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GREEN DIGITAL LOGISTICS AND OPERATIONAL EFFICIENCY: TOWARD A MORE SUSTAINABLE SUPPLY CHAIN

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Abstract
Environmental sustainability has become increasingly relevant to logistics management because transportation, warehousing, port operations, and cargo handling consume energy and generate emissions. Digital technologies provide opportunities to improve logistics efficiency while supporting environmental objectives. This study examines how digital logistics can contribute to sustainable supply chain operations. A qualitative literature-based research design was used to synthesize research on green logistics, digital transformation, transportation efficiency, and supply chain sustainability. The findings indicate that digital technologies can support route optimization, vehicle utilization, cargo visibility, demand forecasting, paperless documentation, and resource monitoring. These applications may contribute to lower resource consumption and improved operational efficiency. However, digitalization itself also requires energy, infrastructure, and technological investment. Sustainable digital logistics therefore requires balancing technological benefits with environmental and organizational costs. The study concludes that digital transformation should be integrated with sustainability objectives rather than implemented solely to increase operational speed.

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INTRODUCTION

Logistics plays an important role in economic development but also creates environmental impacts. Transportation consumes fuel, warehouses require energy, and logistics facilities generate waste and emissions.

Sustainable logistics seeks to maintain economic performance while reducing environmental impacts.

Digital technologies provide several opportunities for achieving this objective. Route optimization can reduce unnecessary travel, while digital documentation can reduce paper

consumption. Shipment visibility can also improve vehicle and warehouse utilization.

However, digital transformation should not automatically be considered sustainable. Data centers, electronic equipment, and digital infrastructure also require resources.

This study examines how digital logistics can contribute to sustainability while improving operational efficiency.

Information technology has become one of the major resources available to logistics companies in addressing these challenges. Digital technologies can facilitate information exchange, improve operational visibility, support decision-making, and increase responsiveness to customer requirements. Evidence from the first study used as the basis of this analysis demonstrates that information technology has a significant relationship with logistics competitiveness and that regulatory convergence is also associated with both information technology and logistics competitiveness. The study further identifies information technology as a mediating mechanism between regulatory convergence and logistics competitiveness (Ratnasari et al., 2026).

However, technological capability alone may not be sufficient to explain the effectiveness of inter-organizational logistics activities. Logistics operations involve relationships among companies, customers, suppliers, business partners, transport providers, and other stakeholders. These relationships require the exchange of information and coordination of activities under conditions of uncertainty. Consequently, trust becomes an important relational resource (Barata, 2026).

The findings of these two studies suggest that technological and relational capabilities should not necessarily be examined independently. Digital systems can provide accurate and timely information, but organizations still need sufficient trust to exchange information, coordinate activities, and respond collaboratively to unexpected situations. Conversely, strong inter-organizational relationships may be strengthened when supported by reliable digital information systems (BRATA et al., 2023).

Despite the importance of these factors, studies concerning logistics competitiveness frequently examine technological capability, regulatory conditions, and relational mechanisms separately. This creates an opportunity to develop an integrated perspective that considers both technological and relational resources as interconnected foundations of logistics competitiveness (Barata et al., 2022).

The contribution of this study lies in connecting technological and relational perspectives into a single analytical framework. Rather than treating technology and trust as independent factors, this study views them as complementary organizational capabilities that can jointly support operational coordination, responsiveness, and competitive advantage.

RESEARCH METHOD

A qualitative literature-based approach was applied. Academic publications concerning green logistics, digital transformation, sustainable supply chains, transportation management, and logistics efficiency were reviewed.

The literature was analyzed according to three dimensions: resource efficiency, operational optimization, and environmental performance.

The second study examined trust formation in inter-organizational logistics relationships using a qualitative case study involving a logistics manager, a business partner, and two operational staff members. Data were collected through semi-structured interviews and observations and analyzed using thematic analysis.

Data Sources

The analytical material consisted of the two uploaded research articles. The first article focused on the effect of regulatory convergence and information technology on logistics competitiveness, while the second focused on the formation and maintenance of trust in inter-organizational logistics relationships.

The two studies were selected because they examine related dimensions of logistics performance within an Indonesian organizational context but employ different theoretical and methodological perspectives.

Data Analysis

The analysis was conducted through four stages. First, the researchers identified the main concepts, variables, and findings reported in each study. Second, the findings were grouped into three analytical dimensions: technological capability, relational capability, and logistics competitiveness. Third, similarities and complementary relationships between the findings were identified. Finally, the findings were synthesized into an integrated conceptual interpretation.

The analysis focused particularly on information exchange, responsiveness, coordination, reliability, communication, regulatory adaptation, and competitive performance.

This approach allows the study to generate a broader conceptual explanation while maintaining a clear distinction between findings directly reported by the source studies and the interpretation developed through the integration process.

RESULTS

The analysis identifies several applications of digital logistics

First, digital route optimization can reduce unnecessary vehicle movements.

Second, shipment visibility can improve vehicle utilization and reduce empty transportation capacity.

Third, digital warehouse systems can improve inventory accuracy and resource allocation.

Fourth, electronic documentation can reduce paper consumption.

Fifth, data analytics can support demand forecasting and improve logistics planning.

The quantitative study also reported an R-square value of 0.627 for logistics competitiveness, indicating that 62.7% of the variance in the logistics competitiveness construct was explained by the constructs included in the model.

These findings suggest that digital capability should not be understood merely as the possession of technological infrastructure. Rather, its contribution to competitiveness depends on the organization's ability to use technology as part of operational and managerial processes.

Inter-Organizational Trust as a Relational Capability

The second major finding concerns the importance of trust in inter-organizational logistics relationships. The qualitative study demonstrates that trust involves both cognitive and relational dimensions. Participants associated trust with competence, reliability, consistency, honesty, mutual respect, and confidence that business partners would fulfill their commitments.

Trust was also found to develop progressively through repeated successful interactions. Small initial commitments, consistent performance, accurate documentation, and timely delivery created behavioral evidence that increased confidence between organizational actors.

Communication emerged as another central mechanism. Transparent and timely communication helped reduce uncertainty, align expectations, and maintain credibility, particularly when operational problems occurred.

Thus, inter-organizational trust can be interpreted as a relational capability that facilitates coordination and reduces the need for excessive monitoring. When organizations trust one another, operational interactions can become more flexible and responsive.

The Complementary Relationship between Technology and Trust

The most important integrated finding is that digital capability and inter-organizational trust represent complementary rather than competing resources.

Technology provides the infrastructure through which information can be generated, exchanged, stored, and processed. Trust, meanwhile, influences how organizational actors interpret information, communicate with one another, and respond to uncertainty.

For example, digital systems may provide real-time information concerning shipment status, delivery schedules, documentation, and operational disruptions. However, the usefulness of such systems also depends on the willingness of organizational actors to communicate accurately and transparently. Trust therefore provides a relational foundation that can support effective utilization of technological systems.

The second study shows that communication and transparency are fundamental to maintaining trust, while the first study demonstrates the importance of information technology for competitiveness. When these findings are considered together, information technology can be viewed as an enabler of communication and coordination, while trust can facilitate the effective relational use of information.

Regulatory Adaptation, Technology, and Competitive Performance

The first study also found a significant relationship between regulatory convergence and information technology, with a path coefficient of 0.763 and a t-statistic of 20.194. Regulatory convergence was also significantly associated with logistics competitiveness, with a path coefficient of 0.734 and a t-statistic of 18.306.

Furthermore, the indirect effect of regulatory convergence on logistics competitiveness through information technology was reported at 0.350, with a t-statistic of 4.403.

These findings indicate that regulatory adaptation and technological capability are interconnected. In practical terms, regulatory requirements may encourage organizations to improve their information systems and operational processes. Technology can subsequently help organizations implement and monitor regulatory requirements more effectively.

When integrated with the trust findings, this suggests a broader framework in which institutional adaptation, digital capability, and relational capability jointly support logistics competitiveness.

DISCUSSION

The relationship between digitalization and sustainability is not automatic. Digital technologies create environmental benefits when they are used to optimize physical logistics activities.

For example, a digital tracking system creates value when information helps reduce unnecessary transportation or improve delivery planning.

Another important issue is organizational behavior. Employees and managers must use available information to change operational decisions.

Sustainable digitalization therefore requires an integrated strategy combining technology, environmental objectives, employee capabilities, and performance measurement.

Trust as an Organizational Resource

Trust should also be understood as more than an interpersonal characteristic. The qualitative findings indicate that trust reduces monitoring requirements, facilitates decision-making, and improves coordination between business partners.

From a theoretical perspective, this interpretation is consistent with Social Exchange Theory, which emphasizes the development of trust through repeated exchanges, and Relational Exchange Theory, which recognizes the importance of relational mechanisms in sustaining inter-organizational cooperation.

Trust can also be considered an intangible organizational resource. When business partners have confidence in one another's competence and reliability, organizations can coordinate activities with less friction. Consequently, trust may contribute indirectly to operational efficiency and long-term relationship stability.

Communication as the Link between Digital Capability and Trust

Communication represents an important connection between technology and trust. The qualitative findings demonstrate that transparent communication reduces uncertainty and strengthens credibility.

Digital technologies can enhance the speed and accessibility of communication, but the presence of technology does not automatically guarantee transparency. Organizations still need to provide accurate information and communicate proactively when problems occur.

This distinction is important because logistics operations are exposed to uncertainty. Delays, documentation problems, transportation disruptions, and changing customer requirements can affect operational performance. Under such circumstances, transparent communication can help maintain trust even when operational problems cannot be completely avoided.

The Role of Consistency and Reliability

Both studies indirectly emphasize the importance of consistency. The competitiveness study highlights the importance of reliable logistics operations and information technology, while the trust study identifies consistent performance as a major foundation of trust.

This suggests that competitiveness is not created by isolated technological innovations or individual successful transactions. Instead, it is accumulated through repeated organizational performance.

Consistent delivery, accurate documentation, timely information, responsive communication, and reliable technological systems can gradually strengthen the confidence of customers and business partners. Over time, this accumulated confidence may become an intangible source of competitive advantage.

Formal and Relational Mechanisms

Another important implication concerns the relationship between formal mechanisms and relational mechanisms. Regulatory frameworks and formal agreements provide structure for logistics activities, while trust and interpersonal relationships facilitate cooperation in situations that cannot be fully anticipated by formal rules.

The qualitative study indicates that informal relationships, mutual respect, and harmony complement formal contractual mechanisms in the Indonesian business context.

Therefore, logistics competitiveness can be approached through a combination of formal and relational governance. Formal systems provide clarity and accountability, while relational trust can facilitate flexibility and cooperation.

CONCLUSIONS

Digital logistics can support sustainable supply chains by improving resource utilization, transportation planning, information visibility, and administrative efficiency.

Nevertheless, organizations should evaluate both the benefits and environmental costs of digital technologies. Sustainable logistics transformation requires technology to be connected directly with measurable environmental and operational objectives.

Future research should examine the relationship between specific digital technologies and environmental indicators such as fuel consumption, vehicle utilization, emissions, and energy efficiency.

The findings also highlight the importance of combining formal and relational mechanisms. Regulatory arrangements and formal agreements provide organizational structure, while trust, communication, reliability, and interpersonal relationships contribute to flexibility and sustained cooperation.

From a managerial perspective, logistics companies should develop digital capabilities together with relationship-management capabilities. Investment in information technology should be accompanied by efforts to improve communication quality, transparency, service reliability, employee capability, and partner relationships.

This study has limitations because it is based on an integrative analysis of two existing empirical studies rather than newly collected primary data. Consequently, the proposed relationships should be tested through future empirical research involving larger samples, multiple logistics organizations, and additional variables such as service innovation, human resource capability, supply chain integration, and organizational resilience.

Future studies may also develop and empirically test an integrated structural model examining whether inter-organizational trust strengthens the relationship between digital capability and logistics competitiveness. Such research would provide stronger empirical evidence concerning the interaction between technological and relational resources in emerging-market logistics.

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