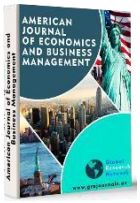

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Article

Economic Impact of LNG Export Infrastructure on Employment, GDP Growth, and Strategic Energy Security

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Abstract: Liquefied Natural Gas export facility has become one of the factors contributing to economic growth through job creation, business expansion, investment security, and energy security. Investments in LNG facilities, there is very little empirical data regarding stakeholders' perception of the impact of such facilities on economic development. A quantitative cross-sectional study was done via an online survey of 155 practitioners in the USA. Data were gathered through a questionnaire that used a five-point Likert scale. The study employed IBM SPSS Statistics version 27 for statistical analysis. It can be noted that respondents viewed LNG export infrastructure development as an important aspect for economic development. The highest means was obtained in the case of Strategic Energy Security (4.27 ± 0.55), followed by GDP Growth (4.18 ± 0.58) and Investment Confidence (4.15 ± 0.59). Over 83% of the respondents indicated that LNG infrastructure development contributes to the development of strategic energy security, while over 80% of respondents believed in the importance of the development of infrastructure for GDP growth. High costs of infrastructure development (22.6%) and environmental and regulatory issues (19.4%) were identified as the major problems in the area. Pearson correlation coefficient showed the presence of positive and significant relationships between all of the studied variables, where the highest was obtained between LNG Export Infrastructure and Strategic Energy Security (r = 0.756). The results of the study show that LNG export infrastructure development is viewed as an important factor of economic development and long-term energy security.

Keywords: LNG Export Infrastructure, Employment Growth, Gross Domestic Product, Strategic Energy Security, Economic Development

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1. Introduction

Export Infrastructure for Liquefied Natural Gas (LNG) has become an indispensable component of the contemporary energy economy, serving an important function in improving energy supply chains, fostering productivity in industries, and ensuring sustainable economic development [1]. With continuing increase in global energy demands and the search for alternatives to traditional fossil fuels, LNG has become an important transitional fuel, owing to its comparatively lower carbon emissions, flexibility, and increasing market demands in international markets [2]. Due to these reasons, investments in liquefaction, storage, pipeline networks, and export terminals have increased greatly across the globe, thus leading to an increase in the importance of LNG infrastructure as an important factor for economic development [3]. Apart from facilitating energy markets, LNG export infrastructure also serves the purpose of employment generation, industry growth, attracting foreign investments, and

national competitiveness, thereby becoming an important area of study in energy economics and public policies [4].

There has been an increasing number of studies that emphasize the positive effect of energy infrastructure investments on the macroeconomic outcomes. Earlier studies have found that investments in major LNG infrastructure contribute to economic growth through capital investments, increased production in the industry, development of technology, and creation of new business opportunities in various industries [5]. Also, export activities in LNG create significant numbers of direct, indirect, and induced jobs as well as drive innovations in the energy supply chain [6]. The role of LNG infrastructure in enhancing energy security strategy has been highlighted as well due to diversified energy sources, improved supply reliability, and decreased risks of geopolitical disruptions and market volatility [7]. However, there have been some issues that have been pointed out in earlier studies including expensive development of infrastructure, regulations, environmental standards, financing difficulties, and volatility of global energy market [8].

However, despite the rising body of academic literature concerning LNG infrastructure, some issues still require attention. The majority of the existing works have focused on macroeconomic models, international trade, engineering performance, or environmental issues, but less research has been conducted concerning the perceptions of stakeholders of the wider economic implications of the development of LNG export infrastructure [9]. Furthermore, there has not been much empirical research conducted in relation to all five aspects (employment, GDP growth, energy security, confidence in investment, and industrial development) together [10]. It is very useful to study professional perceptions since professionals have a practical understanding of how the economy functions and thus can supplement conventional economic measures and shed light on how these dimensions are interlinked [11].

Considering the above context, the current study attempts to assess the economic implications of LNG export infrastructure through a survey conducted among 155 professionals in the United States. The economic implications to be assessed are related to the perceptions of employment creation, GDP growth, strategic energy security, investment confidence, and industrial growth and their correlations. By providing empirical evidence based on the perceptions of professionals in the energy sector, the current research would add to the growing literature on energy infrastructure and economic development. The results of this study are expected to help the policymakers, investors, and energy planners to devise strategies that would maximize the economic gains from the LNG export infrastructure, ensure strategic energy security, and foster sustainable economic growth.

2. Materials and Method

2.1 Research Design and Data Collection

The research used a quantitative and cross-sectional survey design to investigate the effects of LNG export infrastructure perceived by respondents in terms of employment creation, GDP growth, strategic energy security, investor confidence, and industrialization. A well-designed questionnaire was formulated after conducting extensive literature review in energy economics, infrastructure investments, and strategic energy policies [12]. The questionnaire had two parts; the first part involved demographic characteristics and the second part involved perceptions of statements measured on a five-point Likert scale with 1 = Strongly Disagree to 5 = Strongly Agree [13]. The research was conducted in the United States where the primary data was collected via an online survey through emails and LinkedIn. After data screening, 155 usable responses remained.

2.3 Study Variables

The conceptual framework used for the research involved an independent variable and five dependent variables. LNG Export Infrastructure was taken as the independent variable, indicating perceptions regarding development and expansion of infrastructure [14]. Employment Growth, GDP Growth, Strategic Energy Security, Investment Confidence, and Industrial Development constituted the dependent variables [15], [16]. These five variables are considered as the major economic consequences of the development of LNG export infrastructure [17]. Each variable was assessed using a series of statements that were rated on a five-point Likert scale. Higher rating indicated greater agreement to the positive economic impact of LNG export infrastructure. These variables were chosen based on existing literature in energy economics and infrastructure development [18].

2.4 Statistical Analysis

The collected data were subjected to statistical analysis via the use of IBM SPSS Statistics v27. Descriptive statistics such as frequency, percentage, mean, standard deviation, minimum, maximum, skewness, and kurtosis were applied to describe the demographic variables as well as the variables of this study [19], [20]. Normality of data was established through skewness and kurtosis for the appropriateness of parametric analysis [21]. Relationship between the variables of this study was determined using Pearson Correlation Coefficient with the formula below:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\left[\sum_{i=1}^{n}(X_i - \bar{X})^2\right]\left[\sum_{i=1}^{n}(Y_i - \bar{Y})^2\right]}}$$

Where r represents the Pearson correlation coefficient, X and Y denote the paired study variables, $\bar{X}$ and $\bar{Y}$ represent their respective means, and n is the total number of observations. Correlation coefficients were interpreted to determine the direction and strength of relationships among the variables. Statistical significance was assessed at $p < 0.05$, ensuring that the findings were statistically reliable and appropriate for evaluating the economic implications of LNG export infrastructure [22].

3. Results

3.1 Demographic Characteristics of Respondents

The demographics of the 155 respondents as illustrates in **Table 1**. It can be noted that most of them were males (65.8%), whereas the share of female respondents was at 34.2%. Respondents of the age between 35 and 44 were the most numerous (36.8%), whereas 27.1% belonged to the age range of 45-54 years, meaning that most of the participants had relevant industry experience at a mid-level career position. Regarding education level, the highest share of participants (49.0%) had master's degrees, followed by those who possessed doctoral degrees (24.5%). It means that the sample included highly educated individuals, who could share an opinion regarding the economic aspects of LNG exports and related infrastructure development. As for job status, most of the participants (34.8%) were working for a private industry and/or energy and utilities sector (29.7%). Moreover, the vast majority of them had work experience of 6-10 years (30.3%) and 11-15 years (29.0%).

Table 1. Demographic Characteristics of Respondents

Characteristics	Category	Frequency	Percentage (%)
Gender	Male	102	65.8
	Female	53	34.2
Age (years)	25–34	29	18.7
	35–44	57	36.8

	45–54	42	27.1
	≥55	27	17.4
Education	Bachelor's	41	26.5
	Master's	76	49.0
	PhD	38	24.5
Employment Sector	Energy & Utilities	46	29.7
	Government	33	21.3
	Private Industry	54	34.8
	Research/Academia	22	14.2
Professional Experience	1–5 Years	24	15.5
	6–10 Years	47	30.3
	11–15 Years	45	29.0
	>15 Years	39	25.2

3.2 Descriptive Statistics of Study Variables

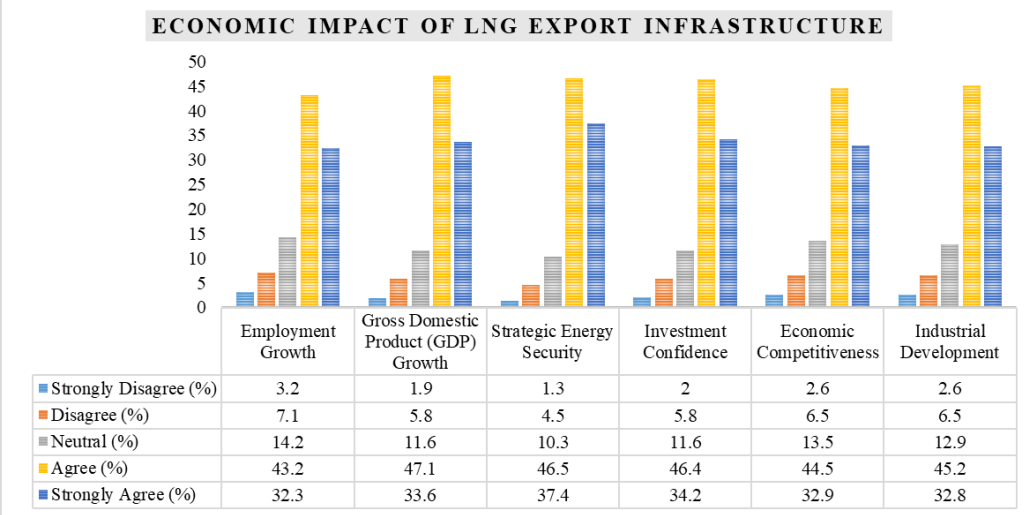
The descriptive statistics for the research variables as presented in **Table 2.** The respondents showed very high levels of agreement on the positive impact of LNG export infrastructure on the economy, with all means being above 4.00. The variable Strategic Energy Security showed the highest mean of 4.27 and standard deviation of 0.55, implying that respondents considered it as the most important impact of LNG export infrastructure. This was followed by GDP Growth with mean and standard deviation of 4.18 and 0.58 respectively and then Investment Confidence with mean of 4.15 and standard deviation of 0.59. Relatively small standard deviation values, ranging between 0.55 and 0.69, imply a high degree of agreement on the part of the respondents. Moreover, the variables had negative skewness and kurtosis values, which were within acceptable range and therefore indicative of normally distributed data.

Table 2. Descriptive Statistics of Study Variables

Variable	Mean	SD	Min	Max	Skewness	Kurtosis
LNG Export Infrastructure	4.12	0.63	2.10	5.00	-0.54	0.38
Employment Growth	4.05	0.69	2.00	5.00	-0.48	0.21
GDP Growth	4.18	0.58	2.40	5.00	-0.61	0.46
Strategic Energy Security	4.27	0.55	2.60	5.00	-0.66	0.57
Economic Competitiveness	4.09	0.61	2.20	5.00	-0.45	0.29
Investment Confidence	4.15	0.59	2.30	5.00	-0.58	0.42
Industrial Development	4.08	0.64	2.10	5.00	-0.51	0.35

3.3 Perceptions of the Economic Impact of LNG Export Infrastructure

The respondents perceived the economic benefits of LNG export infrastructure in terms of six major aspects as shows in **Figure 1.** From the results, it is clear that there is a very positive perception towards the economic benefits of the project, where the majority of the respondents agree and strongly agree on all indicators. Strategic Energy Security was seen to be the aspect which had been given the most support, whereby 46.5% agreed and 37.4% strongly agreed with the statement, meaning that the aspect is seen to be the most important economic benefit of LNG export infrastructure. Similarly, GDP Growth received a lot of positive responses from 47.1% who agreed and 33.6% who strongly agreed with the statement.



	Employment Growth	Gross Domestic Product (GDP) Growth	Strategic Energy Security	Investment Confidence	Economic Competitiveness	Industrial Development
Strongly Disagree (%)	3.2	1.9	1.3	2	2.6	2.6
Disagree (%)	7.1	5.8	4.5	5.8	6.5	6.5
Neutral (%)	14.2	11.6	10.3	11.6	13.5	12.9
Agree (%)	43.2	47.1	46.5	46.4	44.5	45.2
Strongly Agree (%)	32.3	33.6	37.4	34.2	32.9	32.8

Figure 1. Perceptions of the Economic Impact of LNG Export Infrastructure

3.4 Perceived Benefits of LNG Export Infrastructure

The perceived benefits of the LNG export infrastructure as seen by the respondents as presented in **Figure 2.** Strategic Energy Security was the most significant benefit cited by 22.0% of the respondents, underscoring the importance of LNG infrastructure in providing secure energy supply. GDP Growth was the second most significant with 18.5% due to the high level of optimism about its ability to contribute to economic growth in the country. Employment Growth was rated as 17.2%, revealing the potential for employment generation through LNG projects. Investment Confidence comprised 15.8%, Industrial Development, 14.0%, and Economic Competitiveness, 12.5%. In general, it can be observed that the respondents view LNG export infrastructure as an important contributor to sustainable economic development, with strategic energy security and economic growth being the most significant benefits of this infrastructure.

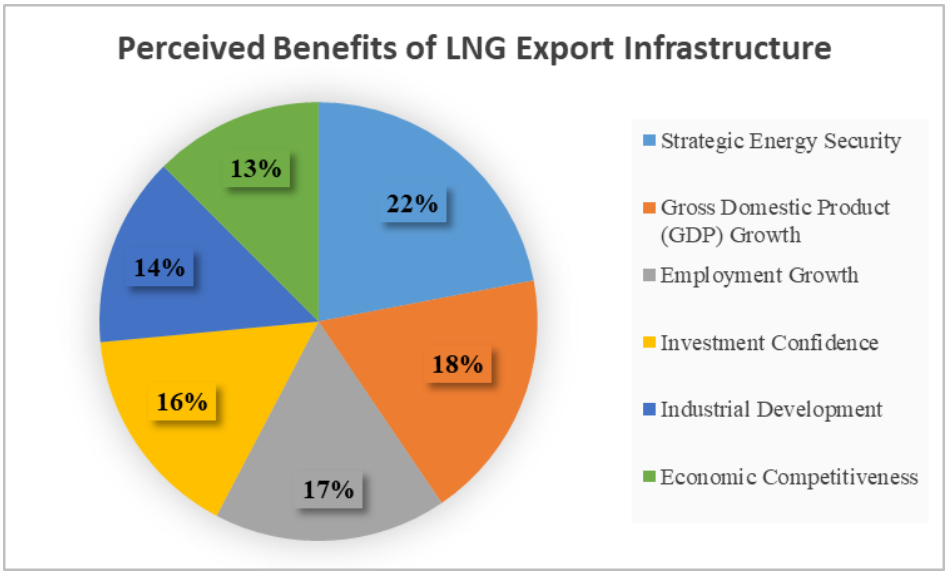


Figure 2. Perceived Benefits of LNG Export Infrastructure

3.5 Major Challenges to LNG Export Infrastructure Development

The primary issues associated with the development of infrastructure for LNG export according to the survey participants as reveals **Figure 3.** High Infrastructure Development Costs turned out to be the most serious issue, making up 22.6% of all answers, showing concerns about the huge investments needed for LNG infrastructure and facilities construction. Environmental and Regulatory Compliance became the

second in terms of percentage, accounting for 19.4%. Market Price Volatility became the third one with 17.4%, pointing to market price changes and uncertainties. Supply Chain and Logistics Constraints came fourth with 15.5%, while Financing and Investment Risks – fifth with 13.5%. Geopolitical and Trade Uncertainty was mentioned by 11.6% of the survey participants. Generally speaking, it can be stated that despite the significant economic advantages of LNG export infrastructure, solving a number of financial, regulatory, and market issues becomes crucial for sustainable development of the latter.

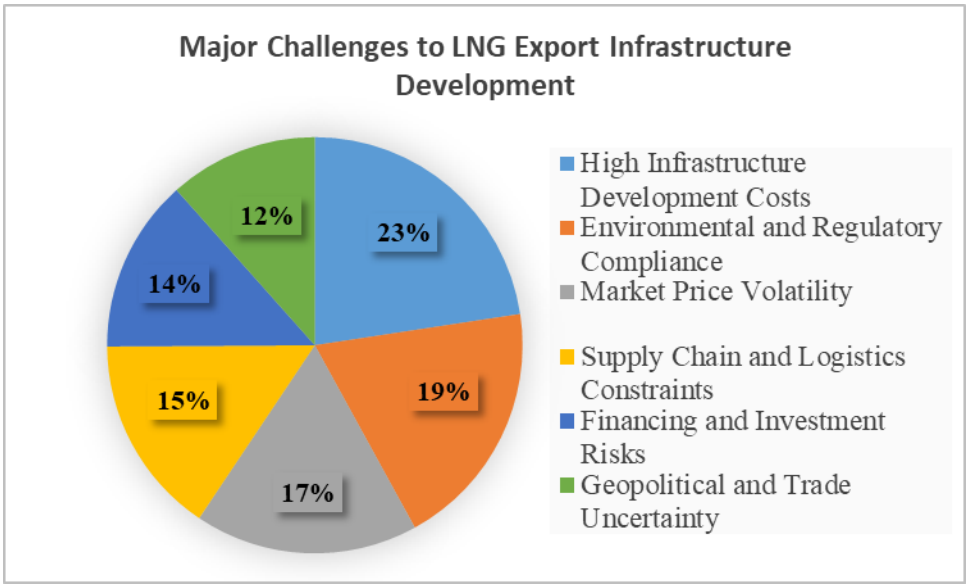


Figure 3. Major Challenges to LNG Export Infrastructure Development

3.6 Pearson Correlation Matrix of the Study Variables

Correlation matrix of the variables under study using Pearson's correlation as presented in **Table 3.** According to the results, there are positive correlations among all the variables indicating that improvement of LNG export infrastructure is positively correlated with economic benefits. In particular, the highest correlation coefficient of 0.756 was registered between LNG Export Infrastructure and Strategic Energy Security, and that of 0.731 between the former and Gross Domestic Product Growth. Additionally, Employment Growth was found to be positively correlated with LNG export infrastructure at a correlation coefficient of 0.684 while that of Investment Confidence and Industrial Development stood at 0.642 and 0.617, respectively. The dependent variables also had positive correlations among each other varying between 0.581 and 0.712. Most importantly, none of the correlation coefficients exceeded 0.80 showing that multi-collinearity was not an issue.

Table 3. Pearson Correlation Matrix of the Study Variables

Variable	1	2	3	4	5	6
1. LNG Export Infrastructure	1					
2. Employment Growth	0.684	1				
3. Gross Domestic Product	0.731	0.668	1			
4. Strategic Energy Security	0.756	0.629	0.712	1		
5. Investment Confidence	0.642	0.581	0.653	0.691	1	
6. Industrial Development	0.617	0.645	0.676	0.624	0.659	1

4. Discussion

As seen from the results, the infrastructure for exporting liquefied natural gas is seen as a significant factor in the process of economic development mainly due to the role of the infrastructure in employment creation, economic growth and energy security [23].

It has been shown that the demographic characteristics of the respondents show that the majority of the respondents were professionals aged 35-44 years old (36.8%). Also, 49.0% of the respondents had the master's degree that proves that the opinion of the informed people was taken into account as they have sufficient experience and knowledge in the economic matters. Thus, the credibility of the results is supported by the fact that professionals can evaluate better the economic aspect of energy infrastructure [24]. The descriptive statistics showed the positive perception of LNG infrastructure in all the studied variables.These include Strategic Energy Security which scored the highest mean of 4.27. This means that the respondents believe that energy security is the most important consequence of the development of LNG infrastructure. Likewise, GDP Growth had a mean of 4.18 which shows that the respondents acknowledge the contribution of LNG exports towards GDP growth and industrial productivity. This study's findings are in line with other research that has indicated how the development of energy infrastructure results in an increase in the capacity of production, increase in business activities, and sustainable economic performance due to energy availability and modern infrastructure [25].

Moreover, respondents were in agreement with regard to the economic effects of LNG export infrastructure projects. Over 83.9% of the respondents agreed or strongly agreed that LNG infrastructure improves Strategic Energy Security, and over 80.7% of respondents held positive views about GDP Growth. This indicates that the respondents view LNG export infrastructures as strategic ventures that are able to contribute to economic performance and energy security [26]. Moreover, the advantages clearly show the significance of the strategic nature of LNG export infrastructure. Strategic Energy Security comprised 22.0% of all listed benefits, while GDP Growth comprised 18.5%. Such results show that respondents value a stable supply of energy as well as economic development when making their judgments about infrastructure projects [27]. They confirm the conclusions made by researchers according to which LNG infrastructure can boost market confidence, foster economic development and create investment opportunities due to provision of reliable and diverse sources of energy [28].

However, along with positive aspects, respondents mentioned some problems related to the implementation of such infrastructure. High Infrastructure Development Costs comprised 22.6% of all problems, while Environmental and Regulatory Compliance comprised 19.4%. Thus, it becomes clear that despite all economic opportunities that LNG infrastructure brings, the project implementation is possible only in case of proper financial planning and environmental management [29].It is important to overcome these issues to improve the feasibility of projects and ensure sustainable LNG export infrastructure. First of all, the Pearson correlation analysis showed that there were significant positive correlations among study variables [29]. The highest correlation was found between the variables LNG Export Infrastructure and Strategic Energy Security ($r = 0.756$) and GDP Growth ($r = 0.731$). Moreover, all correlations were lower than 0.80, which indicated the absence of multi-collinearity and, thus, the fact that study variables were different but correlated. It can be said that improvements in LNG export infrastructure are positively related to the economic situation, which increases the importance of further investments in this sphere and evidence-based policies on energy [30].

5. Conclusion

In this research, the positive contribution of LNG export infrastructure to employment creation, economic growth, energy security, and industrial development is demonstrated. It is shown that there are significant positive correlations between economic factors in this case, which shows the economic importance of investment in infrastructure. Of course, difficulties such as high development expenses still exist; however, it is possible to make long-term plans and apply certain policies for increasing

the positive effect of infrastructure. Overall, it is possible to conclude that the research provides useful data for making decisions.

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