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EDITORIAL

Hydrogen supply chain management

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Abstract
The emergence of green hydrogen as a versatile base chemical and energy carrier has led to a wide range of supply chain design and management challenges, which are addressed in this special issue of the Journal of Business Economics. The contributions offer a multifaceted view on hydrogen supply chain management, spanning national strategies, sector-specific applications, global sourcing considerations, analytical evaluation methods, spatial infrastructure planning, investment decisions, and strategic interaction among market participants. Integrating these complementary perspectives, the special issue illustrates the progress achieved to date and provides a comprehensive outlook on the remaining challenges.

Keywords Hydrogen · Supply Chain Management · Sustainability

JEL Classification M11 Production Management · Q42 Alternative Energy Sources · C61 Optimization Techniques · Programming Models · Dynamic Analysis

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1 Hydrogen supply chain management - an emerging research field

Hydrogen has become a crucial element in the decarbonization strategies of many countries and industries. Especially green hydrogen produced from renewable energy sources is considered a promising energy carrier and chemical feedstock for sectors where direct electrification options are limited, such as heavy industry (e.g. steel, chemicals, cement), long-distance transport (e.g. trucking, shipping, aviation), or large-scale energy storage (e.g. seasonal storage, back-up power generation, grid stabilization). Consequently, demand for hydrogen is expected to grow significantly in the coming decades. While global hydrogen production was slightly below 100 Mt in 2024 (IEA 2025), recent studies estimate an increase in global hydrogen demand to more than 500 Mt by 2050 under ambitious decarbonization scenarios (e.g., IRENA 2023; McKinsey 2023).

Meeting this rapidly growing demand requires a substantial scale-up of hydrogen-related infrastructure across the entire supply chain. Production facilities, storage systems, and transport networks must either be newly built (greenfield approach) or adapted from existing infrastructure through retrofitting and reconfiguration (brownfield approach). These developments are closely linked to the deployment of new technologies and involve high capital investments, long-term planning horizons, and significant coordination challenges. Hydrogen supply chains often operate in global settings, which raises additional questions about supply security, resilience, and risk management. At the same time, advances in data availability and analytical methods enable more detailed and evidence-based design and planning of hydrogen supply chains (Klumpp et al. 2025).

Against this background, the effective analysis, design, and management of hydrogen supply chains has become a dedicated research field. This field entails a wide range of interrelated planning tasks that differ in scope, time horizon, and level of aggregation (Sgarbossa et al. 2023). Strategic decisions concern, for example, the selection of production technologies and locations, the definition of sourcing strategies, and the establishment of long-term cooperations. Tactical and operational planning involves, among other things, adjusting capacities, coordinating supply and demand in the mid- and short term across different stages of a hydrogen supply chain, and determining production, transportation, and storage quantities. While some of these planning tasks can be addressed using established methods from operations and supply chain management, many require adapted, interdisciplinary approaches that are tailored to the distinctive technological, economic, and institutional characteristics of hydrogen supply chains.

Based on a systematic review of the literature, Sgarbossa et al. (2023) propose a planning matrix for managing renewable hydrogen supply chains. It is derived from the well-established supply chain planning matrix of Stadtler et al. (2015) and provides a structured way to organize the diverse planning tasks in the domain of hydrogen supply chains across different decision levels and time horizons. It also supports the identification of areas for further research. We adopted this framework as a conceptual starting point for this special issue of the *Journal of Business Economics*. The included articles populate the framework by addressing topics such as the economic and environmental evaluation of hydrogen supply chains, resilience

Table 1 Overview and classification of the papers included in this special issue

Paper	Planning tasks	Research methods	Geographic focus
External drivers & hydrogen supply chain adoption and market development phases			
Vale de Paula et al. (2026)	Identify the implications of national hydrogen strategies for hydrogen supply chain design	Analysis of national hydrogen strategies, systematic literature review	Australia, Germany, Spain, USA, Netherlands, UK, France
Bianchi et al. (2025)	Identify barriers and enabling solutions to hydrogen adoption in transport applications	Systematic literature review, expert survey	Italy
Long-term planning			
Sroka and Meisel (2026)	Determine the ideal network for the import of green hydrogen to a demand region considering diversification	Mixed-integer linear programming	Germany (importer) / Global (sourcing)
Schmid and Deden (2025)	Economic and environmental evaluation of hydrogen pathways	Activity analysis	Generic
Schneider et al. (2026)	Economic and environmental comparison of alternative fuel production pathways	Life cycle assessment (LCA), life cycle costing (LCC)	Generic (some parameters representative for Germany)
Coquette et al. (2025)	Determine feasible and economically-efficient routes for hydrogen distribution infrastructure (pipelines)	(Geospatial) multi-criteria decision analysis (MCDA), analytical hierarchy process (AHP)	Sauerland (Germany)
Mid-/short-term planning			
Guo et al. (2025)	Determine optimal hydrogen production and storage quantities as well as prices	Bi-level optimization, game theory	Germany
Bätge et al. (2026)	Capacity planning and technology choice of hydrogen refueling stations for heavy-duty trucks	Techno-economic assessment, thermodynamic simulation, mixed-integer linear programming	Generic (some parameters representative for Germany)

and security considerations, application-specific design challenges, and data-driven decision-support approaches. By bringing together these perspectives, the special issue aims to advance the comprehensive understanding of how hydrogen supply chains can be analyzed, designed, and managed effectively.

2 Overview of the papers in this special issue

The eight articles in this special issue illustrate the breadth and depth of current research on hydrogen supply chain management. They comprise conceptual, empirical, and model-based approaches and collectively demonstrate how business economics can contribute to the design and management of hydrogen supply chains. Table 1 provides an overview of the included papers by classifying them according to *planning tasks*, *research methods*, and *geographic focus* and grouping them by *planning horizon*. In the following, we discuss the main ideas and the contribution of the individual papers.

Eugenia Vale de Paula, **Breno Nunes**, and **Juliana Bonomi dos Santos Campos** examine a dedicated political decision-making perspective regarding the role of national hydrogen strategies in shaping the design of clean hydrogen supply chains. Based on a content analysis of national hydrogen strategies from seven leading countries (Australia, Germany, Spain, United States, Netherlands, United Kingdom, France) and findings from a systematic review of 115 scientific articles focusing on hydrogen supply chains in the domain of business and management, the authors develop a framework explaining how global drivers and barriers as well as national antecedents, strategies, and political actions plans shape the design of hydrogen supply chains. The paper provides an important macro-level foundation for understanding how hydrogen supply chains are embedded in geopolitical and national contexts.

Francesca Bianchi, **Giuseppe de Leo**, **Margherita Pero**, **Monica Rossi**, and **Giovanni Miragliotta** focus on hydrogen mobility as a key application field for green hydrogen. Through a systematic literature review complemented by an industry survey, the authors compare maritime, aviation, and road transport applications, highlighting how differing operational requirements, infrastructure needs, and technological maturity levels shape supply chain structures. The study identifies both common barriers and domain-specific challenges, extending the analysis down to individual vehicle types. By linking application characteristics to supply chain implications, the paper offers insights for policymakers and practitioners seeking to align hydrogen infrastructure development with sector-specific decarbonization pathways.

Louis Vincent Sroka and **Frank Meisel** address resilience and security-of-supply for green hydrogen import networks by examining diversification strategies for such networks. Using a mixed-integer linear programming model, the authors determine cost-optimal import networks for hydrogen feedstock and hydrogen derivatives under diversification constraints for the number of exporting partners and their share of supply. A case study for Germany shows that production and conversion costs dominate overall expenditures and that ammonia is often the most cost-efficient transport option. At the same time, the analysis reveals that enforced diversification increases total costs and reshapes network structures. The study highlights how technological improvements, such as reduced boil-off rates, may alter optimal carrier choices and trade-offs between cost efficiency and supply security.

Eberhard Schmid and **Jan Deden** propose an activity-analysis-based framework for the integrated economic and environmental evaluation of hydrogen pathways. By modeling pathways as sequences of activities with associated material flows and emissions, the methodology enables flexible and transparent comparison of alternative production, transport, and storage configurations. The approach is demonstrated through case studies on supplying hydrogen refueling stations for road transport, including comparisons of delivery pathways and sourcing options such as locally produced grey hydrogen versus imported green hydrogen. The paper contributes a versatile decision-support tool that facilitates the identification of efficient hydrogen pathways across differing settings.

Alexander Schneider, **Moritz Harnischmacher**, **Andreas Rudi**, and **Frank Schultmann** conduct a comprehensive comparative evaluation of emissions and costs in renewable fuel production based on Power-to-X processes. Integrating multiple scenario-based supply chain configurations, the study analyzes combinations of electricity generation sources, hydrogen production technologies, heat supply options, and carbon capture methods. The results reveal significant cost–emission trade-offs across technological choices and highlight the sensitivity of supply chain performance to regional infrastructure, resource availability, and regulatory conditions. Beyond identifying promising configurations, the paper emphasizes challenges related to resilience, traceability, and sustainability monitoring across complex, multi-actor value chains.

Dominik Coquette, **Lars-Peter Lauven**, and **Martin Faulstich** investigate hydrogen infrastructure development from a localized, spatial planning perspective. Using a geospatial multi-criteria decision analysis framework based on the Analytical Hierarchy Process, the authors assess the suitability of hydrogen infrastructure deployment in the German Sauerland region. The model integrates environmental, technical, and economic criteria and introduces a novel bundling divisor to account for infrastructure synergies and to avoid isolated developments at the regional decision-making level. The results identify priority areas for infrastructure deployment that balance cost efficiency and environmental impact, demonstrating how spatially explicit decision-support tools can improve regional- and local-level hydrogen infrastructure planning as well as interactions of different supply chain actors.

Tjard Bätge, **Steffen Heinke**, **Christian Weckenborg**, **Marco Karig**, **Wilhelm Tegethoff**, **Jürgen Köhler**, and **Thomas Spengler** investigate the configuration planning for hydrogen-truck refueling stations with a focus on techno-economic investment decisions under uncertain demand. By explicitly modeling the recovery process between refueling events, the authors capture thermodynamic effects that significantly influence station performance and valuation. A simulation-based assessment combined with mixed-integer linear optimization is used to evaluate different configuration options across market ramp-up scenarios for heavy-duty trucks. The results show that the ability to perform back-to-back refueling strongly affects investment outcomes and that under-fulfillment of demand has a greater impact on valuation than electricity consumption. The study provides actionable insights on capacity planning, investment timing, and upgrade strategies.

Shiyu Guo, **Alexander Blume**, **Maria Beranek**, and **Udo Buscher** examine green hydrogen supply chains in the steel industry using a game-theoretic bilevel optimization model that captures strategic interactions between a power plant operator and a steel producer. The analysis demonstrates how hydrogen production can serve as a flexible and profitable option for power producers while enabling emission reductions and cost savings for steel manufacturers. At the same time, the results reveal important trade-offs and uncertainties: higher coal and CO_2 prices do not necessarily increase hydrogen adoption due to structural dependencies in steel production, and consumer demand elasticity plays a critical role in determining hydrogen uptake. The paper underscores the importance of aligning cost reduction efforts with supportive policies and market acceptance mechanisms.

Taken together, the contributions in this special issue provide a multifaceted view of hydrogen supply chain design and management, spanning national strategy, sectoral applications, global sourcing, analytical evaluation methods, spatial infrastructure planning, investment decisions, and strategic interaction among market participants. This breadth highlights both the progress made and the challenges that remain, thereby setting the stage for a broader discussion of implications, research gaps, and future directions in hydrogen supply chain management, which we address in the following.

3 Conclusion and outlook

As green hydrogen is one of the hopeful contenders for a sustainable economy in the future, the design and decision-making processes regarding such supply chains should follow a comprehensive sustainability approach. Even though the articles in this special issue identify possible solutions to selected challenges in hydrogen supply chains, numerous obstacles remain on the path to a comprehensive green hydrogen economy. Regardless of regional positioning, establishing green hydrogen supply chains will require overcoming technical and economic challenges. An isolated cost-oriented view, which currently still reveals a cost disadvantage of green hydrogen compared to grey hydrogen, for example, must be supplemented by an environmentally oriented perspective that attempts to achieve ecological goals by, among other things, internalizing the environmental costs of gray hydrogen. Examples include rising CO_2 prices and the Carbon Border Adjustment Mechanism (CBAM), which aims to prevent the circumvention of CO_2 pricing. Moreover, advanced technological developments in electrolysis are central to mitigating current disadvantages and to potentially making green hydrogen clearly advantageous in the long term.

Especially in light of the experiences of recent years, green hydrogen supply chains must also be designed to be resilient such that disruptions can be responded to as appropriately as possible without being dependent on the goodwill of individual countries or actors. Sustainable success and stability also require a socially responsible supply chain. Examples include local value creation, education and training programs, and the careful use of water amongst other natural resources. If we broaden our perspective even further, it will be interesting to see how green hydrogen supply chains differ across countries and regions. National strategies and guidelines, as well as further technological developments (including digitalization and Industry 4.0/5.0 technologies), will likely have a decisive influence on the organizational design of hydrogen supply chains and their interaction with other hydrogen supply chains.

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Declarations

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