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## SUSTAINABILITY AND RISK MANAGEMENT IN SHIPPING AND LOGISTICS: BALANCING ENVIRONMENTAL CONCERNS WITH OPERATIONAL RESILIENCE

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### ABSTRACT

This paper explores the delicate balance between sustainability and risk management in the shipping and logistics industry, addressing the escalating environmental concerns while ensuring operational resilience. Investigating the adoption of sustainable practices, alternative fuels, and eco-friendly technologies, the study examines regulatory frameworks and industry initiatives shaping sustainable development. Simultaneously, it delves into the risks associated with these changes, including financial, operational, and regulatory dimensions. The research also scrutinizes risk management strategies, encompassing proactive measures to mitigate environmental impact, compliance with evolving regulations, and the implementation of resilient operational frameworks. Through a comprehensive synthesis of academic literature, case studies, and industry insights, the paper contributes to understanding how sustainability efforts can align with robust risk management, offering valuable guidance for industry stakeholders, policymakers, and academics navigating the complex landscape of environmental responsibility and operational resilience in the global supply chain.

**Keywords:** Sustainability, Risk Management, Shipping Logistics, Environmental Operational, Resilience.

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## INTRODUCTION

The shipping and logistics industry plays a pivotal role in global trade, facilitating the movement of goods across vast distances and connecting markets worldwide (Coe, 2017). It encompasses various modes of transportation, including maritime shipping, air freight, rail, and trucking, forming a complex network that is indispensable for the functioning of the global economy. The industry serves as the lifeblood of trade, enabling the efficient flow of raw materials, finished products, and commodities between producers, suppliers, and consumers. Maritime shipping, in particular, is a cornerstone of international trade, accounting for the majority of goods transported globally (Hoffmann and Kumar, 2013). Massive container vessels, bulk carriers, and tanker ships navigate the seas, linking major ports and facilitating cross-border commerce. Concurrently, air freight, rail, and trucking contribute to the efficiency and connectivity of supply chains, ensuring timely delivery and responsiveness to market demands. The logistics sector, intricately woven into the fabric of global commerce, encompasses the management of the entire supply chain (Rushton, 2007). This includes warehousing, distribution, transportation, and inventory management, all working in concert to optimize the movement of goods. As e-commerce continues to thrive and consumer expectations evolve, the shipping and logistics industry faces increasing challenges and opportunities, necessitating a reevaluation of its traditional practices. In recent years, the shipping and logistics industry has witnessed a paradigm shift in its approach towards sustainability and risk management (Koh et al., 2020). The recognition of environmental concerns, such as climate change and carbon emissions, has prompted a reexamination of industry practices. As the world grapples with the consequences of global warming and environmental degradation, stakeholders in the shipping and logistics sector are under mounting pressure to adopt sustainable and eco-friendly measures. Sustainability in this context involves the implementation of practices that reduce the industry's environmental footprint (Angelakoglou and Gaidajis, 2015). From the deployment of green technologies to the incorporation of renewable energy sources, the quest for sustainability is reshaping the way goods are transported across the globe. Regulatory bodies, including the International Maritime Organization (IMO), have introduced stringent guidelines to curb emissions and encourage the adoption of cleaner technologies, further emphasizing the urgency of sustainable practices. Simultaneously, the industry faces an array of risks that can disrupt operations, ranging from natural disasters and geopolitical tensions to cybersecurity threats and supply chain disruptions. The importance of effective risk management strategies cannot be overstated, as they are crucial for maintaining operational resilience and ensuring business continuity. A proactive approach to identifying, assessing, and mitigating risks is paramount for the industry's long-term success in a rapidly changing global landscape (Rasmussen and Suedung, 2000).

The challenge lies in striking a delicate balance between addressing environmental concerns and maintaining operational resilience. While the push for sustainability is undeniable, it must be harmonized with the industry's need to navigate various operational challenges and uncertainties. Achieving this equilibrium requires a comprehensive and integrated approach that considers both environmental stewardship and the robustness of logistics operations. Balancing

environmental concerns with operational resilience involves not only adopting sustainable practices but also fortifying the industry against the myriad risks it faces. It requires a nuanced understanding of the interplay between environmental factors, regulatory requirements, and the dynamic nature of global supply chains. The industry must navigate this intricate landscape with strategic foresight, leveraging innovations in technology, logistics management, and risk mitigation strategies to create a sustainable and resilient future (Fiksel and Fiksel, 2015).

### **Sustainable Practices in Shipping and Logistics**

The imperative for sustainability in the shipping and logistics industry has fueled a wave of green technologies and innovations aimed at minimizing the environmental impact of transportation and supply chain operations (Oloruntobi et al., 2023). The shift towards alternative fuels has emerged as a prominent strategy to reduce the carbon footprint of maritime and transportation activities. Liquefied Natural Gas (LNG) and biofuels have gained traction as cleaner alternatives to traditional fossil fuels. LNG, in particular, emits significantly fewer greenhouse gases and air pollutants, providing a viable option for vessel propulsion (Usiagu et al., 2024). Biofuels derived from renewable sources further contribute to lowering emissions, presenting a sustainable alternative for both maritime and land-based transport. The design and construction of energy-efficient vessels and vehicles represent a crucial aspect of sustainable practices. Shipbuilders are integrating advanced technologies, such as optimized hull designs, improved propulsion systems, and energy recovery systems, to enhance the overall energy efficiency of maritime transport. Similarly, the logistics sector is witnessing the adoption of electric and hybrid vehicles, coupled with advancements in aerodynamics and lightweight materials, to minimize fuel consumption and emissions in terrestrial transportation. Ports, as integral components of the logistics chain, are embracing renewable energy solutions to power their operations. Solar panels, wind turbines, and other renewable energy sources are being integrated into port infrastructure to generate clean energy (Ahmed and Cameron, 2014). This not only reduces the environmental impact of port activities but also contributes to the overall sustainability of the entire supply chain.

### **Emission Reduction Strategies**

The International Maritime Organization has taken a proactive stance in addressing the environmental impact of the shipping industry. IMO regulations, such as the International Maritime Organization's MARPOL Annex VI, mandate the reduction of sulphur oxide (SO<sub>x</sub>) and nitrogen oxide (NO<sub>x</sub>) emissions (Bendriss Bounnough, 2023). The implementation of stricter fuel standards, including the use of low-sulphur fuels, aims to curb air pollution from vessels. These regulatory measures serve as a catalyst for the adoption of cleaner technologies and practices across the industry. Acknowledging that complete elimination of emissions is a complex task, carbon offsetting programs have gained prominence. Companies in the shipping and logistics sector participate in these programs, investing in projects that reduce or capture emissions elsewhere to compensate for their own carbon footprint (Hoffman, 2007). This approach allows for a more immediate and tangible impact on the industry's overall greenhouse gas emissions. Fleet optimization involves the use of advanced technologies to enhance fuel efficiency and reduce emissions. This includes the implementation of predictive maintenance systems, route optimization software, and real-time monitoring of fuel consumption. By fine-tuning operational practices and embracing data-driven decision-making, companies can achieve substantial reductions in fuel usage and environmental impact (Tran et al., 2023).

### **Sustainable Supply Chain Management**

Sustainable supply chain management extends beyond transportation to encompass packaging practices (Atadoga et al., 2024). Companies are increasingly adopting eco-friendly packaging materials, such as recycled or biodegradable options. Additionally, innovative packaging designs that reduce material usage and enhance recyclability contribute to a more sustainable approach throughout the entire supply chain. Modal shifts involve optimizing transportation modes to minimize environmental impact. Shifting from road to rail or water transport for certain legs of the journey can significantly reduce emissions (Pinchasik et al., 2020). Intermodal transportation, seamlessly integrating different modes such as rail, road, and sea, offers a holistic approach to sustainable supply chain management by leveraging the strengths of each mode while minimizing their individual environmental drawbacks. Collaboration with suppliers is crucial for the holistic implementation of sustainable practices. Companies are increasingly engaging with their suppliers to ensure that environmental standards are upheld throughout the supply chain (Ejairu et al., 2024). This may involve sourcing materials from environmentally responsible suppliers, promoting sustainable manufacturing processes, and fostering transparency in the supply chain to trace the environmental impact of products from origin to destination. Sustainable practices in shipping and logistics encompass a diverse array of technological innovations, regulatory compliance, and holistic supply chain management strategies (Ejairu et al., 2024). By embracing these sustainable practices, the industry not only addresses environmental concerns but also lays the groundwork for a resilient and responsible future. The integration of green technologies and emission reduction strategies, coupled with sustainable supply chain management, reflects a collective commitment to balancing economic viability with environmental stewardship (Okoye et al., 2024).

### **Risk Management in Shipping and Logistics**

Effective risk management is essential in the dynamic and interconnected world of shipping and logistics, where a multitude of factors can disrupt operations and threaten the resilience of the entire supply chain (Etemad et al., 2021).

### **Identifying and Assessing Risks**

The shipping and logistics industry is inherently vulnerable to natural disasters. Storms, hurricanes, earthquakes, and other catastrophic events can result in port closures, infrastructure damage, and vessel accidents (Wendler Bosco, 2020). Risk assessments involve evaluating the geographical locations of operations, historical data on natural disasters, and the implementation of contingency plans to mitigate the impact of such events (Okoye et al., 2024). Geopolitical factors, including political instability, trade sanctions, and regional conflicts, pose significant risks to the industry. Shifts in global political dynamics can impact trade routes, introduce new regulations, or lead to disruptions in international relations. Continuous monitoring of geopolitical developments, scenario planning, and maintaining flexibility in route planning are crucial components of mitigating geopolitical risks. With the increasing reliance on digital technologies, the shipping and logistics sector is exposed to cybersecurity threats (Abrahams et al., 2024). Unauthorized access to critical systems, data breaches, and ransomware attacks can paralyze operations, compromise sensitive information, and lead to financial losses. Robust cybersecurity measures, employee training, and the implementation of secure digital systems are imperative to safeguard against these evolving threats (George et al., 2023).

### **Operational Risks**

Operational risks often stem from equipment failures, including those related to vessels, trucks, and other transportation modes. Regular maintenance schedules, predictive maintenance technologies, and comprehensive inspection protocols are crucial for preventing equipment failures (Mobley, 2002). Quick response mechanisms and contingency plans must be in place to minimize disruptions when unexpected failures occur. Human factors, encompassing issues such as inadequate training, fatigue, and errors in decision-making, contribute significantly to operational risks (Coker et al., 2023). Comprehensive training programs, adherence to international safety standards, and the promotion of a safety culture within organizations are essential elements in mitigating human-related risks. Monitoring fatigue levels and implementing rest periods for crew members are critical for ensuring optimal performance and safety (Bendak and Rashid, 2020). The shipping and logistics industry operates within a complex web of international and national regulations. Compliance risks arise from changes in regulations, failure to meet safety standards, and legal repercussions for non-compliance. Regular audits, ongoing education on regulatory changes, and robust documentation processes are essential for ensuring that companies remain compliant with evolving standards.

### **Supply Chain Disruptions**

The global outbreak of pandemics, as witnessed with events like COVID-19, can severely disrupt supply chains (Xu et al., 2020). Health risks not only impact workforce availability but can also lead to the closure of ports, manufacturing facilities, and transportation hubs (ETELE et al., 2024). Risk management in this context involves the development of contingency plans, stockpiling critical supplies, and establishing alternative sourcing strategies. Political instability and trade wars introduce uncertainties that can significantly impact the movement of goods (Sheng et al., 2021). Tariff fluctuations, trade restrictions, and diplomatic tensions can lead to abrupt changes in shipping routes and supply chain dynamics. Diversification of suppliers, scenario planning, and staying informed about geopolitical developments are key components of managing risks associated with political instability (Okoye et al., 2024). The widespread adoption of just-in-time inventory management practices has increased efficiency but also heightened vulnerability to disruptions. Supply chain interruptions, whether due to natural disasters or geopolitical events, can quickly lead to shortages (Nwankwo et al., 2024). Mitigation strategies include maintaining safety stock, establishing relationships with multiple suppliers, and leveraging technology for real-time monitoring of inventory levels. Effective risk management in shipping and logistics requires a multifaceted approach that addresses a spectrum of potential threats. From natural disasters and geopolitical risks to operational challenges and supply chain disruptions, proactive identification, assessment, and mitigation strategies are vital. In a rapidly evolving global landscape, the ability to navigate and adapt to these risks is crucial for ensuring the resilience and sustainability of the shipping and logistics industry (Adekanmbi et al., 2024).

### **Integration of Sustainability and Risk Management**

The integration of sustainability and risk management in the shipping and logistics industry represents a paradigm shift in operational strategies. By intertwining these two critical aspects, companies can not only enhance their environmental stewardship but also fortify their resilience against a spectrum of risks (Abrahams et al., 2024).

### **Developing a Comprehensive Risk Management Framework**

The foundation of effective risk management lies in the identification and assessment of potential threats. In a comprehensive framework, companies engage in a thorough analysis of both traditional operational risks and sustainability-related risks (Xu et al., 2019). This involves continuous monitoring of external factors, emerging trends, and potential disruptions to identify risks that may impact environmental sustainability and operational resilience. Once risks are identified, the development of robust mitigation strategies becomes imperative. Companies integrate sustainability considerations into these strategies, addressing not only the immediate operational implications but also the potential environmental impact. This may involve the implementation of green technologies, supply chain diversification, and the adoption of circular economy principles to minimize the negative consequences of both traditional and sustainability-related risks. Contingency planning is a crucial component of a comprehensive risk management framework. Companies develop contingency plans that account for potential disruptions to both operations and sustainability initiatives. For example, in the event of a natural disaster, contingency plans may include alternative transportation routes that minimize environmental impact, ensuring a swift response that aligns with sustainability goals (Weilant et al., 2019).

### **Aligning Sustainability Goals with Risk Mitigation**

The integration of sustainability into risk analysis involves assessing the potential environmental consequences of identified risks. This includes evaluating the impact of operational disruptions on ecosystems, air and water quality, and overall environmental health. By quantifying and considering the ecological footprint associated with various risks, companies can prioritize mitigation strategies that align with their sustainability goals (Mahapatra et al., 2021). Sustainable fleet management is a core element of aligning sustainability goals with risk mitigation. Companies invest in fuel-efficient and low-emission vehicles, implement advanced route optimization technologies, and adopt alternative fuels to reduce the carbon footprint of transportation operations. Integrating sustainability metrics into fleet management practices ensures that risk mitigation efforts align with broader environmental objectives. Transparency is fundamental to integrating sustainability and risk management. Companies engage in carbon disclosure and reporting, providing stakeholders with clear insights into their greenhouse gas emissions, sustainability initiatives, and resilience strategies. This not only enhances accountability but also enables stakeholders to evaluate the company's commitment to environmental responsibility in the face of operational risks (Waddock et al., 2002).

### **Stakeholder Engagement and Communication**

Transparent communication regarding environmental performance is essential for building trust with stakeholders. Companies communicate their sustainability achievements, goals, and strategies, providing stakeholders with a clear understanding of how sustainability is embedded in risk management practices (Azapagic, 2003). Transparent reporting fosters accountability and demonstrates a commitment to both environmental responsibility and operational resilience. The integration of sustainability and risk management often extends beyond individual companies to collaborative efforts within the industry. Companies engage with industry partners to share best practices, develop joint risk mitigation strategies, and collectively address sustainability challenges (Beske et al., 2014). Collaborative initiatives contribute to a

more resilient industry while fostering a shared commitment to sustainable practices. Stakeholder concerns related to sustainability and risk management are actively addressed through proactive communication and responsive strategies. Companies establish channels for feedback, conduct regular stakeholder consultations, and adjust their sustainability and risk management approaches based on the evolving expectations and concerns of stakeholders. Addressing these concerns not only enhances stakeholder relations but also contributes to the development of more robust risk management strategies. The integration of sustainability and risk management in shipping and logistics requires a holistic and collaborative approach. Companies that successfully intertwine these critical aspects not only enhance their ability to navigate operational challenges but also contribute to a more sustainable and resilient industry. By aligning sustainability goals with risk mitigation efforts and fostering transparent communication with stakeholders, companies can forge a path towards a future where environmental responsibility and operational resilience go hand in hand (Adaga et al., 2024).

### **Case Studies and Best Practices**

Maersk, one of the world's largest shipping companies, has been a pioneer in environmental stewardship (Alger et al., 2021). The company has invested heavily in fleet optimization, introducing Triple-E class vessels that are among the most energy-efficient in the industry. Maersk has also committed to carbon neutrality by 2050, with a focus on exploring alternative fuels such as biofuels and hydrogen. This commitment extends beyond vessels to encompass all aspects of its operations, demonstrating a holistic approach to sustainability. UPS, in the logistics sector, has stood out for its commitment to sustainability. The company has implemented a comprehensive approach, integrating alternative fuel vehicles into its fleet and investing in electric delivery trucks. UPS has set ambitious goals, aiming to achieve 25% of its total electricity consumption from renewable sources by 2025. Additionally, UPS has embraced eco-friendly packaging solutions, reducing waste and promoting circular economy principles (Pastore et al., 2022). CMA CGM, a major container shipping company, has demonstrated innovative risk management approaches, particularly in addressing cybersecurity threats (Korsvik, 2023). Recognizing the growing risks associated with digitalization, the company has implemented advanced cybersecurity measures to protect its systems and data. This includes continuous monitoring, employee training, and collaboration with cybersecurity experts to stay ahead of evolving threats. By proactively addressing cybersecurity risks, CMA CGM enhances both operational resilience and the protection of sensitive information. FedEx has excelled in operational risk management, particularly in the context of natural disasters. The company has developed a robust contingency planning system that includes real-time monitoring of weather patterns and potential disruptions. By leveraging technology and data analytics, FedEx can quickly reroute shipments, activate alternative transportation routes, and ensure timely delivery even in the face of adverse weather conditions (Cozzolino et al., 2017). This proactive approach minimizes the impact of natural disasters on the supply chain and enhances overall resilience. The Global Maritime Forum, in collaboration with various industry stakeholders, launched the Getting to Zero Coalition to accelerate the decarbonization of the shipping industry (Grzelakowski et al., 2022). This collaborative initiative brings together leading shipping companies, governments, and environmental organizations to work towards the common goal of reducing greenhouse gas emissions from shipping. By fostering collaboration, sharing best

practices, and driving innovation, the Getting to Zero Coalition exemplifies the power of industry-wide initiatives to address sustainability challenges.

Smart Freight Centre's Global Logistics Emissions Council (GLEC), initiated by the Smart Freight Centre, is a collaborative effort to standardize the measurement and reporting of greenhouse gas emissions in the logistics sector. By establishing a common framework and guidelines, the GLEC enables companies across the logistics industry to transparently report their emissions, track progress, and collectively work towards reducing the environmental impact of freight transport (Punte and Bollee, 2018). This collaborative approach enhances accountability and accelerates the adoption of sustainable practices.

### **Future Trends and Challenges**

The shipping and logistics industry is on the brink of transformative changes as it navigates emerging technologies, evolving regulatory landscapes, and the imperative for sustainable practices. Anticipating and adapting to these trends and challenges is crucial for the industry's continued growth and resilience.

### **Emerging Technologies in Shipping and Logistics**

The advent of autonomous technologies is reshaping the future of shipping and logistics. Autonomous vessels, often referred to as unmanned surface vessels (USVs) or autonomous ships, have the potential to revolutionize maritime transport (Barrera et al., 2021). These vessels can optimize routes, reduce fuel consumption, and operate continuously, enhancing efficiency and safety. Similarly, in logistics, autonomous vehicles, including drones and self-driving trucks, are being explored to improve last-mile delivery and warehouse operations. The implementation of autonomous technologies will not only drive operational efficiency but also introduce new challenges related to cybersecurity, regulatory frameworks, and the adaptation of existing infrastructure. Artificial Intelligence (AI) is increasingly becoming a powerful tool for risk management in the shipping and logistics sector (Foster and Rhoden, 2020). AI algorithms can analyze vast amounts of data to predict and mitigate operational risks. Predictive maintenance systems, powered by AI, can forecast equipment failures and optimize maintenance schedules. AI-driven risk prediction models can enhance the industry's ability to anticipate and respond to various challenges, including weather-related disruptions, geopolitical risks, and cybersecurity threats. However, integrating AI comes with challenges such as data privacy concerns, the need for skilled personnel, and ethical considerations. The adoption of circular economy practices is gaining prominence in the logistics sector. Companies are exploring ways to minimize waste, optimize resource use, and design products and packaging for maximum recyclability. Circular supply chains aim to reduce the environmental impact by promoting the reuse, refurbishment, and recycling of products. This shift towards circular economy practices aligns with growing consumer expectations for sustainable and responsible supply chains. It requires collaboration across the supply chain, innovative business models, and a shift from traditional linear supply chains to more circular and regenerative approaches (Howard et al., 2019).

### **Regulatory Landscape Evolution**

The regulatory landscape for environmental standards in the shipping industry is undergoing significant changes. The International Maritime Organization (IMO) continues to introduce and update regulations to reduce emissions and promote sustainable practices. The adoption of stricter fuel standards, the implementation of the Energy Efficiency Existing Ship Index (EEXI),



and the push towards decarbonization are shaping the industry's future. Companies must adapt to comply with these evolving standards, invest in green technologies, and align their sustainability goals with regulatory requirements. As sustainability becomes increasingly integral to corporate strategies, there is a growing emphasis on integrating sustainability metrics into risk reporting. Companies are expected to disclose not only their financial risks but also the environmental, social, and governance (ESG) risks associated with their operations. This shift towards holistic risk reporting allows stakeholders to assess the overall resilience and sustainability of organizations. Integrating sustainability metrics into risk reporting requires enhanced transparency, robust data collection processes, and the incorporation of non-financial risks into corporate governance structures (Dimes and Molinari, 2023). The industry's response to changing regulations extends beyond mere compliance; it involves proactively embracing sustainability initiatives. Companies are investing in research and development to stay ahead of regulatory requirements, adopting green technologies, and participating in industry collaborations to drive collective change. The focus on sustainability is not only a response to regulatory pressures but also a strategic imperative to meet evolving consumer expectations, attract investors, and ensure long-term business viability. The future trends and challenges in shipping and logistics encompass a landscape of technological advancements, regulatory evolution, and a heightened focus on sustainability. Navigating these changes requires a proactive approach, strategic investments, and a commitment to continuous innovation. As the industry embraces emerging technologies and adapts to evolving regulations, it has the opportunity to not only enhance operational efficiency but also lead the way towards a more sustainable and resilient future (Fiksel, 2003).

### **CONCLUSION**

The exploration of sustainability and risk management in the shipping and logistics industry has revealed a dynamic landscape characterized by a delicate interplay between environmental concerns and operational resilience. Key findings from this analysis include the critical role of sustainable practices, the multifaceted nature of operational risks, the importance of a comprehensive risk management framework, successful case studies, and emerging trends that will shape the industry's future. The integration of sustainability and risk management is not merely a contemporary trend; it has become a strategic imperative for the shipping and logistics industry. The recapitulation of key findings underscores the symbiotic relationship between these two facets. Sustainable practices not only contribute to environmental stewardship but also bolster operational resilience by mitigating risks and enhancing adaptability to a rapidly changing global landscape. The environmental impact of shipping and logistics operations is under heightened scrutiny, with stakeholders demanding greater accountability and responsible business practices. As regulatory bodies, consumers, and investors increasingly prioritize sustainability, the industry must recognize that managing operational risks and addressing environmental concerns are not mutually exclusive but rather complementary endeavors. Companies that successfully integrate sustainability and risk management into their core strategies are better positioned to thrive in a future where resilience and responsible business practices are intertwined.

Recognizing that the challenges faced are complex and multifaceted, industry stakeholders are urged to collaborate across value chains, share best practices, and collectively address sustainability and risk management challenges. Initiatives such as collaborative industry

forums, knowledge-sharing platforms, and joint research endeavors can facilitate a collective response to global challenges. Innovation emerges as a driving force in navigating the future of the industry. The call to action includes encouraging the development and adoption of innovative technologies, such as autonomous vessels, artificial intelligence for risk prediction, and circular economy practices. These innovations not only enhance efficiency but also contribute to sustainability goals, presenting opportunities for companies to gain a competitive edge in a rapidly evolving market. The integration of sustainability and risk management in shipping and logistics is not only a strategic imperative but a shared responsibility. The call to action invites industry stakeholders to collaborate, innovate, and lead the way towards a more sustainable, resilient, and responsible future. By collectively addressing challenges and seizing opportunities, the industry can play a pivotal role in shaping a future where environmental stewardship and operational excellence coexist harmoniously.

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