economic stability are deeply interconnected concepts that together ensure the long-term well-being of societies. Sustainable development emphasizes meeting present needs without compromising the capacity of future generations, which requires efficient resource use and environmental protection (Mensah, 2019). Economic stability, in turn, provides the foundation for sustainable development by supporting job creation, stimulating investment, and maintaining social welfare (Liu, 2025). When countries adopt sustainability-oriented policies, they strengthen their resilience to economic and social shocks, thus promoting greater stability. (Cleveland, 2024)

Natural gas, as a transitional fuel, plays a central role in this context. Compared with other fossil fuels, it generates lower carbon emissions and contributes to climate change mitigation efforts. For producing countries, natural gas revenues are

a crucial source of public finance, enabling infrastructure development and social investment (Ouki, 2015) However, the sector is also characterized by volatility, price fluctuations, and large capital requirements, all of which can threaten both environmental sustainability and macroeconomic stability.

This study explores the relationship between natural gas sustainability and economic stability. It seeks to answer the following research question:

What is the role of natural gas sustainability in achieving economic stability?

By focusing on a sample of five major gas-producing countries (the United States, Australia, Russia, Qatar, and Algeria) over the period 2000–2022, the paper combines a descriptive analysis of sustainability indicators with an econometric panel model. In doing so, it aims to clarify how the sustainable management of natural gas resources can enhance growth, energy security, and resilience in the context of global energy transitions.

I. Theoretical framework :

1. Economic Stability :

Economic stability refers to a state of balance in which an economy achieves sustainable growth while maintaining low levels of inflation and unemployment. Several scholars have approached this concept from different perspectives:

- **John Maynard Keynes** viewed economic stability as an equilibrium between supply and demand, stressing that government intervention is essential to maintain this balance**. (Young, 2024)**
- **Milton Friedman** emphasized price stability and argued that controlling the money supply is the key to avoiding major economic fluctuations**..** (Beckworth, 2022**)**
- **Alan Greenspan** highlighted the central role of financial system stability in fostering investor confidence and supporting long-term growth. (Héron, 2006)
- **Joseph Stiglitz** expanded the concept beyond growth and prices to include social justice and equitable wealth distribution, suggesting that stability requires a balance between economic and social policies. (Stiglitz, 2019**)**
- **Amartya Sen** linked stability with human development, arguing that improving living standards and expanding opportunities are integral to achieving lasting equilibrium. (MABOLOC, 2008)

In summary, economic stability is a multidimensional concept that combines growth, price control, employment, social justice, and human development. For natural gas–producing countries, stability often depends not only on macroeconomic policies but also on how effectively energy resources are managed to mitigate volatility and sustain long-term development

1.1. Sustainable Development :

Sustainable development is generally defined as the ability to meet present needs without compromising the capacity of future generations to meet their own. It requires a balance between economic progress, social equity, and environmental protection **(**Holden, 2014). More specifically, it involves harmonizing resource

exploitation, investment priorities, institutional reforms, and technological change to achieve long-term well-being (Abou El Nasr, 2017).

1.2. Indicators of Sustainable Development :

Sustainability can be measured through a broad set of indicators that reflect economic, social, environmental, and institutional dimensions (Ammar Ammari, 2008):

- *Economic indicators*: GDP per capita, investment rates, trade balance, external debt.
- *Social indicators*: unemployment, literacy, education enrollment, health outcomes.
- *Environmental indicators*: land use change, desertification, forest cover, biodiversity.
- *Institutional indicators*: research and development expenditure, access to information, governance.

1.3. Dimensions of Sustainable Development :

They are as follows : (Sharma, 2020)

- *Economic dimension*: ensuring continuous growth through efficient capital use, reinvestment, and the satisfaction of basic needs.
- *Social dimension*: prioritizing human development by reducing poverty, ensuring equity, and fostering democratic participation.
- *Environmental dimension*: respecting ecological limits by managing resources sustainably, reducing pollution, protecting biodiversity, and adopting clean technologies.

Taken together, these dimensions highlight that sustainable development cannot be achieved without integrating environmental stewardship with economic and social objectives. In the context of natural gas, sustainability implies not only reducing emissions and minimizing ecological damage but also reinvesting revenues into diversified, resilient economies.

2. Natural Gas :

Natural gas is a non-renewable fossil fuel formed over millions of years through the decomposition of organic matter under high pressure and temperature in sedimentary basins. Its main components include methane, ethane, propane, carbon dioxide, and other hydrocarbons, typically extracted through hydraulic fracturing and drilling (Panja, 2022). As one of the cleanest fossil fuels, natural gas emits less carbon dioxide than coal and oil, which makes it an important transitional energy source in the shift toward low-carbon economies.

2.1. Uses of Natural Gas :

Natural gas has multiple applications across sectors (Wadhwa, 2019):

- *Electricity generation*: a major global source of power due to its efficiency and relatively low emissions.
- *Heating*: widely used in residential, commercial, and industrial heating systems.
- *Industry*: a feedstock for fertilizers, petrochemicals, hydrogen, and methanol.

- *Transportation*: used as compressed natural gas (CNG) for vehicles, providing a cleaner alternative to gasoline and diesel.

2.2. Importance in the Global Economy :

Natural gas accounts for about 24% of global energy consumption and is central to electricity production, industry, and heating. Its relatively low cost supports industrial productivity and economic growth in consuming countries (Kan, 2019**)**. For producing countries, it is a vital source of government revenues, foreign exchange, and investment, often shaping their macroeconomic stability and development strategies.

2.3. Challenges to Natural Gas Sustainability :

Despite its advantages, natural gas faces several sustainability challenges that directly affect economic stability (Hayani, 2016):

- *Price volatility*: fluctuations in supply and demand lead to uncertainty in investment and fiscal revenues.
- *High investment requirements*: infrastructure development demands significant capital, potentially constraining other development priorities.
- *Environmental concerns*: extraction and transport can cause methane leaks, water contamination, and air pollution.
- *Competition from renewables*: the expansion of solar, wind, and other clean sources threatens gas's long-term role.
- *Geopolitical risks*: dependence on imported gas exposes countries to supply disruptions and political tensions.
- *Policy changes*: energy transition policies and carbon neutrality commitments may reduce reliance on gas.

In summary, natural gas plays a dual role: it offers cleaner energy compared to other fossil fuels and contributes to economic growth, but its volatility, environmental risks, and uncertain future position require careful management to ensure that it contributes positively to both sustainability and economic stability.

3. Previous studies :

- **Brauers (2022):** Conducted a systematic review on sustainability transitions and argued that natural gas, while often labeled as a "bridge fuel," cannot ensure long-term climate objectives due to methane emissions and stranded-asset risks. This study highlights the environmental constraints of relying on gas for stability.
- **Al-Jawarin (2021):** Analyzed Qatar's LNG industry and found that gas revenues strengthened fiscal stability and supported growth. However, the heavy dependence on LNG exports exposed the economy to price volatility, underlining the vulnerabilities of resource-dependent economies.
- **Aksyutin (2020):** Explored the role of natural gas in achieving Sustainable Development Goals (SDGs), showing that gas supports economic and social development more effectively than other fossil fuels in the short term. Yet, the study stressed that long-term sustainability depends on environmental balance.

- **Tagliapietra & Zachmann (2021):** Examined the European Union's energy transition and the role of natural gas. They concluded that gas may help stabilize energy systems during the transition but warned that delaying renewable deployment could lock economies into fossil fuel dependency, creating instability in the long run.
- **Yuan et al. (2023):** Investigated the relationship between natural gas consumption, economic growth, and carbon emissions in emerging economies. Using panel econometric models, they found that natural gas contributes to short-term economic growth but exacerbates carbon pressures, suggesting that stability is conditional on environmental policies and diversification sustainability

The literature reveals a clear duality in the role of natural gas:

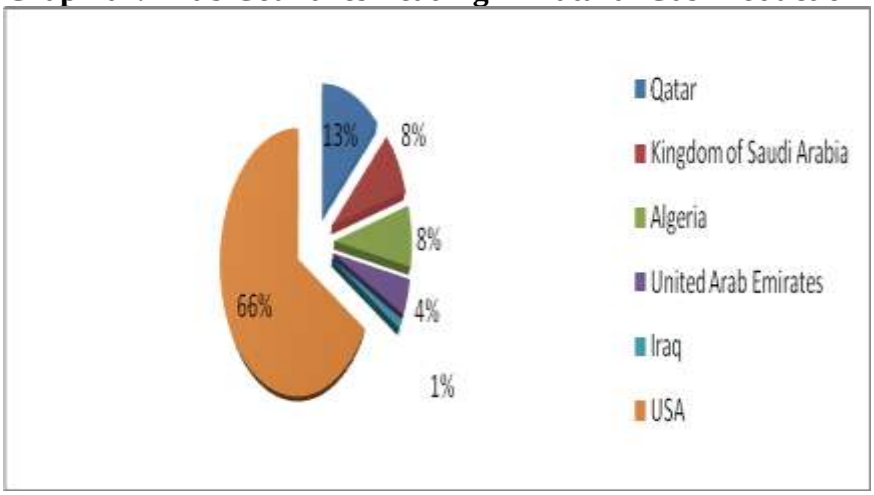
- **Opportunities**: revenue generation, fiscal stability, and support for development goals (Al-Jawarin, Aksyutin, Yuan et al.).
- **Risks**: environmental externalities, stranded assets, and long-term instability due to resource dependence (Brauers, Tagliapietra & Zachmann).

While most previous studies focus either on the **economic benefits** or the **environmental risks**, few attempt to empirically integrate both dimensions. This study addresses that gap by using panel data to analyze how natural gas sustainability—measured through ecological footprint, production, and energy investments—affects economic stability, thereby linking short-term economic outcomes with long-term sustainability challenges.

II. Application framework :

Natural gas is one of the most important sources of energy in the world, as it is used in many fields such as electricity generation, heating, and chemical industries. In the Arab world, Qatar is one of the most prominent gas producers, with the world's largest natural gas reserves, followed by Algeria and the United Arab Emirates. These countries take advantage of their natural resources to meet the needs of the local market and export gas to global markets. Internationally, the United States and Russia are the largest producers of natural gas. These two countries have advanced gas extraction technologies, which enhances their competitiveness in the global market. These countries contribute to meeting the growing demand for energy, making them key players in the global economy**.**

Graph 01: Arab Countries Leading in Natural Gas Production



Source :Ali Sabt Bensabt, natural Gas Industry in the Arab Countries: Current Scene and Prospects, GECF,pp1-18,2020

The graph shows the distribution of natural gas production among major countries, with statistics revealing that the United States leads with 66% of global production, reflecting its economic and technological strength in this sector. Russia comes in second place with 13%, highlighting its dependence on gas as the main source of revenue, especially in the context of geopolitical tensions that may affect its trade. Qatar, which ranks third with 8 percent, stands out as a relatively small but resource-rich country, one of the world's leading exporters of liquefied natural gas. The remaining percentages are distributed between Iraq, Algeria and Saudi Arabia, as these figures reflect economic challenges , these countries struggle in increasing their productiontur, particularly with infrastruce and investment. Overall, the graphic shows how some countries dominate the natural gas market, requiring various economic strategies for other countries to boost their production and position in the global market.

Several countries around the world aim to achieve natural gas sustainability through various strategies, the most prominent of which include :

- The United States: Promoting the use of natural gas as part of its shift towards cleaner energy sources, with a focus on emission reduction technologies.
- Qatar: Invests in sustainable technology and practices in the natural gas sector, especially in the field of liquefied natural gas.
- Norway: A pioneer in the development of sustainable energy sources, including natural gas, working to reduce the environmental impact of production processes.
- Australia: seeks to develop LNG projects in sustainable ways, with a focus on reducing emissions.
- UAE: Sustaining the gas sector through innovation and clean technology projects.

- Algeria: focuses on modernizing its infrastructure and enhancing the efficiency of the use of natural gas.
- UK: Invests in natural gas projects with a focus on sustainability and emission reduction technologies.

These countries are working to strike a balance between utilizing natural gas as a major energy source , preserving the environment , and achieving Sustainable Development Goals.

Table 01: Largest natural gas producers in 2021

Company	Country	Production (Cubic Feet)	Revenue
Gazprom	Russia	18.2 trillion	$137.71 billion
China National Petroleum Corporation	China	4.4 trillion	$366 billion
Sinopec	China	1.2 trillion	$383.72 billion
ExxonMobil	United States	3.1 trillion	$285.64 billion
BP	United Kingdom	2.9 trillion	$164.19 billion
Chevron	United States	2.8 trillion	$155.6 billion
Royal Dutch Shell	Netherlands	2.6 trillion	$272.66 billion
Total Energies	France	2.6 trillion	$205.86 billion
Rosneft	Russia	2.3 trillion	$122.65 billion
Lukoil	Russia	1.1 trillion	$131.6 billion

Source : https://www.worldometers.info/gas/gas-production-by-country/

The table shows the largest natural gas producers in 2021, with Russia's Gazprom topping the list with 18.2 trillion cubic feet of production, reflecting its dominance in the global market and its vital role in the Russian economy, with revenues of $137.71 billion contributing significantly in government income . Gazprom follows China National Oil Corporation (PetroChina), which produces 4.4 trillion cubic feet, generating revenues of $366 billion, demonstrating the strength of the Chinese market and its ability to generate significant values from its operations. Followed by Sinopec, which produces 1.2 trillion cubic feet and generates high revenues of $383.72 billion, reflecting its efficiency in managing operations. In the United States, ExxonMobil and Chevron are leading companies, producing 3.1 and 2.8 trillion cubic feet respectively, with revenues of $285.64 billion and $155.6 billion, highlighting U.S. competitiveness in the sector.

European companies such as BP, Deutsche Shell and Total Energy are also showing good results, generating revenues of between $164.19 billion and $272.66 billion. Although their production is lower compared to other major companies ; data shows that production and revenues are not always proportionate; some companies like Sinopec achieve high revenues despite their smaller volumes. The table also reflects the significant disparity between countries and companies in the ability to benefit from natural gas resources, which confirms the importance of diversified economic strategies in strengthening positions in the global market.

this study examines the impact of natural gas sustainability on economic stability using panel data for five major producing countries—the United States, Russia, Australia, Qatar, and Algeria—over the period 2000–2022. The empirical framework combines a descriptive analysis of sustainability and stability indicators with an econometric model designed to capture the relationship between natural gas variables and per capita income.

1. Model Specification :

The following functional form was estimated

$$E=\alpha+\beta_1 S+\beta_2 G+\beta_3 I+\epsilon_{it}$$

where:

E : Economic stability (measured by GDP per capita growth index)

S: Natural gas sustainability (measured by the ecological footprint index)

G: Domestic production of natural gas (amount of gas produced locally).

I: investments in the energy sector (expressed using energy in industry)

α\alphaα: fixed.

β1,β2,β3 Impact coefficients for each of the variables.

ε\ Random error.

The logarithm was introduced on all variables to obtain the homogeneity of the data, and also for the following reasons:

- Standardize different units, allowing comparison of relative changes rather than absolute values.
- Convert nonlinear relationships to linear relationships, making it easier to analyze data using regression models.
- Reduce the discrepancy between data, bringing it closer to the normal distribution, and mitigating the impact of outliers.
- Facilitate the interpretation of the results, where regression coefficients can be understood as percentages of the change in the dependent variable resulting from a unit change in the independent variable.

Table 02. Variables and Data Sources

Variable	Proxy / Measurement	Source
Economic Stability (E)	GDP per capita (constant US$)	World Bank (World Development Indicators)
Sustainability (S)	Ecological Footprint Index (global hectares per capita)	Global Footprint Network
Gas Production (G)	Natural gas production (billion cubic meters)	BP Statistical Review of World Energy
Energy Investments (I)	Gross fixed capital formation in energy & industry (% of GDP)	World Bank, IEA

- **Estimation Method:** The model was estimated using pooled least squares (PLS) and generalized least squares (GLS) for comparison, incorporating fixed and random effects. The Hausman test was then applied to determine the most appropriate specification.
- **Rationale for Variable Selection:** The use of the ecological footprint index is central to this analysis, as it captures the environmental dimension of sustainability, thus linking energy use with long-term ecological balance. GDP per capita was chosen as the dependent variable because it reflects both economic well-being and stability at the national level. Gas production and energy investment represent the resource and capital dynamics that potentially influence stability.
- **Limitations:** While the model provides useful insights, it remains simplified. Economic stability encompasses dimensions beyond GDP per capita (such as inflation and unemployment), which were excluded due to data limitations. Similarly, sustainability is captured only by the ecological footprint index, though alternative indicators (such as CO_2 emissions) could enrich future research.

2. Results and Discussion :

This section presents the econometric findings from the pooled least squares (PLS) and generalized least squares (GLS) estimations, followed by the Hausman test to determine the most appropriate specification

Table 3. Pooled Least Squares (PLS) Results

Variable	Coefficient	t-Statistic	Prob.
C (Constant)	9.4800	2.35	0.0208**
LS	-1.3707	-1.10	0.2730
LI	-1.0053	-2.71	0.0079***
LG	-0.0220	-0.09	0.9250
Statistic	**Value**	**Statistic**	**Value**
R^2	0.309	Adjusted R^2	0.260
F-statistic	6.21	Prob(F-statistic)	0.0000***
S.E. of regression	0.694	D–W statistic	0.966

Source**:** Author's calculations based on *EViews* analysis and official statistics from https://www.worldometers.info/gas/us-natural-gas/#gas-production

Cross-section fixed effects: Included (USA, Russia, Australia, Qatar, Algeria)

Notes: *** $p < 0.01$, ** $p < 0.05$

A detailed version of the table is presented in the Appendix section

- The coefficient of **energy investments (LI)** is negative and statistically significant at the 1% level ($t = -2.71$, $p = 0.0079$). This indicates that increases in energy-related investments are associated with decreases in GDP per capita in the sample countries.

- The coefficient of **ecological footprint (LS)** is negative but statistically insignificant (p = 0.27), suggesting no robust short-term relationship between ecological footprint and per capita income.
- The coefficient of **gas production (LG)** is also statistically insignificant (p = 0.92), meaning domestic gas output does not significantly explain variations in per capita income.
- The fixed effects by country highlight heterogeneity: the United States and Russia contribute positively, while Qatar and Algeria contribute negatively.
- The negative impact of investments suggests that capital-intensive energy projects may burden public budgets or generate inefficiencies, reducing growth in the short run.
- The insignificance of the ecological footprint implies that environmental costs are not yet fully internalized into economic activity, though they remain critical for long-term sustainability.
- The insignificance of gas production supports the "resource curse" hypothesis: higher production does not automatically yield stability without economic diversification and sound fiscal management.
- Positive effects in advanced economies (USA, Russia) reflect institutional strength and diversification, while negative effects in Algeria and Qatar reflect vulnerabilities of resource-dependent economies.

Table 4. Random Effects (GLS) Results

Variable	**Coefficient**	**t-Statistic**	**Prob.**
C (Constant)	1.137	0.43	0.6668
LS	0.110	0.13	0.8970
LI	-0.359	-1.34	0.1830
LG	0.038	0.18	0.8577
Statistic	Value	Statistic	Value
R^2	0.058	Adjusted R^2	0.030
F-statistic	2.06	Prob(F-statistic)	0.110
S.E. of regression	0.723	Durbin–Watson stat	0.851

Source**:** Author's calculations based on *EViews* analysis and official statistics from https://www.worldometers.info/gas/us-natural-gas/#gas-production

Random effects (cross-sections): USA, Russia, Australia, Qatar, Algeria
Note: No variables are statistically significant at the 1% or 5% levels, indicating limited explanatory power of the random effects model.
The complete version of the table is provided in the Appendix

- None of the explanatory variables (LS, LI, LG) are statistically significant under the random effects model.
- The overall explanatory power is very low (R^2 = 0.058), and the F-statistic is not significant (p = 0.11).

- The insignificance of all variables suggests that random effects do not capture country-specific characteristics that are essential for explaining the gas–stability nexus.
- Economic stability in gas-producing countries is heavily dependent on structural and institutional factors, which random effects estimation overlooks.
- This result highlights the importance of considering fixed effects, as each country's economic resilience, fiscal policies, and diversification strategies strongly condition the gas–stability relationship.

Table 5. Hausman Test

Test Summary	**Chi-Sq. Statistic**	**d.f.**	**Prob.**
Cross-section random	11.798	3	0.0081***
Variable	Fixed Effects	Random Effects	Prob.
LS	-1.371	0.110	0.1022
LI	-1.005	-0.359	0.0117**
LG	-0.022	0.038	0.5074

Source**:** Author's calculations based on *EViews* analysis and official statistics from https://www.worldometers.info/gas/us-natural-gas/#gas-production

Decision: Since *Prob. < 0.05*, the null hypothesis of random effects is rejected.
Conclusion: The **fixed effects model** is preferred over the random effects model.
Note: *** p < 0.01, ** p < 0.05
The complete version of the table is provided in the Appendix

- The Hausman test yields a Chi-Square statistic of 11.79 (p = 0.0081), indicating that fixed effects are preferred over random effects.
- This confirms that unobserved heterogeneity across countries is correlated with the explanatory variables, making fixed effects the appropriate specification.
- The importance of country-specific effects highlights that gas sustainability and economic stability are shaped by national contexts—such as governance, institutional quality, and diversification strategies.
- Policies that integrate gas sustainability into broader economic frameworks are therefore crucial, as there is no one-size-fits-all relationship across countries.

3. Overall Discussion :

From an econometric standpoint, the results indicate that energy investments significantly affect economic stability, but in a negative way, while gas production and ecological footprint show no significant impact in the short term. Fixed effects are more reliable, confirming that country-specific characteristics matter.
From an economic standpoint, the findings suggest that:

- **Natural gas alone is not sufficient** to ensure stability; it must be accompanied by sound governance and diversification.

- **Resource-dependent economies** (Algeria, Qatar) remain vulnerable to volatility, while **diversified economies** (USA, Russia) are better able to turn gas resources into stability.
- **Environmental sustainability** (ecological footprint) does not yet affect short-term stability but will become more relevant as environmental policies tighten.

Conclusion :

This study examined the relationship between natural gas sustainability and economic stability in five major producing countries — the United States, Russia, Australia, Qatar, and Algeria — over the period 2000–2022, using panel data econometric techniques.The main empirical results can be summarized as follows:

- **Energy investments (LI)** exert a significant but negative effect on economic stability, indicating the fiscal burden and inefficiencies associated with capital-intensive energy projects in the studied countries.
- **Ecological footprint (LS)** has a negative but statistically insignificant impact, suggesting that environmental pressures are not yet internalized in short-term growth patterns, although they remain critical for long-term sustainability.
- **Gas production (LG)** shows no significant relationship with per capita income, confirming that resource abundance alone does not guarantee stability and supporting the "resource curse" hypothesis.
- **Country-specific effects** are decisive: the United States and Russia benefit from natural gas as a stabilizing factor due to economic diversification and strong institutions, while Algeria and Qatar face negative outcomes from overreliance on gas revenues and exposure to price volatility.

From an economic perspective, these findings reveal that natural gas can contribute to economic stability only when managed within a broader framework of diversification, institutional quality, and sustainability-oriented governance. Overdependence on gas revenues increases vulnerability to external shocks, while neglecting environmental integration undermines long-term resilience.

Policy Recommendations

Based on these findings, several policy directions are suggested:

- **Promote economic diversification:** reduce fiscal and structural dependence on gas revenues by supporting industrial and technological sectors.
- **Enhance investment efficiency:** prioritize innovation, technology transfer, and the integration of renewable energy into national energy strategies.
- **Internalize environmental costs:** incorporate ecological sustainability into economic planning through regulatory frameworks and green fiscal instruments.
- **Strengthen governance and institutions:** ensure that gas revenues are managed transparently and transformed into inclusive and stable development outcomes

In conclusion, while natural gas sustainability holds significant potential to foster economic stability, its benefits remain uneven across countries. Achieving lasting stability requires strong institutions, forward-looking energy policies, and long-term strategies that balance economic growth, environmental protection, and social welfare.

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Appendix 1 : Pooled Least Squares (PLS) Results

Dependent Variable: LE?
Method: Pooled Least Squares
Date: 05/11/25 Time: 20:41
Sample (adjusted): 2000 2022
Included observations: 22 after adjustments
Cross-sections included: 5
Total pool (unbalanced) observations: 105

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	9.480018	4.033090	2.350559	0.0208
LS?	-1.370713	1.243422	-1.102371	0.2730
LI?	-1.005289	0.370594	-2.712642	0.0079
LG?	-0.021965	0.232725	-0.094380	0.9250
Fixed Effects (Cross)				
USA--C	2.159530			
RUSSIA--C	2.219485			
AUSTRALIA--C	0.178516			
QATAR--C	-1.763784			
ALGERIA--C	-2.473102			

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.309495	Mean dependent var	-3.405598
Adjusted R-squared	0.259665	S.D. dependent var	0.806171
S.E. of regression	0.693652	Akaike info criterion	2.179438
Sum squared resid	46.67180	Schwarz criterion	2.381644
Log likelihood	-106.4205	Hannan-Quinn criter.	2.261376
F-statistic	6.210981	Durbin-Watson stat	0.966373
Prob(F-statistic)	0.000005		

Appendix2 : Random Effects (GLS) Results

Dependent Variable: LE?
Method: Pooled EGLS (Cross-section random effects)
Date: 05/11/25 Time: 20:43
Sample (adjusted): 2000 2022
Included observations: 22 after adjustments
Cross-sections included: 5
Total pool (unbalanced) observations: 105
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.137389	2.633778	0.431847	0.6668
LS?	0.110484	0.851149	0.129806	0.8970
LI?	-0.358641	0.267488	-1.340774	0.1830
LG?	0.038479	0.214121	0.179705	0.8577
Random Effects (Cross)				

USA--C	0.288529
RUSSIA--C	0.490930
AUSTRALIA--C	-0.217935
QATAR--C	0.051360
ALGERIA--C	-0.612883

Effects Specification	S.D.	Rho
Cross-section random	0.492074	0.3348
Idiosyncratic random	0.693652	0.6652

Weighted Statistics			
R-squared	0.057670	Mean dependent var	-1.000371
Adjusted R-squared	0.029680	S.D. dependent var	0.733888
S.E. of regression	0.723233	Sum squared resid	52.82972
F-statistic	2.060385	Durbin-Watson stat	0.850713
Prob(F-statistic)	0.110216		

Unweighted Statistics			
R-squared	-0.035816	Mean dependent var	-3.405598
Sum squared resid	70.01162	Durbin-Watson stat	0.641935

Appendix 3: Hausman Test

Correlated Random Effects - Hausman Test
Pool: COUNTRIES
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	11.798270	3	0.0081

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
LS?	-1.370713	0.110484	0.821645	0.1022
LI?	-1.005289	-0.358641	0.065790	0.0117
LG?	-0.021965	0.038479	0.008313	0.5074