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Research Article

Strategic Financing of LNG Expansion for Infrastructure Development, Export Competitiveness and National Energy Security

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Abstract

Background: Liquefied Natural Gas (LNG) as a vital energy resource because it enables infrastructure development through capital investment which creates new economic opportunities and boosts export product competitiveness and enables countries to access their domestic and international energy resources. The fast-moving energy market creates an extremely tough environment for businesses to compete while facing unknown market conditions. **Methods:** A quantitative survey method was used to collect data through a questionnaire which assessed people view LNG project funding systems and their effects on infrastructure growth and export market competitiveness and energy availability. The study sample consisted of 215 people lived in different areas across the United States. Pearson's correlation analysis helped us identify the connection between our main independent variable and dependent variable through statistical evaluation. **Results:** The study identified three main financial obstacles which block LNG growth because of lacking financial transparency and foreign exchange control and restricted access to long-term financial resources. The developers identified terminal construction as their primary infrastructural benefit which they rated at 56.7%, followed by LNG storage space at 55.1%, and pipeline system development at 54.9%. The study found the highest correlation between LNG financing and risk control which achieved an r value of 0.634 and maintained statistical significance at $p = 0.01$. **Conclusion:** The strategic financing for LNG expansion serves as a fundamental element which supports LNG growth through infrastructure construction and enables export market success and strengthens national energy security.

Keywords

LNG Expansion, Infrastructure Development, Export Competitiveness, National Energy Security

1. Introduction

The modern global economy depends on energy as its essential power which drives economic expansion and industrial growth and international market success (Mujiyanto & Tiess, 2013). Liquefied Natural Gas (LNG) as a vital transition fuel because it produces less carbon pollution than coal and oil while maintaining strong energy performance and allowing for extended pipeline transportation (Schach & Madlener, 2018). The United States has developed into a top LNG producer and exporter throughout the past few decades which makes LNG a vital element of national energy strategy and worldwide energy distribution systems (Austvik, 2016). LNG infrastructure demands investors to provide major financial backing for building liquefaction terminals and regasification facilities and pipelines and storage facilities and transportation networks (Umbach, 2009). The investments need large financial resources because they continue for long

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periods while facing various market and financial and geopolitical risks. The financing strategy needs to become a main business component which supports LNG project development and their continuing operations (Yin & Lam, 2021).

The United States connects its LNG expansion to its national priorities which include infrastructure development and industrial power and energy security (Gritsenko, 2017). While, manufacturing sector along with electricity generation and petrochemical production and export-based businesses all depend on natural gas supply which remains both reliable and affordable (Gritsenko, 2017). The country receives economic advantages from LNG exports because these exports create better trade balance results and they increase Japan's power in worldwide energy markets (Wu, 2014). LNG market reacts to three main influences which include price fluctuations and supply chain interruptions and worldwide market needs that affect both American power costs and industrial operating expenses (Ruble, 2017). The export sector depends on two main factors which include stable energy prices and affordable power supply (Zeng et al., 2022). The availability of dependable LNG supply enables export-oriented businesses to prevent production stops while they achieve better capacity utilization and operational efficiency (Norouzi, 2021). The global market becomes less competitive because of two major problems which include expensive energy prices and unpredictable power availability (Tong et al., 2014).

The United States continues to face energy security as its most vital national policy issue. Energy system becomes more diverse through LNG which offers additional fuel sources and improves operational system flexibility (Kim, 2016). The system enables users to obtain power from various suppliers because it establishes multiple energy delivery choices which protect against power disruptions from outside forces (Len, 2015). The worldwide LNG market creates two major risks for the United States because international price changes and political conflicts affect their operations which requires energy policy to develop risk management systems and strategic planning for their management (Lacher & Kumetat, 2010). Therefore, this study aims to examine the role of strategic financing of LNG expansion in shaping infrastructure development, export competitiveness, and national energy security in the United States. The study analyzes survey-based evidence from relevant stakeholders to show financial strategies create effects on energy sector results. The study findings will help policymakers together with investors and industry leaders to develop better LNG production methods which protect the environment.

2. Materials and Methods

2.1 Study Design and Data Collection

A quantitative survey with a cross-sectional design to study Liquefied Natural Gas expansion receives strategic funding which helps build better infrastructure and improves export market access and protects the United States energy system. United States offers a suitable environment because its Liquefied Natural Gas industry connects directly to major terminal construction and pipeline systems and export operations and private investment and enduring supply contracts (Miller, 2020). Primary data were collected through a structured online questionnaire. The survey link reached professional email networks and energy-sector groups and industry associations and export-related communities and digital communication platforms which operated throughout the United States (Cardinale, 2023). The online survey method allowed researchers to gather answers from distant participants who possessed professional expertise about energy and industry and logistics and export operations and public policy and academic research. A total of 215 complete and usable responses were retained after screening for missing information and inconsistent answers.

2.2 Survey Instrument and Measurement

Their structured questionnaire by following the study objectives which they linked to established concepts about energy financing and Liquefied Natural Gas infrastructure and industrial productivity and export performance and national energy security in the United States. The document consisted of two main parts (Wang & Xue, 2017). The first section required participants to provide their personal details which included their age and gender and their educational background and their professional role and their total years of employment (Litvinenko, 2020). The second measured the core study constructs using a five-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree. The researchers organized the data into three groups which included Agree, Neutral, and Disagree for their descriptive analysis (Yao et al., 2017).

2.3 Statistical Analysis

We processed the gathered data through coding and cleaning before statistical software programs performed their analysis. Frequency and percentage analyses to display respondent demographics together with their perception patterns. Descriptive statistics established an organized summary which showed how stakeholders viewed strategic financing and their expected results from United States Liquefied Natural Gas expansion (Prontera & Plenta, 2019). Internal consistency of the measurement items was assessed using Cronbach's alpha coefficient (Odgaard & Delman, 2014). A value of 0.70 or above was considered acceptable, indicating adequate reliability of the survey instrument (Lin &

Reilly, 2023) . The study maintained respondent privacy through its decision to avoid collecting any personal data which could identify individual participants. Combined all answers into one set of data which they used to produce their academic report.

2.4 Correlation Analysis

Pearson correlation analysis established the strength and direction of relationships which exist between strategic financing and infrastructure development and export competitiveness and national energy security (Sovacool & Mukherjee, 2011). The study investigated how improved financial support for Liquefied Natural Gas expansion projects affected the development of infrastructure facilities together with export performance and national energy security levels in the United States (Kar et al., 2022). Pearson correlation coefficient through the following formula:

$$r = \frac{\sum(X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum(X - \bar{X})^2 \sum(Y - \bar{Y})^2}}$$

Correlation coefficient stands for r while the study variables X and Y show their linked observations and the respective means appear as $\bar{X}$. The coefficient shows values which start at −1 and go up to +1. A positive coefficient indicates a direct relationship, while a negative coefficient indicates an inverse relationship. Statistical significance was evaluated at the 5% level (Novikau, 2020).

3. Results

3.1 Demographic Profile of Respondents

Demographic composition of the 215 respondents. The sample was dominated by respondents aged 25–34 years (32.1%) and 35–44 years (28.8%), together representing 60.9% of the total sample as **Table 1.** Active professionals who understand energy systems and industrial operations and business matters participate strongly in this activity. Male respondents made up 60.0% of the sample while female respondents accounted for 40.0% which resulted in a gender distribution that was fairly equal. The respondents included 43.3% graduates and 30.2% postgraduates which established a group of respondents with strong educational backgrounds. The three largest occupational groups consisted of industry professionals at 20.5% and energy professionals at 18.1% and export/business stakeholders at 17.7%. The experience distribution showed that most employees worked between 6 and 10 years which accounted for 27.9% of the total work experience data. The group consists of experienced professionals who bring diverse professional backgrounds which makes them ideal for studying LNG financing and infrastructure development and export competitiveness and national energy security.

Table 1. *Demographic Profile of Respondents*

Variable	Category	Frequency	%
Age	<25	19	8.8
	25–34	69	32.1
	35–44	62	28.8
	45–54	43	20.0
	55+	22	10.2
Sex	Male	129	60.0
	Female	86	40.0
Education	Diploma	44	20.5
	Graduate	93	43.3
	Postgraduate	65	30.2
	Other	13	6.0
Occupation	Energy	39	18.1
	Industry	44	20.5
	Business	38	17.7
	Academic	32	14.9
	Government	28	13.0
	Logistics	20	9.3
	Other	14	6.5
Experience	<3 years	32	14.9
	3–5 years	49	22.8
	6–10 years	60	27.9
	11–15 years	43	20.0
	15+ years	31	14.4

3.2 Financing Factors for Liquefied Natural Gas Expansion

Respondents' perceptions regarding strategic financing factors for Liquefied Natural Gas expansion as **Table 2.** The study results show that financial transparency achieved the

highest agreement level at 63.4% because respondents believe LNG projects need strong accountability systems together with proper monitoring and clear financial governance structures. The public supports foreign exchange control at 59.8% and long-term funding at 58.6% which shows that people want stable currency risk management and continuous access to long-term funding for LNG development operations. The Public–Private Partnership model (52.1%) shows moderate agreement, reflecting acceptance of private sector involvement in large infrastructure financing. The agreement rate for soft loans reached its lowest point at 46.5% while the highest rate of disagreement reached 30.5% which shows people worry about loan repayment and their ability to maintain debt levels.

Table 2. *Financing Factors for Liquefied Natural Gas Expansion*

Financing Factor	Agree (%)	Neutral (%)	Disagree (%)
Long-term fund	58.6	22.8	18.6
PPP model	52.1	22.7	25.2
Soft loan	46.5	23.0	30.5
Transparency	63.4	22.8	13.8
FX control	59.8	23.1	17.1
Supply contract	55.2	22.4	22.4

LNG = Liquefied Natural Gas; PPP = Public–Private Partnership; FX = Foreign Exchange.

3.3 Infrastructure Development Effects

The public opinion about infrastructure advantages which result from expanding Liquefied Natural Gas operations across American territory as **Table 3.** Terminal development obtained the most substantial backing from 56.7% of respondents who also supported Liquefied Natural Gas storage capacity expansion at 55.1% and pipeline expansion at 54.9%. The survey results show that respondents believe energy systems need integrated facilities which combine terminals with storage and transmission operations to maintain their operational stability. Expansion projects received 53.4% positive support for employment generation which shows these initiatives will create construction work and permanent operational positions. The study shows that 50.8% of participants connect the growth of Liquefied Natural Gas to industrial expansion because manufacturing operations need steady access to fuel. The study showed port and logistics development received the lowest agreement rate of 47.6% while facing the highest disagreement rate of 31.9%. The study results indicate that energy infrastructure development needs to join its efforts with transport and port and supply-chain enhancement projects to create better overall development results.

Table 3. *Infrastructure Development Effects*

Infrastructure Factor	Agree (%)	Neutral (%)	Disagree (%)
LNG terminal	56.7	21.9	21.4
Pipeline	54.9	21.3	23.8
Port/logistics	47.6	20.5	31.9
Industry growth	50.8	19.7	29.5
Jobs	53.4	20.4	26.2
LNG storage	55.1	20.6	24.3

LNG = Liquefied Natural Gas.

3.4 Competitiveness Effects of Liquefied Natural Gas Expansion

Liquefied Natural Gas expansion affects United States export competitiveness as shown **Figure 1.** The complete majority of respondents (64.3%) selected cost risk as their top concern because they believe industrial production expenses depend on LNG price trends and available supply levels. Production operations need continuous gas supply because 60.5% of respondents agree that reliable gas availability leads to reduced production interruptions. Agreement about productivity reached its highest point at 57.8% while 55.6% of respondents supported capacity utilization. The delivery reliability percentage reached 52.4% stable energy supply enables companies to fulfill their export delivery timelines. Lowest agreement rate for product quality stood at 48.1% while the highest disagreement rate reached 31.4%. The data suggests that energy availability does not guarantee better product quality.

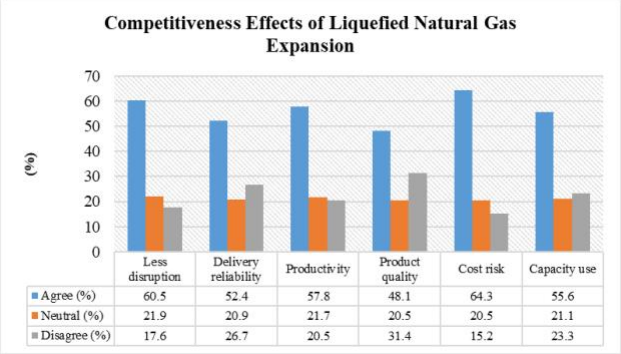

Figure 1. *Competitiveness Effects of Liquefied Natural Gas Expansion*

3.5 National Energy Security Effects of Liquefied Natural Gas Expansion

The graphical presentation in **Figure 2** displays respondents view the growth of Liquefied Natural Gas facilities and their impact on national energy stability. Renewable energy mix received the highest agreement from 66.1% of respondents who want LNG expansion to work together with renewable energy systems. The research showed that 65.8% of people agreed about import risk which demonstrates their concern about foreign LNG imports and their fear about international market price instability. Data shows that 61.9% of participants agreed with energy diversification because LNG operations help people reduce their dependency on various fuel types. The study found that 58.2% of participants agreed with supply reliability yet 56.4% supported gas-shortage reduction measures. Liquefied Natural Gas received lower agreement levels at 54.7% but the disagreement rate reached 25.3% which shows that storage facilities and reserve areas need to become more powerful.

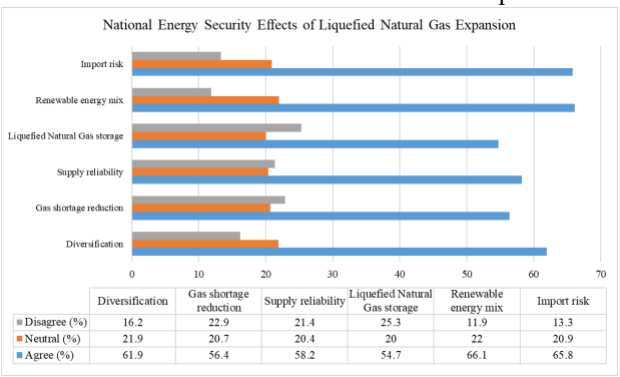

Figure 2. *National Energy Security Effects of Liquefied Natural Gas Expansion*

3.6 Pearson Correlation Matrix

Correlation matrix shows that Liquefied Natural Gas finance together with infrastructure development and export competitiveness and energy security and risk control maintain strong positive connections throughout the United States. Data reveals a strong connection between LNG finance and risk control through a correlation value of 0.634 which shows that better financial systems lead to superior risk management procedures according to **Figure 3.** The data reveals a strong connection between LNG finance and two variables which are infrastructure development and energy security through correlation values of 0.586 and 0.552 respectively. The data shows that strategic financial management activities work to improve physical infrastructure development which maintains reliable energy supply systems. Infrastructure development maintains positive connections with risk control through a correlation value of 0.529 and with energy security through a correlation value of 0.518 which demonstrates how energy systems operate through their mutual connections.

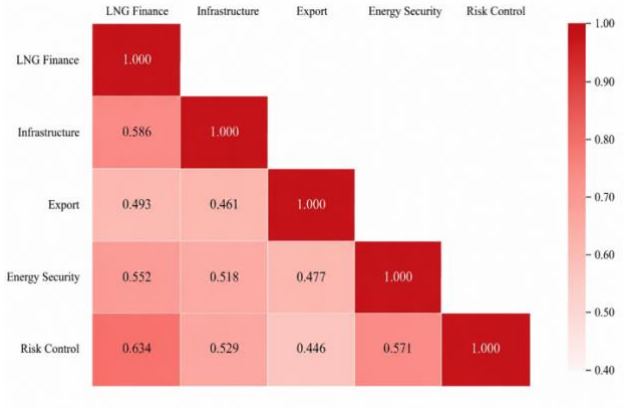

Figure 3. *Pearson Correlation Matrix*

4. Discussion

The study proves that strategic financing functions as a vital factor which enables LNG growth and infrastructure building and export market access and national energy protection. Financial transparency agreement of 63.4% shows that stakeholders strongly support open governance systems which maintain accountability through strong monitoring systems for their LNG project backing. The open financial systems which show investor risk levels create better investor trust because they handle capital-intensive LNG infrastructure projects (Bridge & Bradshaw, 2017). The foreign exchange control system receives strong public support at 59.8% and the long-term funding program receives 58.6% support because financial stability with ongoing capital access remains essential for LNG project success and their permanent sustainability. Infrastructure shows that LNG facility expansion functions as an essential strategic element (Siddi, 2017). Terminal development received the highest level of agreement (56.7%), followed by LNG storage capacity

(55.1%) and pipeline expansion (54.9%). The research findings show that survey participants identify infrastructure as the fundamental structure which supports an effective LNG distribution network. The energy distribution system requires proper terminal facilities together with storage areas and transmission networks to maintain continuous service while preparing for upcoming LNG market expansion (Dyduch & Skorek, 2020). The public supports LNG infrastructure development because they understand it will create new jobs and expand industrial operations which they see as a complete economic development plan. The public supports LNG infrastructure projects because they generate employment opportunities and industrial expansion which they view as a complete economic growth plan (Campos et al., 2016).

The study about export competitiveness shows that survey participants believe LNG expansion will create a major impact on industrial and trade sector growth (Liu & Dunford, 2016). The highest level of agreement emerged for cost-risk reduction at 64.3% because people see stable LNG supply as vital to control production expenses and achieve improved market competition. Reliable energy supply at 60.5% and 57.8% respectively helps industries reduce their production downtime while boosting their operational performance. The research shows that LNG infrastructure supports export-based businesses because it provides stable power delivery which enables better manufacturing operations and creates more competitive products for global markets (Safari et al., 2019). The study shows that product quality received the least agreement at 48.1% but respondents still recognized LNG expansion would boost business results and international market reach. The data shows that most people support LNG expansion because it provides them with better energy security. People support LNG for its ability to work with renewable energy sources during its highest point of approval at 66.1% although they do not want it to become their only energy source. The research reveals that people now understand LNG functions as a backup power source which supports renewable energy systems because it delivers dependable and adaptable power generation (Belaïd et al., 2023).

The study shows that 65.8% of participants agreed on import-risk management and 61.9% supported energy diversification because they view LNG expansion as an effective method to protect against outside energy disruptions while building sustainable power system security. Feedback showed that 58.2% of people believed in supply reliability and 56.4% supported gas-shortage reduction which demonstrates their belief in LNG operations to establish stable and secure national energy systems. The research team proved their observations through correlation analysis which showed all major study variables had significant positive relationships between them (Szabo & Fabok, 2020). Data shows that better financing methods help businesses reduce their operational and investment risks because they maintain the highest correlation rate of 0.634 with risk management systems. The data shows that financial investment leads to two main results which involve building physical infrastructure and reaching strategic energy targets (Yang et al., 2023). The data shows that all three infrastructure development and export competitiveness and energy security dimensions maintain strong positive relationships with each other.

5. Conclusion

This study shows that Liquefied Natural Gas expansion needs strategic financing to achieve better infrastructure development and enhanced export competitiveness and national energy security for the United States. LNG investment success will emerge from four essential elements which include transparent financial operations and stable long-term funding and foreign-exchange control and dependable supply agreements. The combination of LNG terminals with storage facilities and pipeline networks will boost energy access while supporting industrial growth and generating new employment possibilities. The export-driven industries will achieve better operational stability through reliable LNG delivery which simultaneously boosts their output performance and maximizes their production capabilities.

Author Contributions

R.T. written whole manuscript.

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