Investigating the Impact of Sustainable Logistics Services Quality on the Efficiency of Egyptian Container Terminal Operation Performance

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Abstract:

Container terminals facilitate global trade by acting as essential nodes that link diverse transportation modalities. Given the increasing global apprehensions about environmental degradation and operational inefficiencies, the adoption of sustainable practices in port-related logistics has become essential. This study examines the influence of Sustainable Logistics Services Quality (SLSQ) on operational performance (OP) at Egyptian container terminals. A thorough literature review facilitated the creation of a conceptual framework that connects SLSQ encompassing its principal dimensions of

sustainable transportation, training, collaboration, and information sharing to operational performance metrics, including throughput, turnaround time, and cost efficiency. A mixed-methods approach was employed: qualitative data were gathered through semi-structured interviews with principal stakeholders from prominent Egyptian terminals, while quantitative data were acquired from a survey distributed to industry experts. The analysis, conducted through regression techniques and structural equation modeling (SEM), demonstrates a statistically significant positive correlation between SLSQ and operational performance. Sustainable information sharing emerged as the most significant predictor of enhanced performance. The study advances theoretical knowledge by integrating sustainability with logistics research and offers practical recommendations for port authorities and logistics service providers.

Keywords: Sustainable Logistics Services Quality - Operational Performance - Sustainable Service Quality - Logistics Service Provider - Logistics Service Quality

1. Introduction

Maritime transport is essential to international logistics networks and promotes economic development among regions and nations. A significant volume of global trade transits between nations via seaports (Martins et al., 2020). Ports have transcended their

conventional function as mere transfer points for transportation modes; they have evolved into logistics hubs and intermodal terminals (Stojanović et al., 2021). The rise in cargo handling yields economic advantages, yet it also generates social and environmental repercussions, both beneficial and detrimental (Guimarães, Leal Jr., & da Silva, 2018). Consequently, evaluating the sustainable performance of ports (or their terminals) aids in terminal management and informs public policies aimed at alleviating the adverse effects of operations. Sustainability in container terminals guarantees environmental protection and the conservation of natural resources, while addressing the welfare of terminal personnel and the requirements of the public. This underscores the significance of sustainability concerns in the shipping, port, and maritime logistics sectors (hereinafter referred to as maritime transport and logistics); historically, logistics was primarily perceived as a cost incurrence. Hossain and Walker (2019) assert that sustainable logistics services (SLS) processes effectively generate new value for both customers and service providers. Organizations attain enhanced customer satisfaction (CS) and loyalty via sustainability initiatives. Companies find it difficult to ascertain if they fulfill customer expectations and whether customers are content with their services and products. Tong (2022) asserts that companies undertake significant measures and enforce essential policies when selecting logistics service providers (LSP). Efficient logistics services are regarded as a competitive advantage, as they reduce overall costs and improve the quality of

products or services provided by companies (Fonseca, Domingues, & Dima, 2020). The sustainability of natural resources has emerged as a priority for governments, international organizations, and multinational corporations (Elnakib and Elzarka, 2014). In March 2015, Egypt resolved to implement dynamic innovations to attain optimal sustainable development. They established short-term objectives for 2020 and long-term objectives for 2030 ("Egypt's Vision 2030"). These strategies seek to elevate Egypt's status on national, regional, and global scales. The Ministry of Transport formulates the logistics development plan for Egypt's cities, encompassing three primary components: the enhancement of logistics infrastructure, the establishment of a logistics organizational framework, and the optimization of customs operations.

The main aim of this study is to explore how the sustainable logistics services quality affects the operational performance of container terminals in Egypt. This involves investigating the extent to which sustainable practices such as green transportation, efficient resource utilization, and waste management contribute to improvements in various aspects of operational performance, including productivity, efficiency, environmental sustainability, safety, and customer satisfaction within container terminal operations.

2. Literature Review

Sustainability is broadly conceptualized as the ability to maintain systems and outcomes over time (Jenkins, 2008; Bedoya-Dorado et al., 2022). Concerns regarding sustainability date back to Malthus (1872), who predicted resource limitations amid population growth. Subsequent discourses, such as the "Limits to Growth" report, underscored the consequences of unregulated resource exploitation, emphasizing the need for systemic reforms to ensure societal and environmental co-existence (Ruban & Yashalova, 2021; Kwateng et al., 2022).

Global institutional efforts, such as the 1980 World Conservation Strategy and the 1987 Brundtland Report, institutionalized sustainable development by highlighting the dual imperatives of eradicating poverty and preventing environmental degradation. Today, sustainable logistics, or green logistics, focuses on minimizing ecological footprints through innovations in material handling, waste management, transportation, and packaging (Stolka & Kubicka, 2019; Schaap & Schaap, 2023). Organizations increasingly integrate sustainability into operations by aligning economic, social, and environmental goals (Bradley, 2023).

In maritime and port logistics, the expansion of terminal operations has frequently led to environmental degradation, ranging from greenhouse gas emissions to public health risks (Sun, 2020;

UNCTAD, 1993; Peris-Mora et al., 2005; Acciaro et al., 2014; O'Neil et al., 2022a). Thus, the challenge lies in enhancing logistics performance while addressing sustainability imperatives.

2.1 Dimensions of Sustainability

Sustainability is generally classified into three dimensions: environmental, social, and economic (Amoako et al., 2021; Bedoya-Dorado et al., 2022; Obadahun et al., 2022). When strategically aligned, these dimensions contribute to the holistic optimization of logistics systems.

2.1.1 Environmental Sustainability

Environmental sustainability aims to mitigate the ecological impact of logistics operations, encompassing domains such as air and water pollution, land use, and energy consumption (Garcés-Ayerbe, C., Rivera- Torres, P., & Suárez-Perales, I. 2019). Mercuri (2022) and Batsakis (2023) categorized environmental impacts into six domains: air (e.g., emissions and ozone depletion), water (quality and usage), land (pollution and use), materials (type and waste), and energy (non-renewable consumption). Port logistics must address these domains to reduce their environmental burden.

2.1.2 Social Sustainability

Social sustainability reflects how logistics organizations treat internal and external stakeholders, including employees, customers, and communities (Hassini et al., 2012; Klassen et al., 2023). While

often underexplored, it includes labor rights, equity, working conditions, and community engagement (Scott et al., 2021; Waldinger & Schulz, 2023). Pinzon & Jabeen (2024) argue for a clearer framework, while Bentz (2022) segments social performance into workplace, community, and systemic dimensions.

2.1.3 Economic Sustainability

Economic sustainability refers to the financial viability of logistics operations, focusing on profitability, return on investment, and macroeconomic contributions such as GDP and labor productivity (Jain & Singhal, 2024; Işık et al., 2024a). Key elements include economic performance, financial health, market structure, and institutional processes (Işık et al., 2024b). Notably, economic performance is often easier to quantify, serving as a foundational criterion for sustainability initiatives.

3. Service Quality in Sustainable Logistics

Logistics service quality (LSQ) is a critical determinant of competitiveness in the logistics sector, influencing customer retention and operational excellence (Parhi S, Joshi K, Gunasekaran A, Sethuraman K (2022). As the container terminal sector grapples with sustainability, integrating high-quality services with environmental and social responsibility becomes crucial. Sustainable logistics service quality thus emerges as a nexus point where operational efficiency and ecological stewardship converge. By conceptualizing sustainable logistics

service quality as a multidimensional construct, this perspective review underscores its relevance for terminal performance, stakeholder engagement, and long-term industry viability. Further investigation into SLSQ-performance linkages can foster innovative frameworks for sustainable terminal operations, contributing to global environmental objectives while securing economic resilience.

3.1 Sustainable Logistics Service Quality Elements

Sustainable Logistics Service Quality (SLSQ) embodies a multidimensional framework of practices that logistics service providers (LSPs) adopt to enhance sustainability performance, customer satisfaction, and operational efficiency across diverse business sectors. Prior research (Ali et al., 2021; Gupta et al., 2018; Jaafar, 2006) has identified key elements of SLSQ that serve as critical indicators for evaluating the quality of logistics services in a sustainability context. These elements encapsulate sustainable transportation, packaging, information sharing, employee training, and collaboration, each contributing uniquely to the holistic sustainability performance of LSPs.

The integration of **sustainable transportation** within LSP operations is widely recognized for its positive impacts on corporate reputation and customer perceptions. According to Luque González et al. (2021), employing alternative fuels and eco-friendly transport methods not only reduces environmental footprints but

also enhances service reliability by minimizing damage and improving timeliness. This aligns with broader sustainability goals by promoting greener supply chains, which is critical as logistics activities contribute substantially to global carbon emissions.

Sustainable packaging constitutes another pivotal element that bridges operational logistics and marketing functions. Packaging serves as a communication medium and protection for products during transit; thus, shifting towards sustainable materials reduces waste and disposal costs while maintaining or improving product integrity (Ali et al., 2021). This shift not only minimizes environmental impacts but also resonates with the increasing consumer demand for eco-conscious products, reinforcing brand loyalty and differentiation in competitive markets.

Information exchange, or **sustainable information**, between LSPs and their clients plays an essential role in optimizing logistics flows and ensuring compliance with environmental standards. Timely and accurate sharing of sustainability-related data ranging from product information to environmental performance metrics enables better forecasting, risk mitigation, and regulatory adherence (Du et al., 2024). The dynamic nature of this exchange demands constant updates and mutual transparency, which ultimately reduce operational costs and enhance strategic decision-making.

A less frequently discussed but equally crucial dimension is **sustainable training**. Employee competence and awareness regarding sustainability practices directly influence service quality and customer satisfaction. In developing countries, such as Egypt, the deficit in sustainability knowledge among logistics personnel is a significant barrier (Ali et al., 2021). Targeted training programs can empower employees with the necessary skills to implement sustainability initiatives effectively, reduce accident rates, and foster environmental consciousness within organizations. Such training serves as a foundation for embedding sustainability into the organizational culture, thereby building long-term customer relationships.

Lastly, **collaboration** emerges as a strategic imperative amid globalization and fierce international competition. The collaborative approach entails LSPs and their clients jointly working toward environmental goals and sharing sustainability knowledge. This symbiosis fosters innovation, enhances resource efficiency, and improves overall sustainable performance (Ali et al., 2021). In the context of developing economies, where firms face resource constraints and external pressures from multinational corporations, collaboration helps fill capability gaps and drives competitive advantage through collective action.

The empirical validation of these SLSQ elements, as presented through the Q-sorting technique (Ali et al., 2021),

reinforces their practical relevance and applicability across industries. This comprehensive framework not only aligns with established theoretical perspectives (Joe F. Hair, Ringle, & Sarstedt, 2011; Kline, 1998, 2012) but also provides actionable insights for LSPs to operationalize sustainability principles, thereby advancing the integration of environmental and social dimensions into logistics service delivery.

Previous studies have explored Logistics Service Quality (LSQ) in terms of reliability, assurance, tangibles, empathy, and responsiveness (Parasuraman et al., 1988). Subsequent research expanded this approach to incorporate green or sustainable activities (Ali et al., 2021; Gupta et al., 2018). Scholars have shown that sustainable transportation strategies, such as using electric or low-emission cars, may lower operating costs and environmental impact (McKinnon, 2016; Notteboom & Vernimmen, 2020). Similarly, green training programs have been connected to increased staff efficiency (Dubey et al., 2022), and effective cooperation is acknowledged as critical for resource sharing and process innovation in container ports (Tufail et al., 2024). Real-time data from sophisticated information systems enhances decision-making and coordination in terminal operations (Sarkis et al., 2017).

According to the literature, operational performance in container terminals is often measured using productivity measures

(such as container throughput and vessel turnaround time), cost efficiency, safety, and customer satisfaction (Jarbran & Kara, 2022; Loke et al., 2014). While numerous studies have independently investigated service quality and sustainability concerns, there is a significant vacuum in the marine logistics literature in terms of an integrated focus on the quality of sustainable logistics services and their direct impact on terminal performance.

3. Hypothesis development

Based on the review, we propose a conceptual framework (see Figure 2.1) that links Sustainable Logistics Services Quality (SLSQ) to operational performance (OP) at container terminals. SLSQ is conceptualized as having four dimensions:

Sustainable Transportation, Sustainable Training, Sustainable Collaboration, Sustainable Information. Accordingly, the following hypotheses are proposed:

H1: There's a statistically significant relationship between SLSQ & operational performance of container terminals

H2: Sustainable transportation has a statistically significant positive impact on operational performance.

H3: Sustainable training has a statistically significant positive impact on operational performance.

H4: Sustainable collaboration has a statistically significant positive impact on operational performance.

H5: Sustainable information sharing has a statistically significant positive impact on operational performance.

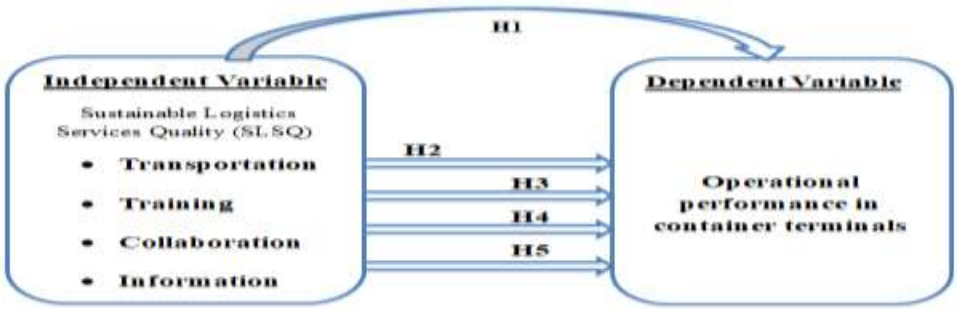

Figure 2.1: Research Variables

Source (Author)

The dependent variable in our framework is Operational Performance (OP), assessed through container handling efficiency, turnaround time, labor productivity, equipment utilization, and cost efficiency. The independent variable is Sustainable Logistics Services Quality (SLSQ), defined by the following dimensions:

1. Sustainable Transportation: Use of eco-friendly vehicles and intelligent route planning.
2. Sustainable Training: Provision of targeted training programs focused on sustainability.

3. Sustainable Collaboration: Joint initiatives and partnership engagements with stakeholders.
4. Sustainable Information Sharing: Integration of advanced data systems for better decision-making.

Based on the literature and preliminary interviews, the following hypotheses are formulated:

- H1: SLSQ is positively correlated with the operational performance of container terminals.
- H2: Improved sustainable transportation practices significantly enhance operational performance.
- H3: The quality and extent of sustainable training significantly boost operational performance.
- H4: Effective collaboration among stakeholders positively influences operational performance.
- H5: The availability and use of sustainable information significantly contribute to operational performance.

4. Methodology

4.1 Research Design

This study employs a mixed-methods research design to guarantee a comprehensive understanding. A deductive methodology underlies the quantitative phase, whereas an interpretive perspective directs the qualitative investigation. The research design consists of:

- Qualitative Phase: Semi-structured interviews with stakeholders, including terminal managers, logistics officers, and operational supervisors from major ports in Egypt. The interviews were employed to authenticate the research variables and to contextualize sustainable practices within local operations.
- The quantitative phase involved the distribution of a structured survey, utilizing a 5-point Likert scale, to 150 professionals at Egyptian container terminals. Data were examined utilizing the Statistical Package for the Social Sciences (SPSS) for descriptive statistics, regression analysis, and normality assessment.

4.2 Data Collection

Interviews: Comprehensive interviews, ranging from 20 to 40 minutes, were conducted through in-person meetings and Zoom. The interview protocol comprised open-ended questions examining perceptions, practices, and challenges associated with SLSQ.

Questionnaire: A structured questionnaire was employed to obtain quantitative data concerning various SLSQ dimensions and operational performance metrics.

Secondary Data:

A systematic literature review established context and facilitated the formulation of the conceptual framework and measurement items.

4.3 Data Analysis

Data analysis included the following steps:

Descriptive Analysis: Frequencies, means, and standard deviations were computed to evaluate demographic and principal variable attributes.

Normality Assessment: Both formal (Kolmogorov-Smirnov test) and informal (skewness and kurtosis) evaluations were performed. Due to multiple variables deviating from normality, nonparametric methods (Spearman's correlation) were utilized.

Regression Analysis: Simple and multiple linear regression models were employed to evaluate the individual effects of sustainable transportation, training, collaboration, and information on operational performance.

Structural Equation Modeling (SEM): The associations among variables were additionally confirmed through path analysis in LISREL. Goodness-of-fit indices (e.g., χ^2/df, GFI, RMSEA) validated the model's adequacy.

The data analyses are conducted using the Statistical Package for the Social Sciences (SPSS), version 25. The conclusion section summarizes the main findings of the current research. The next step involves analyzing the data using Structural Equation Modeling (SEM) through the path analysis method. In this process, the matrix of correlation coefficients between the independent variables (transportation, training, collaboration, and information), and the dependent variable, operational performance in container terminals, is subjected to path analysis to test causal relationships.

5. Results

5.1 Descriptive Statistics

The respondent profile (n = 150) indicated that 70.7% were male and 62.7% possessed a bachelor's degree, with most professionals having 1–11 years of experience in logistics operations. Key variables were assessed through aggregated scores derived from survey responses, with the SLSQ and Operational Performance receiving predominantly favorable evaluations.

5.2 Normality Assessment

The Kolmogorov-Smirnov test revealed that the variables "Sustainable Logistics Services Quality" and "Sustainable Information" exhibited a normal distribution ($p > 0.05$), whereas other dimensions (training, transportation, collaboration, and operational performance) did not conform to normality ($p <$

0.05). Analysis of skewness and kurtosis indicated near symmetry for the majority of variables.

5.3 Regression Analysis

Simple regression analyses confirmed that:

- Transportation: Explained 20.3% of the variance in operational performance ($\beta = 0.450$, $p < 0.001$).
- Training: Accounted for 25.5% of the variance ($\beta = 0.505$, $p < 0.001$).
- Collaboration: Explained 26.9% of the variance ($\beta = 0.519$, $p < 0.001$).
- Information: Had the strongest effect, explaining 33% of the variance ($\beta = 0.575$, $p < 0.001$).

A multiple regression model that included all SLSQ dimensions demonstrated an overall R^2 of 0.443, signifying that 44.3% of the variance in operational performance was collectively accounted for by the four dimensions.

5.4 Structural Equation Modeling

Path analysis using LISREL produced excellent fit indices ($\chi^2/df = 2.79$, GFI = 0.983, RMSEA = 0.050). All path coefficients were significant, reinforcing the model's robustness. The standardized effects were:

Transportation:	Training:	Collaboration:	Information:
0.52	0.4	0.62	0.71

5.5 Hypothesis Testing Summary

All five hypotheses (H1–H5) were statistically confirmed:

- H1: A significant positive relationship exists between SLSQ and operational performance.
- H2–H5: Each SLSQ dimension (transportation, training, collaboration, and information) significantly and positively impacts operational performance.

6. Discussion

6.1 Interpretation of Findings

1. The Significance of Transportation in Operational Efficiency. The findings demonstrate a substantial positive direct impact of Transportation ($\beta = 0.52$, $p < 0.01$) on Operational Performance. This indicates that effective transportation logistics, encompassing the optimization of supply chain routes and port infrastructure, can significantly improve the efficiency of container terminals. This corresponds with prior studies highlighting transportation networks as a vital factor in the operational success of ports.

2. The Influence of Training on Operational Efficiency. The significant positive effect of Training ($\beta = 0.47$, $p < 0.01$) underscores the critical role of workforce skill enhancement in augmenting performance. Training programs equip employees to proficiently manage contemporary logistics systems, advanced

technology, and crisis management, resulting in more efficient terminal operations. These findings corroborate research suggesting that investment in employee training enhances productivity and operational efficiency.

3. The Importance of Collaboration, Collaboration demonstrated the most significant positive impact ($\beta = 0.62$, $p < 0.01$) on operational performance, underscoring the importance of inter-organizational cooperation, supply chain alliances, and teamwork among port authorities, shipping companies, and logistics firms in attaining enhanced efficiency. These findings align with the literature highlighting that collaborative practices enhance coordination, decrease turnaround time, and optimize resource utilization.

4. The Impact of Information Dissemination, The most significant direct effect was noted for Information ($\beta = 0.71$, $p < 0.01$), signifying that real-time data exchange, digital transformation, and sophisticated information systems are essential for enhancing operations and decision-making in container terminals. The findings correspond with research indicating that data-driven logistics and integrated information systems markedly improve efficiency, minimize delays, and enhance overall performance.

6.2 Theoretical Implications

This research advances theory by merging sustainability with logistics service quality, a neglected domain in the maritime industry. The validated conceptual framework illustrates the interaction of specific sustainable dimensions to improve performance. The study validates the multifaceted impact of SLSQ on operational performance, thereby promoting the enhancement of service quality models in logistics.

6.3 Practical Implications

The study provides pragmatic recommendations for container terminal operators in Egypt and comparable emerging economies:

Prioritize investment in Information Technologies: to enhance digitalization, thereby improving tracking, data transparency, and decision-making.

Formulate Comprehensive Training Programs: Targeted sustainability training can enhance overall operational proficiency.

Establish Strong Collaborations: Involving stakeholders via strategic alliances can enhance environmental outcomes and customer contentment.

Embrace Sustainable Transportation Methods: Shifting to eco-friendly fleets and advanced routing systems can diminish emissions and operational expenses.

6.4 Limitations

The study's geographical focus is exclusively on Egyptian container terminals, which may limit the generalizability of the findings to other regions. Additionally, data collection was conducted within a restricted timeframe, resulting in an inability to observe longer-term performance impacts. Furthermore, access limitations were encountered, as certain terminals provided only limited access to internal operational data due to confidentiality concerns. These factors should be considered when interpreting the results and their applicability beyond the context of this research.

7. Conclusion & Implications.

This study provides a comprehensive exploration of how Sustainable Logistics Services Quality (SLSQ) impacts container terminal operational performance in Egypt. The mixed-methods research design enabled a robust investigation by integrating qualitative insights from stakeholder interviews with quantitative survey data. The empirical analysis confirms that sustainable practices especially sustainable information sharing and training significantly enhance operational performance, as evidenced by improved throughput, reduced turnaround time, and optimized cost efficiency.

7.1 Recommendations

The conclusions drawn from semi-structured interviews and surveys offer distinct insights into the existing practices, challenges, and opportunities for sustainable logistics in emerging economies. Given the practical significance of the subject, the research presents the following recommendations to enhance operational performance in container terminals in Egypt and to encourage the implementation of sustainable logistics practices:

1. Formulate Comprehensive Strategies for Sustainable Quality in Logistics Services: Container terminals must implement comprehensive and integrated strategies to elevate the quality of sustainable logistics services, emphasizing the development and enhancement of sustainable transportation, specialized training programs, effective collaboration among all pertinent stakeholders, and investment in advanced information systems.
2. Prioritize Investment in Information Infrastructure: Due to the substantial influence of information on operational performance, container terminals must prioritize the development of a robust technological infrastructure and integrated information systems that facilitate the efficient collection, analysis, and exchange of data to enhance informed decision-making and operational efficiency.
3. Develop and Execute Specialized Sustainable Training Programs: Sustainable training programs must be meticulously crafted and executed to address the specific requirements of personnel across different departments within container terminals, emphasizing the

skills and knowledge essential for the application of sustainable logistics practices and enhancement of operational performance.

4. Enhance Strategic Partnerships and Collaboration: It is advisable to fortify strategic partnerships and implement collaborative mechanisms among container terminals and pertinent stakeholders in the supply chain, including transportation firms, regulatory bodies, and clients, to facilitate the exchange of knowledge, resources, and best practices in sustainable logistics.

5. Implement Sustainable Performance Metrics and Impact Assessment: Container terminals must adopt performance metrics that incorporate sustainability factors and evaluate the environmental, social, and economic impacts of their logistics practices, utilizing these metrics to pinpoint areas for enhancement and monitor progress towards sustainability and operational performance objectives.

6. Endorse Governmental Policies and Initiatives for Sustainability: Container terminals are encouraged to actively endorse and engage in governmental policies and initiatives designed to enhance sustainability within the transport and logistics sector, thereby contributing to the realization of a national vision for more sustainable and efficient logistics.

7. LSPs ought to invest in employee training and environmental awareness initiatives.

8.Policymakers ought to establish incentives and regulatory frameworks that promote sustainability in logistics.

7.2 Recommendations for Further Research

Future research should concentrate on creating a sector-specific index to assess and benchmark Sustainable Logistics Services Quality (SLSQ) in ports worldwide. Furthermore, it is imperative to examine the incorporation of SLSQ within additional logistics nodes, including dry ports and inland terminals. The utilization of simulation modeling may yield significant insights by forecasting the long-term effects of diverse sustainability strategies. These methodologies will augment the comprehension of SLSQ across various contexts and facilitate the progression of sustainable practices within the logistics industry.

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