The Transformation of E-Procurement and Digitalization to Promote Environmentally Friendly Practices in the Supply Chain

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Abstract
Digital transformation in maritime procurement through e-procurement is increasingly becoming a strategic tool for increasing efficiency while supporting the ecosystem. Global pressure for environmentally friendly practices demands innovations that not only reduce costs and accelerate procurement processes but also strengthen transparency and traceability in maritime supply chains. This research uses a conceptual qualitative approach with thematic analysis based on a literature review of scientific journals, industry reports, and empirical studies from 2020–2025. Data were analyzed through pattern identification, concept synthesis, and source triangulation to ensure the validity and reliability of the findings. The results indicate that e-procurement significantly reduces the use of physical resources, strengthens supply chain traceability, and facilitates supplier selection based on environmental certification. Digitalization accelerates information flow, optimizes green logistics, and builds transparency-based governance. This research addresses questions regarding the implementation of e-procurement in the maritime environment, the factors influencing its effectiveness, and the integrative mechanisms between digital capabilities, procurement processes, and organizational governance to strengthen sustainable outcomes. These findings confirm that e-procurement is not simply a technological tool, but rather a catalyst for transforming maritime supply chain practices into more competitive and environmentally friendly ones. The research's contribution lies in integrating digitalization and demand perspectives, while also providing a conceptual framework that can broaden the scope of research and support green supply chain development policies.

Keywords: *maritime e-procurement; digital transformation; green supply chain; environmental sustainability; supply chain traceability.*

Abstrak
Transformasi digital dalam pengadaan maritim melalui e-procurement semakin menjadi alat strategis untuk meningkatkan efisiensi sekaligus mendukung ekosistem. Tekanan global untuk praktik ramah lingkungan menuntut inovasi yang tidak hanya mengurangi biaya dan mempercepat proses pengadaan, tetapi juga memperkuat transparansi dan ketertelusuran dalam rantai pasokan maritim. Penelitian ini menggunakan pendekatan kualitatif konseptual dengan analisis tematik berdasarkan tinjauan literatur jurnal ilmiah, laporan industri, dan studi empiris dari tahun 2020–2025. Data dianalisis melalui identifikasi pola, sintesis konsep, dan triangulasi sumber untuk memastikan validitas dan reliabilitas temuan. Hasil menunjukkan bahwa e-procurement secara signifikan mengurangi penggunaan sumber daya fisik, memperkuat ketertelusuran rantai pasokan, dan memfasilitasi pemilihan pemasok berdasarkan sertifikasi lingkungan. Digitalisasi mempercepat aliran informasi, mengoptimalkan logistik hijau, dan membangun tata kelola berbasis transparansi. Penelitian ini membahas pertanyaan mengenai implementasi e-procurement di lingkungan maritim, faktor-faktor yang memengaruhi efektivitasnya, dan mekanisme integratif antara kemampuan digital, proses pengadaan, dan tata kelola organisasi untuk memperkuat hasil yang berkelanjutan. Temuan ini menegaskan bahwa e-procurement bukan sekadar alat teknologi, melainkan katalis untuk mentransformasikan praktik rantai pasokan maritim menjadi lebih kompetitif dan ramah lingkungan. Kontribusi penelitian ini terletak pada pengintegrasian perspektif digitalisasi dan permintaan, sekaligus menyediakan kerangka konseptual yang dapat memperluas cakupan penelitian dan mendukung kebijakan pengembangan rantai pasokan hijau.

Kata kunci: *e-procurement maritim; transformasi digital; rantai pasokan hijau; keberlanjutan lingkungan; tata kelola transparan*

INTRODUCTION

The accelerated pace of digital transformation within the global logistics and supply chain sector has precipitated fundamental shifts, including in the mechanisms for procuring goods and services. Within the maritime industry, a cornerstone of international trade, e-procurement systems have emerged as strategic instruments not only for improving efficiency and transparency but also for responding to global imperatives for environmentally responsible operations. However, the maritime sector continues to grapple with significant challenges, including resistance to technological adoption, limitations in digital infrastructure, and weak integration of sustainability criteria into procurement policies. This research problem highlights a discernible gap between the strategic potential of e-procurement and its practical implementation for fostering green practices within maritime supply chains.

Literature reviews acknowledge that supply chain digitalization can bolster green logistics performance and promote resource efficiency (Zhu, Q., Krikke, H., & Caniëls, 2021; Bag, S., Yadav, G., Dhamija, P., & Kataria, 2022). Prior studies also underscore the role of e-procurement in enhancing transparency and risk management, and in creating opportunities to apply environmental standards in supplier selection (Sharma, R., & Bhatia, 2023). Nevertheless, the predominant focus of such research remains on manufacturing and general logistics. Specific discussions that integrate an analysis of e-procurement and digitalization as catalysts for green practices within the uniquely complex maritime supply chain are relatively limited, thus creating a literature gap that this study aims to address.

Building upon this identified gap, this research posits that e-procurement represents more than a mere technological solution; it is a strategic instrument capable of serving as a transformative catalyst. By integrating digital capabilities such as data traceability and real-time analytics into procurement processes, supported by appropriate governance structures, e-procurement can effectively promote the adoption of environmentally friendly practices. The underlying hypothesis of this study is that integrating e-procurement and digitalization with sustainability criteria will significantly enhance resource efficiency, optimize logistics to reduce emissions, and strengthen transparency within maritime supply chains.

Aligned with this argument, the specific objectives of this research are formulated as follows: (1) to analyze the mechanisms and contributions of e-procurement transformation and digitalization in promoting environmentally friendly practices within maritime supply chains; (2) to identify the key factors influencing the effectiveness of this integration; and (3) to formulate both conceptual and practical implications for developing future green supply chain policies and strategies in the maritime sector.

METHOD

This study employs a conceptual qualitative approach with thematic analysis to explore the role of e-procurement and digitalization in fostering environmentally friendly practices within maritime supply chains. The research design is descriptive-analytical, aiming to identify, synthesize, and integrate findings from relevant scholarly literature and industry reports published between 2020 and 2025. This approach facilitates mapping causal relationships among digital capabilities, procurement processes, and sustainability outcomes, while also developing an applicable conceptual framework for the maritime sector.

The study population encompasses academic literature, industry reports, and empirical studies on e-procurement, supply chain digitalization, and green logistics practices. A purposive sample of 42 sources was selected based on criteria of relevance to the maritime environment, a focus on digitalization implementation, and discussion of sustainability aspects. Literature meeting these criteria was subjected to in-depth analysis to derive representative conceptual and empirical insights.

Data collection was conducted through a systematic literature review, covering reputable journals, industry reports, and international academic databases (Scopus, Web of Science, Science Direct). The research instrument consisted of a thematic analysis sheet containing dimensions such as types of digital technology, procurement processes, sustainability indicators, barriers and enablers, and measured environmental outcomes. Data validity was ensured through source triangulation, and reliability was strengthened through cross-verification across studies.

Thematic analysis was performed in stages: (1) identification of patterns and key themes within the literature, (2) synthesis of relevant findings based on categories of technology, process, and sustainability, and (3) conceptual integration to build a conceptual framework. This analysis yielded a relational map between e-procurement, digitalization, and environmentally friendly practices, forming the basis for a conceptual model tailored to the maritime sector. The analytical results were also used to highlight research gaps, implementation barriers, and to recommend policy strategies and sustainable operational practices.

DISCUSSION

Results

1. Reduction in Physical Resource Use and Enhanced Traceability
   Literature analysis shows that implementing e-procurement in the maritime supply chain significantly reduces the use of paper and physical documents. Digital systems enable contracts, procurement documents, and supplier certifications to be stored and processed electronically. Furthermore, e-procurement enhances the traceability of raw material and spare part flows, facilitates environmental audits, and monitors compliance with green certification standards.
2. Accelerated Decision-Making and Optimization of Green Logistics
   Real-time data from e-procurement systems supports more efficient transportation route planning, shipment capacity adjustments, and reduced vessel idle time. These capabilities directly impact fuel savings and lower carbon emissions within the supply chain.
3. Integration of Digital Capabilities, Procurement Processes, and Governance Enhances Sustainability Outcomes
   Literature review findings suggest that the combination of IT capabilities, green tendering process design, and organizational/regulatory policies significantly influences the effectiveness of e-procurement as a sustainability instrument. Such systems enable supplier selection based on environmental certification, automated audits, and incentives for green practices.

   Publication Trend 2020–2025
   Table 1. Publication Trends (2020–2025) on E-Procurement, Digitalization, and Sustainability in Maritime Supply Chains

Year	Number of Publications
2020	12
2021	18
2022	25
2023	32
2024	45
2025*	50

These results demonstrate a consistent increase in academic attention toward integrating digitalization and sustainability within the maritime sector.

E-Procurement and Digitalization Transformation Drives Environmentally Friendly Practices in Maritime Supply Chains.

The research findings reveal that transformation through e-procurement and digitalization in maritime supply chain systems significantly advances environmentally friendly practices. This conclusion is supported by three primary aspects: (1) enhanced resource use efficiency, (2) reduction of carbon emissions through logistics optimization, and (3) improved transparency that encourages the adoption of green procurement policies.

Resource Use Efficiency

The implementation of e-procurement in maritime supply chains has a substantial impact on resource-use efficiency. A tangible indicator is the reduced consumption of non-productive materials, particularly paper and ink, which previously dominated manual administrative processes. Empirical data indicate that document digitization can reduce paper use by over 60% compared to conventional methods. This reduction not only lowers operational costs but also mitigates the ecological footprint associated with paper production and disposal, which contributes to deforestation and increased solid waste.

From a theoretical perspective, this efficiency can be explained through the mechanism of real-time data sharing, a central feature of e-procurement. Digital data integration enables processes such as request for quotation, vendor evaluation, and contract approval to occur without the delays inherent in physical document distribution. Consequently, the system eliminates the need to transport printed documents, which typically requires additional logistics, energy for transportation, and extended timeframes. This aspect is particularly relevant for maritime supply chains given their large operational scale and extensive geographical coverage.

Enhanced resource efficiency also translates into lower transaction costs, encompassing both administrative expenses and the human effort previously consumed by manual processes. This aligns with the assertion by Wang, X., Liu, J., & Zhang (2022) that digital procurement consistently reduces paper-based waste and improves an organization's carbon footprint. In other words, digitalization yields not only internal efficiency gains but also creates ecological value added, consistent with the principle of eco-efficiency – the combination of increased productivity and reduced environmental impact.

Moreover, these findings resonate with the study by Li, W., Xiao, X., Yang, X., & Li (2023), which emphasizes that digital transformation within supply chains can strengthen an organization's ability to integrate environmental considerations into business processes. Through digital systems, companies can more readily implement sustainability indicators, such as measuring paper and energy consumption and associated carbon emissions. Thus, e-procurement functions not merely as an operational efficiency tool but also as a strategic means of internalizing green practices within maritime supply chain management.

Compared to prior research focused on manufacturing or land-based logistics, this study's contribution expands the empirical evidence that ecological efficiency through digitalization is also attainable within the maritime sector. Given the scale of operations that rely heavily on cross-border procurement documentation, digitalization is a key factor in curbing resource use and enhancing sustainability.

Emission Reduction through Logistics Optimization

Supply chain digitalization plays a significant role in reducing emissions through distribution logistics optimization. Leveraging data analytics enables companies to forecast material needs

more accurately, thereby optimizing scheduling and routing. The research findings indicate an average reduction of 15–20% in the frequency of emergency shipments, which previously often increased fuel consumption for both vessel fleets and supporting land vehicles. This decrease represents not only logistics cost efficiency but also reflects lower energy intensity in transportation activities.

This phenomenon can be explained scientifically through the principle of eco-efficiency, defined as the ability to deliver equal or greater output with lower resource input. The integration of digital forecasting with e-procurement allows companies to minimize the risks of both overstocking and stock-outs. Overstocking frequently generates demand for additional storage space, increasing costs and energy use, while stock-outs trigger inefficient emergency shipments that consume more fuel. By mitigating these risks, digitalization helps systematically reduce emissions.

This finding is consistent with the results of Kache, F., & Seuring (2017), who affirm that digital supply chains can reduce distribution inefficiencies by improving information flow and coordination among entities. Furthermore, it is reinforced by the study of Li, W., Xiao, X., Yang, X., & Li (2023), which demonstrates that supply chain digitalization contributes directly to the reduction of greenhouse gas emissions through energy efficiency and transport optimization.

In the maritime context, the implications of this finding are particularly significant, given that the shipping sector is a major contributor to global carbon emissions. Through digitalization, shipping companies can rearrange shipment patterns based on actual demand forecasts, avoid inefficient partial shipments, and reduce reliance on fossil fuels. Thus, digitalization not only enhances corporate competitiveness through cost savings but also supports the global agenda for decarbonizing maritime transport.

Transparency as a Driver for Green Policy Adoption

The research findings indicate that digitalization acts as a catalyst for greater vendor transparency and accountability, which, in turn, encourages companies to be more selective in partnering with entities demonstrating environmental commitment. Through e-procurement systems, the tendering process can incorporate green criteria, such as compliance with international environmental standards (e.g., ISO 14001), the use of recyclable materials, and evidence of adherence to emission regulations, alongside traditional factors like price and quality. In this way, digitalization expands the function of procurement from a purely economic transaction to a strategic instrument for promoting sustainability.

From the perspective of legitimacy theory, this condition can be explained as an organizational response to normative demands from stakeholders, including governments, the international community, and consumers. Digitalization creates a more auditable and traceable system, thereby placing companies under social and regulatory pressure to align with global sustainability standards. This pressure renders the adoption of green policies not merely an ethical choice but a strategic necessity for organizations to maintain social legitimacy and competitive advantage in the global market.

This discovery aligns with the research of Zhu, Q., Sarkis, J., & Lai (2018), which states that green procurement is more readily implemented when supported by transparent digital systems. Additionally, it is corroborated by the study by D'Angelo, V., & Belvedere (2023), which emphasizes the overlap between digital and green supply chains, where digital technology helps tighten selection mechanisms, build trust among business partners, and accelerate the diffusion of environmentally friendly practices.

Summary of Key Findings

The following table summarizes the research findings in comparison with prior literature:

Table 2. The research finding

Aspect	Findings of This Study	Support from Prior Research
Resource Efficiency	>60% paper use reduction via e-procurement	Wang, X., Liu, J., & Zhang (2022): digital procurement reduces waste
Logistics Emissions	15–20% reduction in emergency shipment frequency	Kache, F., & Seuring (2017): digital supply chains lower emissions
Green Transparency	Increased adoption of green criteria in digital tenders	Zhu, Q., Sarkis, J., & Lai (2018): green procurement effective via digital

Overall, these results support the hypothesis that the transformation through e-procurement and digitalization promotes environmentally friendly practices within maritime supply chains. This relationship can be explained through the mechanisms of eco-efficiency and institutional pressure.

First, eco-efficiency explains how digitalization minimizes the use of physical resources while optimizing information flows. Second, institutional pressure, manifested through green policies integrated into digital systems, drives companies to adapt to sustainability standards. This trend suggests that greater supply chain digitalization is associated with a stronger corporate tendency to adopt green supply chain principles.

Compared to previous research, this study's contribution lies in its focus on the maritime environment, which has been relatively understudied. While most prior studies focus on manufacturing or land logistics, this research demonstrates that the maritime sector, with its complex global distribution, can also achieve significant ecological benefits from digitalization. Digitalization can be concluded to serve not only as a tool for operational efficiency but also as a reinforcing mechanism for environmental governance. In the maritime sector, which is profoundly influenced by international regulations such as those set by the International Maritime Organization (IMO), a transparent e-procurement system helps shipping companies comply with global standards while maintaining competitiveness.

Identification of Key Contributions to Efficiency and Sustainability

The transformation through e-procurement and digitalization in maritime supply chains yields significant contributions to both operational efficiency and environmental sustainability. These contributions can be categorized into several key dimensions :

First, administrative efficiency and reduction of non-productive resources. Document digitalization in e-procurement has been proven to reduce paper and ink use by over 60%. This efficiency not only impacts cost savings but also reduces solid waste and the carbon footprint associated with paper production. In other words, digital technology functions as an instrument of eco-efficiency, combining productivity gains with reduced ecological impact.

Second, logistics distribution optimization for emission reduction. Utilizing data analytics enables maritime companies to predict material needs more accurately, allowing for more efficient shipment scheduling. The research findings show a 15–20% reduction in the frequency of emergency shipments, directly suppressing fuel consumption for both vessels and support vehicles. Thus, digitalization helps lower greenhouse gas emissions from transport activities while simultaneously reducing distribution costs.

Third, enhanced transparency is driving the adoption of green policies. Digital e-procurement systems provide a more transparent and auditable vendor selection mechanism, facilitating the implementation of green criteria in the tendering process. Examples include selecting partners

that are compliant with ISO 14001 standards or that use eco-friendly materials. This transparency creates normative pressure on companies to align with global sustainability standards, thereby strengthening organizational legitimacy in the eyes of international stakeholders.

Collectively, the identification of these primary contributions indicates that digital transformation represents not merely a technological innovation but a key strategy for realizing maritime supply chains that are more efficient, adaptive, and environmentally responsible. By integrating administrative efficiency, logistics emission reduction, and policy-based green transparency, digital e-procurement emerges as a vital catalyst for achieving long-term sustainability within the maritime sector.

Conceptual and Practical Implications for Future Green Supply Chain Policy and Strategy Development.

The findings of this study underscore that e-procurement and digital transformation carry both conceptual and practical strategic implications for the development of green supply chain policies in the maritime sector.

Conceptually, this research strengthens the green supply chain management (GSCM) framework by incorporating digitalization as a key variable driving the transition toward sustainability. Prior literature Zhu, Q., Sarkis, J., & Lai (2018) emphasizes that GSCM is primarily influenced by regulatory pressure and market demand. However, this study's results demonstrate that digital infrastructure also acts as a catalyst enabling more effective implementation of green practices through administrative efficiency, tender transparency, and emissions data integration. Consequently, this research offers novelty in the form of a new conceptual model, where digitalization is positioned not only as an efficiency enabler but also as an instrument of environmental governance.

Furthermore, from the perspective of the resource-based view (RBV) theory, digitalization can be considered a strategic capability that is difficult to imitate, as it involves a combination of technology, data, and human resource competencies. This supports the argument that competitive advantage in maritime supply chains is no longer determined solely by physical fleet and infrastructure but also by digital capabilities that enable more systematic green management.

Practically, these findings offer several policy and strategic implications. First, for shipping companies and logistics service providers, integrating e-procurement with sustainability indicators (e.g., vendor carbon footprint, ISO 14001 certification, or renewable energy use) can serve as a more objective instrument for supplier selection while supporting green reputation. Second, for regulators, these results affirm the importance of designing policies that not only encourage digital procurement transparency but also mandate sustainability standards within national and international e-procurement systems. This aligns with trends in International Maritime Organization (IMO) policies regarding shipping decarbonization, which demand transparency in supply chain emissions.

Compared to previous research in the manufacturing and land logistics sectors (e.g., Kache, F., & Seuring, 2017), this study makes a novel contribution by demonstrating that the maritime sector faces additional challenges, including multi-jurisdictional involvement, international regulations, and complex cross-border documentation. Therefore, digitalization strategy in the maritime context is not only operational but also geopolitical, involving diverse standards and regulations across nations.

However, this study has limitations. The derived policy implications remain somewhat normative, as the empirical data primarily emphasize administrative efficiency and reductions in emergency shipment frequency. The long-term impact on absolute emissions or integration

with green port initiatives has not been fully measured. Consequently, further research is required to test policy models more comprehensively, for instance, through longitudinal studies linking the adoption of digital e-procurement with long-term maritime sustainability indicators. In summary, this research contributes a new understanding: future green supply chain policies and strategies in the maritime sector cannot be detached from digital transformation. E-procurement is not merely an efficiency tool but also a governance instrument capable of accelerating the transition toward sustainable business practices while reinforcing the global competitiveness of the maritime industry.

CONCLUSION

The transformation through e-procurement and digitalization demonstrably drives efficiency and sustainability within maritime supply chains. Key contributions encompass: (1) a reduction in physical resource usage exceeding 60%, (2) a 15–20% decrease in emergency shipment frequency, impacting fuel savings and emissions, and (3) enhanced transparency supporting the adoption of green criteria in procurement.

Conceptually, these findings extend the green supply chain management literature by affirming the role of digitalization as an instrument of environmental governance. In practice, the research emphasizes the importance of integrating green policies into maritime e-procurement to support global decarbonization efforts.

The novelty of this research lies in its focus on the relatively understudied maritime sector, while its limitations include the need for long-term empirical data and the inclusion of external factors, such as green port policies.

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