

Liquefied Natural Gas Economic Impacts on Green Supply Chains: A Bibliometric Review of Energy Journals and Towards a Green Economy

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KEYWORDS

Bibliometric analysis,
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green supply chain,
LNG,
sustainable
development.

ABSTRACT

Liquefied natural gas (LNG) has emerged as a key transitional fuel supporting the global shift toward a low-carbon energy system. However, research on the economic role of LNG within green supply chains remains fragmented and lacks a coherent knowledge structure. This study aims to systematically map the intellectual landscape of LNG research and identify key economic and sustainability themes. Using a bibliometric analysis of 246 Scopus-indexed articles published between 1983 and 2025, the study applies keyword co-occurrence and co-authorship analyses to examine the evolution and structure of the field. The results identify six interconnected research clusters shaping contemporary LNG research: (i) economic feasibility and cost-effectiveness across energy supply chains; (ii) carbon emissions mitigation and decarbonisation, emphasizing CO₂ reduction and techno-economic evaluation; (iii) environmental impacts and sustainability assessment; (iv) energy efficiency and thermodynamic performance; (v) liquefaction process optimization and cold energy utilization; and (vi) infrastructure development and investment perspectives. Overall, the findings indicate that LNG research in energy journals is primarily driven by economic analysis. Environmental and technological dimensions act as complementary mechanisms. This study provides valuable insights for academics, practitioners, and policymakers by clarifying the economic role of LNG in supporting sustainable and resilient energy transition pathways. It also suggests future research directions for developing a sustainable and environmentally responsible LNG supply chain.

1. Introduction

The transition to a low-carbon green economy necessitates a delicate balance between carbon reduction and energy security (Ma & Arras, 2025). Within this context, Liquefied Natural Gas (LNG) emerges as a pivotal transitional fuel, often regarded as a crucial bridge from fossil fuel dependency to a renewable energy future due to its comparatively

lower carbon emissions (Al-Haidous & Al-Ansari, 2019). However, the full emission reduction potential of LNG is contingent upon an optimized supply chain. As Younes et al. (2025) emphasize, effective supply chain management is vital not only for facilitating the green energy transition but also for directly mitigating emissions from key logistics activities such as transportation, liquefaction, and regasification (Younes et al., 2025). Furthermore, analyses of the

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energy transition reveal that this process extends beyond carbon metrics; it is intrinsically linked to the efficiency of energy networks and influences broader economic factors like production capacity and resilience to global risks (Khurshid et al., 2025).

In recent years, research on LNG within supply chain management (SCM) has grown significantly. These studies cover diverse aspects such as logistics, maritime transport, infrastructure, cold chain management, and the role of LNG in green and sustainable supply chains. This expansion reflects the increasing interest in LNG amid the global energy transition (Mi et al., 2024). The research employs a variety of interdisciplinary approaches. Integrated fields include operations research, transport logistics theory, environmental and sustainability economics, as well as energy transition and policy studies (Adekoya et al., 2024; Fang et al., 2022). Methodologically, scholars utilize a range of tools such as optimization modeling, empirical analysis, simulation, case studies, and discrete literature reviews. However, the rapid growth of the field has also led to increasing knowledge fragmentation. Many studies focus on isolated and specialized topics, creating a pressing need for a synthesized analytical framework. Such a framework is essential to guide future research within the context of the transition to a green economy. Despite LNG being recognized as a crucial pillar of the energy transition, and SCM playing a key role in emission reduction, a significant research gap persists. To date, there is a lack of a systematic bibliometric review of LNG within the SCM context. Notably, no study has constructed a comprehensive knowledge map for this domain. The absence of such a map limits our ability to clarify the knowledge structure, identify key research themes, and understand scholarly networks. Consequently, the capacity to pinpoint promising research directions and forecast emerging trends in this field is significantly constrained.

Given the rapidly evolving and interdisciplinary nature of research on LNG in supply chain management (SCM), the LNG supply chain itself has garnered significant academic interest. This supply chain is inherently global and inter-regional, closely tied to cross-border trade flows. Furthermore, it is profoundly influenced by energy policies, environmental regulations, and fluctuations in the international market. Consequently, reviewing this field necessitates a globally scoped approach, one that transcends the boundaries of any single nation or region. In this context, bibliometric analysis emerges as a particularly suitable and essential methodology. It enables the synthesis and systematization of the vast body of international research on LNG. Specifically, bibliometric analysis provides the means to evaluate research performance based on journals, authors, and countries. Moreover, it facilitates the mapping of

knowledge through techniques such as co-authorship and co-keyword analysis. Thereby, this methodology helps to illuminate the underlying knowledge structure and dominant developmental trends within LNG research on its path toward a green economy transition. Specifically, this study aims to:

(1) To examine the evolution and publication patterns of LNG research in energy journals. The analysis focuses on its economic impacts and role in supporting green supply chains.

(2) To identify and map the major research themes and knowledge clusters. This will be achieved using bibliometric mapping and keyword co-occurrence analysis.

(3) To analyze the development trends of LNG research over time. The analysis will emphasize four key dimensions: economic performance, carbon management, energy efficiency, and sustainability within green supply chains.

(4) To suggest future research directions. These directions aim to enhance the economic viability, resilience, and environmental sustainability of LNG in the context of a green economy.

This study delivers significant contributions, both academic and practical, to the field of LNG in supply chain management. From an academic perspective, it provides a comprehensive knowledge map of the subject. This map clarifies the knowledge structure, identifies the main research clusters, and highlights the developmental trends within the field. From a practical standpoint, the findings offer actionable insights. They serve as a valuable reference for policymakers, logistics and energy enterprises, and other relevant stakeholders. This information aids in formulating strategies for developing sustainable LNG supply chains.

2. Research methodology

2.1. Theoretical Basis of LNG

From a theoretical perspective, the role of LNG in green supply chains can be explained through the sustainable supply chain management (SSCM) framework, which emphasizes the integration of economic efficiency, environmental sustainability, and operational resilience across supply networks (Seuring & Müller, 2008). Within the broader context of energy transition theory, LNG is widely recognized as a transitional fuel that bridges conventional fossil fuel systems and renewable energy infrastructures (Sovacool, 2016). These perspectives highlight that LNG contributes not only to energy security but also to the gradual decarbonization of energy logistics systems.

Research on LNG is increasingly expanding within the fields of energy and supply chain management, reflecting its growing significance for both energy

security and sustainability. The LNG supply chain is inherently global and complex, encompassing a series of activities from extraction to final consumption, involving numerous transnational stakeholders (Al-haidous & Al-ansari, 2020; Unruh, 2000). Key factors such as long-distance maritime transport, intricate logistics, and market volatility are central to this complexity, ultimately shaping the development and efficiency of the entire system (Aczel, 2022; Yu et al., 2025).

As a cleaner fossil fuel, LNG plays a pivotal role in the global energy transition. It helps reduce greenhouse gas emissions while ensuring a stable and secure energy supply (Vuskovic et al., 2023). Consequently, LNG is frequently termed a "transition fuel," facilitating the shift towards low-carbon energy systems (Basak et al., 2019).

Within supply chain management (SCM), LNG is no longer viewed merely as a tradable commodity. Instead, it has evolved into a strategic element that actively transforms supply chains. Its application in maritime shipping, freight transport, and heavy industry enables operations with lower carbon emissions, facilitates compliance with environmental regulations, and supports the transition to more sustainable supply chains (Al-haidous & Al-ansari, 2020; Aseel et al., 2021). By influencing logistics design, energy sourcing, and emission profiles, LNG significantly contributes to the green economic transformation. Therefore, contemporary SCM research focuses less on merely managing LNG flows and more on its critical role in driving decarbonization (Wood, 2024). LNG enhances sustainability, fosters resilient low-carbon economic systems, and strongly aligns with the green economy transition (Qi et al., 2025).

Despite the growing body of research on LNG, knowledge within SCM remains fragmented. Studies often concentrate on isolated mechanisms or specific industry contexts, lacking an integrated view of the overall knowledge structure. To address this gap, this study applies a bibliometric analysis to systematically map the literature on LNG's role in SCM. The research aims to identify key research domains and analyze temporal trends. Ultimately, this work seeks to clarify LNG's function as a catalyst for green transformation, both at the supply chain level and within the broader context of a net-zero economy.

2.2. Research methods

Bibliometric analysis is a widely used method for examining the development, structure, and dynamics of scientific knowledge in a research field (Donthu et al., 2021). This method operates on the premise that scientific findings are interconnected over time, with new studies building upon earlier work (Donthu et al., 2021). Consequently, bibliometric tools can uncover patterns, trends, and underlying knowledge structures that are difficult to detect systematically using

traditional review methods. According to Van Eck and Waltman (2019), there are five primary bibliometric techniques: bibliographic coupling, citation analysis, co-citation analysis, co-word analysis, and co-author analysis (Van Eck & Waltman, 2010). For this study, co-author and co-word analyses were selected to clarify the knowledge structure and thematic evolution of the research area.

Co-word analysis focuses on the co-occurrence of keywords, allowing for the exploration of conceptual networks and shifts in research directions over time (Ding et al., 2001). Co-author analysis examines the co-occurrence of authors in scientific publications. This technique reveals scholarly collaboration networks, identifies research groups, and locates knowledge centers within a field (Zupic & Čater, 2015). In this study, co-author analysis included authors with a minimum of three publications and at least one citation. Co-occurrence keyword analysis was performed for keywords appearing at least five times.

3. Results and discussion

3.1. Description of retrieved documents

As reported in Table 1, the dataset comprises 246 LNG-related documents indexed in Scopus and published between 1983 and 2025. These publications are drawn from 108 sources and contributed by 882 authors, highlighting the multidisciplinary nature of LNG research. The literature exhibits a steady growth trend, with an annual growth rate of 9.6%. Collaborative research dominates the field, as reflected by an average of 4.14 co-authors per document, while single-authored papers account for only 19 documents. International co-authorship represents 19.92% of the sample, indicating a moderate level of cross-country collaboration. The corpus shows a moderate scholarly impact, with an average of 14.41 citations per document. The average document age is 7.15 years, suggesting a relatively recent and evolving research domain.

Table 1. Data description

Description	Results
Main information about data	
Timespan	1983:2025
Sources (Journals, Books, etc)	108
Documents	246
Annual Growth Rate %	9.6
Document Average Age	7.15
Average citations per doc	14.41
Keywords Plus (ID)	2363
Author's Keywords (DE)	706

3.2. Document sources

In research on liquefied natural gas (LNG) and its economic efficiency within supply chains, the literature is predominantly published in energy-focused journals. A small group of leading journals has played a central role in shaping the academic foundation of this field. These journals primarily focus on studies addressing cost efficiency, energy performance, and green logistics within the green economic transition. Energy leads with 25 publications, followed by Energy Conversion and Management (12 articles) and Energies (9 articles). Additional contributions are found in Applied Thermal Engineering (8 articles) and Applied Energy (5 articles).

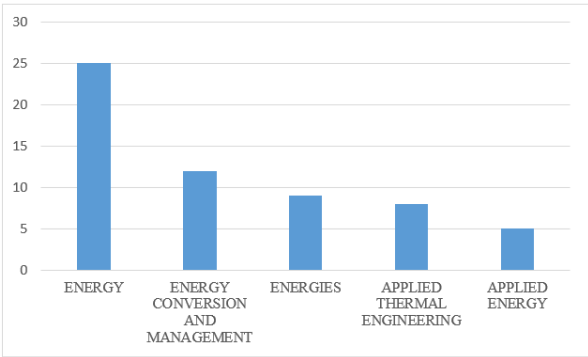


Figure 1. Energy-Related Publication Sources in LNG and Green Supply Chain Research

3.3. Development of the topic by year

From 1983 to 2017, publications on liquefied natural gas (LNG) related to economic impacts, green logistics, and supply chain management remained largely negligible in major energy journals. A clear upward trend emerged after 2018. This marked a turning point in scholarly attention to LNG within the context of the green economic transition. Notably, the journal Energy exhibits the most pronounced growth. Its publication count increased from just 2 articles in 2018 to 25 by 2025. This trend underscores the journal's central role in advancing research on the economic efficiency of LNG-enabled supply chains. Other journals, including Energy Conversion and Management, Applied Thermal Engineering, and Applied Energy, also demonstrate steady growth during this period. Their contributions reflect a sustained interest in operational efficiency and energy performance. Furthermore, the Journal of Cleaner Production began contributing to this research stream in 2020. By 2025, it had reached five publications. This indicates a growing emphasis on sustainability and environmental performance within LNG supply chain research.

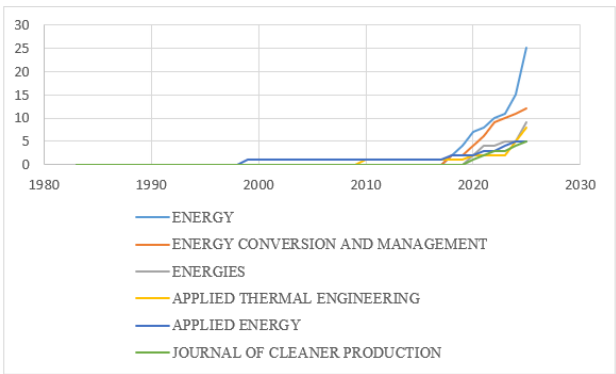


Figure 2. Trends in Publications from Energy-Related Sources Over Time

3.4. Geographical Distribution of Research Topics

Research on liquefied natural gas (LNG) and its economic impacts in green supply chains has gained increasing global attention. The international collaboration network reveals a well-connected global research landscape, with China (135 publications), the United States (52 publications), and South Korea (49 publications) emerging as the most prolific contributors and central hubs of scholarly activity. Other active countries, including Japan, Indonesia, Saudi Arabia, Turkey, the United Kingdom, Italy, and Iran, further reflect the broad international engagement in this research field. Overall, this geographical distribution highlights the global and interdisciplinary nature of LNG-related research. It also underscores its relevance to both developed and emerging economies within the context of the green economic transition.

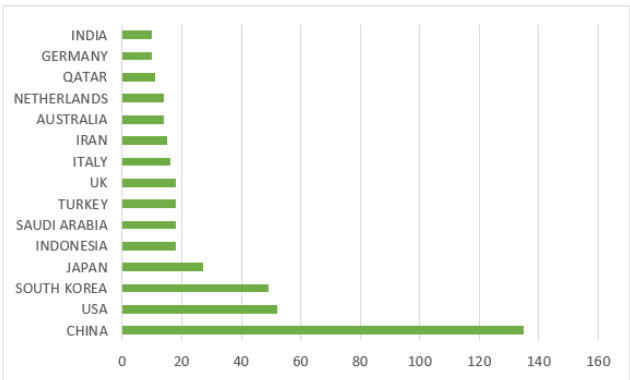


Figure 3. Geographical Distribution of Publications

Based on the international collaboration network Figure 4, China exhibits the highest level of cooperation among the 48 countries analyzed. It has 17 partner countries and 27 collaborative links. The United States, Japan, South Korea, Germany, and the United Kingdom also emerge as key cooperation hubs. These countries

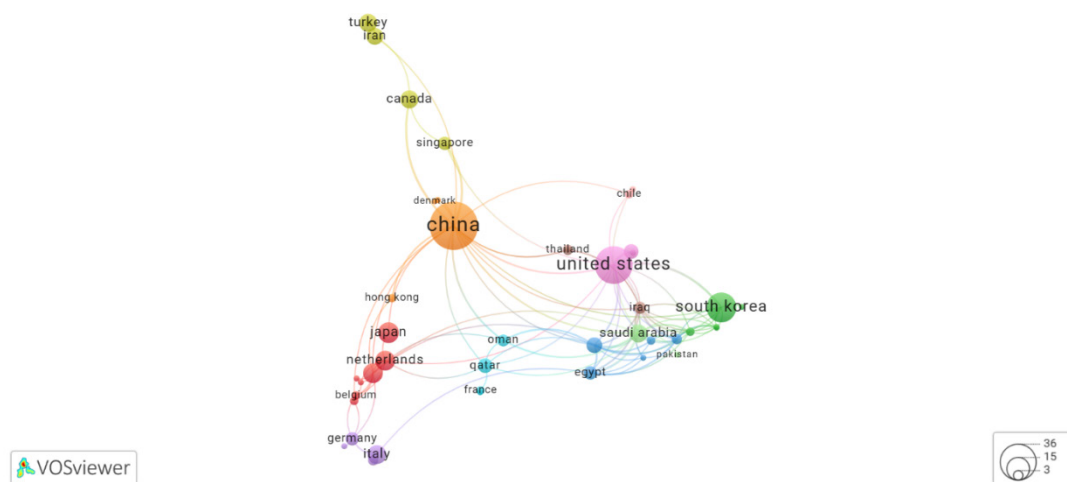


Figure 4. Network of Contributing Countries and Regions in LNG Research

demonstrate dense and well-connected networks. Overall, international collaboration in LNG and green supply chain research is mainly concentrated among developed economies and leading Asian countries. This pattern highlights the increasingly central role of the Asia-Pacific region in this research field.

3.5. Leading Authors and Organizations

The bibliometric analysis identifies the leading authors and organizations contributing to research on LNG and its economic impacts in green supply chains. Among the most prolific authors, Wang Z and Zhang J lead with seven publications each, followed by Kim J and Li Y with six publications. Other influential contributors include Zhang H, Ergin S, Faaij A, and Ju Y, each with four to five publications. This reflects a diverse and internationally engaged research community.

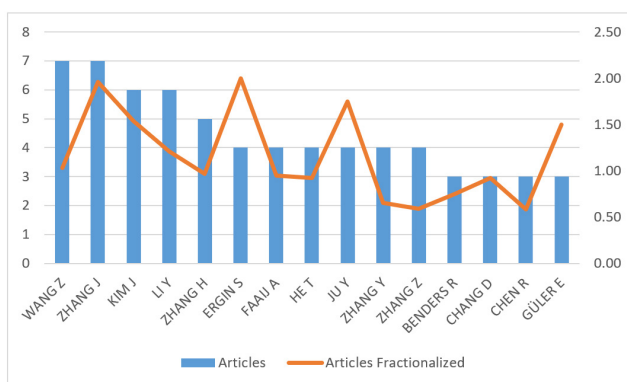


Figure 5. Publication Performance of the Most Prolific Authors

Regarding institutional productivity, the largest

share of publications is linked to records lacking standardized institutional affiliations. This may reflect variations in reporting practices across different journals and databases. Among the clearly identified institutions, Shanghai Jiao Tong University ranks first with nine publications. It is followed by Universitas Indonesia (6 publications), Rijksuniversiteit Groningen (5), The University of Queensland (5), and Universitas Gadjah Mada (5). Additional contributions come from institutions such as the China University of Petroleum (both East China and Beijing campuses), Imperial College London, and King Khalid University. These leading institutions underscore the geographically diverse and multidisciplinary nature of LNG-related research within energy-focused journals.

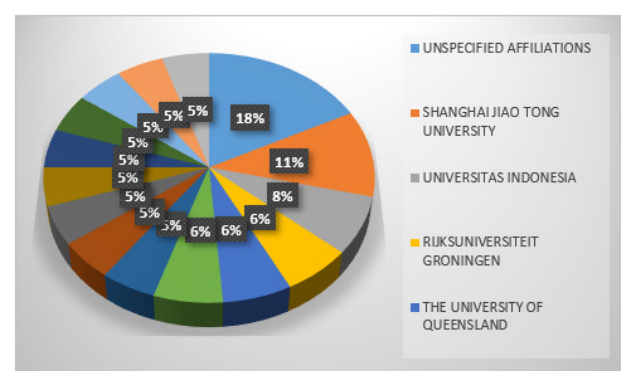


Figure 6. Percentage of Publications by Leading Organizations

The research collaboration network (Figure 7) shows cooperative relationships among scholars studying LNG and its economic impacts in green supply chains. Generated using VOSviewer, the network consists of 22 items grouped into three clusters, with a

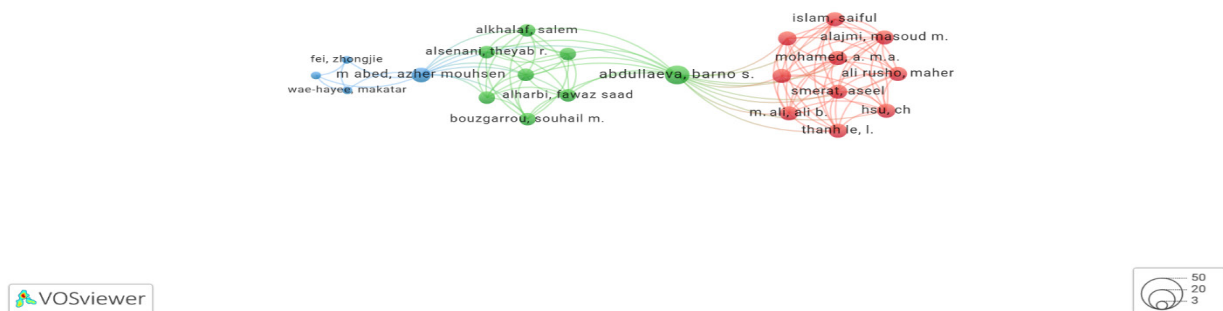


Figure 7. Key Authors Identified in the Bibliometric Analysis

total of 97 collaborative links. This structure indicates a moderate level of research connectivity. It highlights the presence of several closely linked author groups that collectively shape the intellectual landscape of LNG-related research in energy-focused journals.

3.6. Co-occurrence Analysis of Keywords

Based on the VOSviewer co-occurrence analysis shown in Figure 8, the knowledge structure related to LNG in green supply chains is clearly delineated. In addition, the analysis identifies the key research directions concerning the economic impacts of LNG within sustainable and green supply chain contexts. The keyword “liquefied natural gas” occupies a central position in the network, with 198 occurrences and 1,780 links, highlighting its pivotal role in studies on clean energy, carbon emissions, and supply chain efficiency. “Energy efficiency”, appearing 40 times with a total link strength of 501, indicates a strong association between LNG and sustainable energy performance improvements. Meanwhile, “economic analysis”, with 49 occurrences and 650 total link strength, reflects growing scholarly attention to cost-benefit assessments and the economic implications of integrating LNG into green supply chains. Overall, the co-occurrence network reveals an interdisciplinary research trend integrating LNG, energy efficiency, and emission reduction. This trend underscores the strategic importance of LNG and economic evaluation in sustainable supply chain development.

Based on the VOSviewer visualization, the keyword co-occurrence network is structured into six main research clusters, distinguished by node colors, sizes, and link densities. These clusters reflect the dominant research themes surrounding LNG as an alternative fuel, including its economic impacts, environmental performance, and role in green supply chain development, as detailed below.

Cluster 1: LNG as an Alternative Fuel and Supply Chain Economics

This cluster centers on the keyword “liquefied natural gas” (LNG) and is closely linked to concepts such as supply chains, natural gas transportation, gas emissions, and cost-related terms. The dense interconnections indicate that LNG is widely studied as an alternative fuel option within green supply chains, with a strong focus on cost-effectiveness, economic feasibility, and operational performance across energy logistics and transport systems. From the perspective of this study, this cluster emphasizes that the adoption of LNG is not merely a technical solution but also a strategic economic decision, where cost competitiveness is a key driver of the energy transition.

Cluster 2: Carbon Emission Mitigation and Decarbonization

Dominated by “carbon dioxide” and “economic analysis,” this cluster is closely associated with carbon capture, carbon capture and storage (CCS), environmental impact, and renewable energy sources. The strong linkages highlight research focused on CO₂ reduction, decarbonization pathways, and economic evaluation, reflecting the financial and policy implications of integrating LNG and carbon mitigation technologies into green supply chains. Our analysis suggests that this cluster serves as an important bridge, indicating that the future of LNG is tied to its potential role within a broader clean energy ecosystem, rather than as a standalone solution.

Cluster 3: Environmental Impact and Sustainability Assessment

This cluster links LNG with environmental performance indicators, including emissions, sustainability, and green supply chain performance. The network structure suggests a research focus on carbon footprint assessment, lifecycle impacts, and sustainability evaluation, examining how LNG adoption affects environmental outcomes across green supply

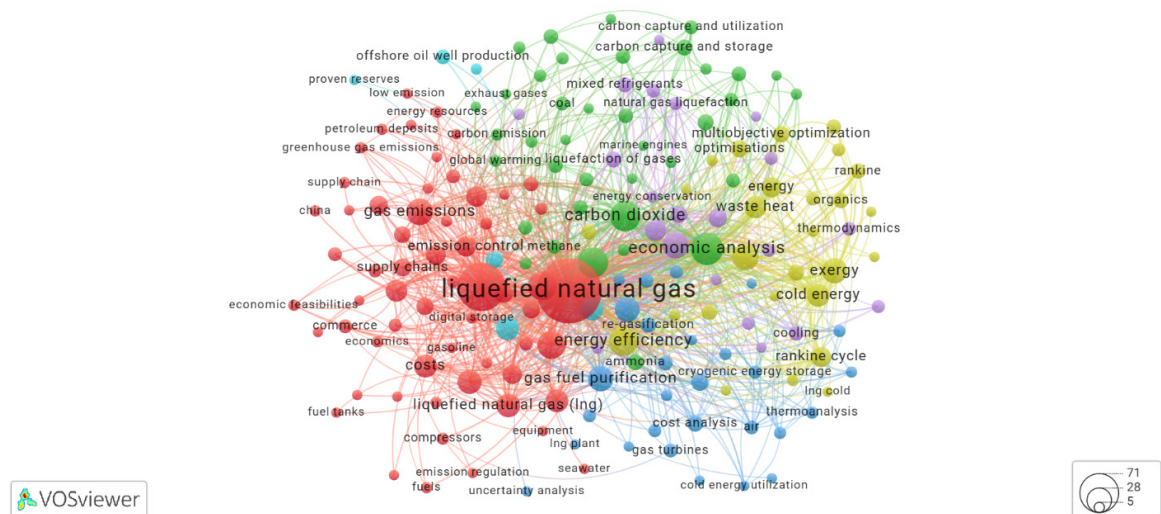


Figure 8. Keyword Set for Co-occurrence Analysis

chains. We observe that research within this cluster is gradually shifting from simple comparisons between LNG and other fossil fuels toward a more holistic approach, assessing LNG's role in supporting circular economy objectives and net-zero emission targets.

Cluster 4: Energy Efficiency and Thermodynamic Performance

Comprising keywords such as energy efficiency, thermodynamics, exergy, waste heat, and Rankine cycle, this cluster represents studies focused on system optimization and power generation efficiency. The strong internal linkages indicate that thermodynamic and exergy-based analyses are extensively used to enhance energy performance in LNG-related energy systems. In our view, the development of this cluster reflects an engineering-oriented research trend, where maximizing operational efficiency is considered a foundational element for improving the economic and environmental sustainability of the entire LNG value chain.

Cluster 5: Liquefaction Process Optimization and Cold Energy Utilization

This cluster highlights themes such as optimization, multi-objective optimization, cold energy utilization, and exergy-based methods. The research focus lies in technological improvements and process optimization in LNG liquefaction and regasification, aiming to enhance energy recovery, operational efficiency, and economic performance within LNG supply chains. We consider this to be the most "technically core" cluster, where technological breakthroughs directly enhance LNG's competitiveness while creating new business opportunities through cold energy utilization.

Cluster 6: Infrastructure, Investment, and Resource Perspectives

This cluster includes storage facilities, compressors, vessels, fuel tanks, and equipment, reflecting studies

on LNG infrastructure development, investment decisions, and resource management. Although smaller in scale, its connections to other clusters emphasize the importance of infrastructure resilience, capital investment, and supply chain robustness in supporting sustainable LNG deployment. From an overall perspective, we argue that infrastructure development, as reflected in this cluster, is a material prerequisite for realizing the economic, environmental, and technical benefits highlighted in the other clusters.

Overall, the interconnected structure of these six clusters demonstrates that research on LNG in energy journals adopts a systemic and interdisciplinary perspective. It integrates elements of economic feasibility, emission mitigation, environmental sustainability, energy efficiency, technological optimization, and infrastructure development. This bibliometric evidence confirms the strategic role of LNG in advancing green supply chains that are both economically viable and environmentally sustainable.

4. Discussion and implications

This study offers a systematic bibliometric review of Liquefied Natural Gas (LNG) research within green supply chains, drawing on publications from leading energy journals. The analysis maps the field's intellectual structure, thematic evolution, and collaborative dynamics from 1983 to 2025.

4.1. Key Findings

The findings directly address the research objectives proposed in this study. First, the bibliometric analysis reveals the evolution and publication patterns of LNG research in energy journals. Second, the study identifies

six dominant research clusters shaping the knowledge structure of LNG within green supply chains. Third, the results demonstrate a clear shift toward integrating economic performance, carbon management, and sustainability considerations.

The research landscape has evolved from a marginal topic to a vibrant, interdisciplinary field post-2018, driven by the global green energy transition. The journal *Energy* emerged as the leading publication venue. Geographically, research leadership and collaboration are concentrated among developed economies and major Asian nations, with China and the United States as central hubs in the international cooperation network. The knowledge structure, revealed through keyword co-occurrence analysis, is organized into six interconnected clusters: (i) LNG as an Alternative Fuel and Supply Chain Economics; (ii) Carbon Emission Mitigation and Decarbonization; (iii) Environmental Impact and Sustainability Assessment; (iv) Energy Efficiency and Thermodynamic Performance; (v) Liquefaction Process Optimization and Cold Energy Utilization; and (vi) Infrastructure, Investment, and Resource Perspectives. This interconnected structure confirms the systemic nature of LNG research. It inherently integrates economic, environmental, technological, and infrastructural dimensions to advance green supply chains.

4.2. Theoretical and Practical Implications

The findings offer significant implications for both academia and industry.

Theoretical Implications: This study contributes to the literature in three main ways.

First, it provides the first comprehensive bibliometric mapping of LNG research within the green supply chain context.

Second, it integrates economic, technological, and environmental perspectives into a unified analytical framework.

Third, it identifies emerging interdisciplinary research directions linking energy economics with sustainable logistics.

This study consolidates a fragmented literature by providing a comprehensive knowledge map. It establishes a foundational taxonomy of research themes through the six clusters. Furthermore, it clarifies the interdisciplinary connections between energy engineering, supply chain management, environmental science, and economics. A critical evolution in the field's theoretical focus is evident: a shift from purely technical analyses toward studies that integrate economic viability and lifecycle sustainability.

Practical Implications: For policymakers, the results highlight the need for integrated policies. These policies must support LNG technology R&D while creating stable market and regulatory frameworks

for green supply chain investments. For industry practitioners, the identified clusters point to clear priority areas. These include optimizing logistics to reduce costs and emissions, investing in carbon capture and storage (CCS) compatibility, harnessing cold energy, and building resilient infrastructure. Finally, the collaboration network analysis reveals strategic partnership opportunities, especially with leading institutions in the Asia-Pacific region.

4.3. Future Research Directions and Governance Considerations

To address existing gaps and fully leverage LNG's potential as a transition fuel, future research must advance beyond optimization and impact assessment. The next phase should focus on integrative governance and strategic management. Four priority research directions are proposed:

Resilience and Risk Governance: Future work should develop frameworks to govern supply chain resilience against geopolitical, market, and climate-related disruptions. This involves modeling risk scenarios and designing adaptive governance mechanisms for global LNG networks.

Lifecycle Carbon Accounting and Policy Integration: Research is needed to create standardized models for governing and auditing the full lifecycle carbon footprint of LNG supply chains. Subsequent studies must examine how to effectively integrate these metrics into international carbon pricing and trading mechanisms.

Strategic Integration with Renewable Systems: Investigations should focus on optimal governance and business models for hybrid energy systems. In these systems, LNG infrastructure would support and integrate with hydrogen, ammonia, and variable renewable energy sources to ensure a managed transition.

Equitable Transition Governance: Scholars should explore policy frameworks and multi-stakeholder governance models. These models must ensure the shift toward LNG and greener supply chains is socially just, mitigating adverse impacts on communities and workers in traditional fossil fuel sectors.

In conclusion, LNG remains a critical, though complex, enabler of the green economic transition. Its ultimate value will be determined not by its standalone technical attributes, but by how effectively it is governed within integrated, resilient, and equitable supply chain systems. This study provides the foundational map to navigate that future.

5. Conclusion

This study provides a systematic bibliometric overview of LNG research in the context of green

supply chains. By identifying six major research clusters and mapping global collaboration patterns, the study clarifies the evolving knowledge structure of the field. The findings highlight the increasing integration of economic analysis, sustainability assessment, and technological innovation in LNG research. Overall, LNG remains a critical transitional component in the global shift toward sustainable and resilient energy supply chains. Future studies may further explore the economic and environmental implications of LNG development within emerging green energy systems.

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