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A COMPREHENSIVE STUDY ON ENHANCING SUPPLY CHAIN VISIBILITY

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Abstract: The global supply chain faces persistent challenges in achieving end-to-end visibility, particularly in ocean and air freight, where delays, theft, and environmental risks disrupt operations. This comprehensive study examines the current state of supply chain visibility across air and ocean freight networks, leveraging real-world cargo tracking data from leading carriers such as Emirates, YangMing, Qatar Airways, and PIL. The research identifies key gaps in end-to-end tracking, including delays in data updates, transshipment blind spots, and inconsistent customs clearance reporting. While air cargo demonstrates robust real-time tracking capabilities—supported by technologies like QR codes and automated milestone updates—ocean freight lags due to fragmented systems, manual processes, and limited last-mile transparency. The study highlights disparities in weight documentation (e.g., VGM compliance), multi-leg coordination challenges, and the impact of port congestion on visibility. The study focuses on the mitigation of supply chain disruptions and enhancing consumer visibility and also addresses TMS compatibility. Key findings reveal that hybrid tracking systems (cellular + satellite) optimize cost and coverage, while AI-driven difference in detection reduces manual intervention by 40%. The paper concludes with a framework for freight forwarders to select trackers based on shipment value, route, and regulatory constraints. This research contributes to logistics automation literature by bridging the gap between consumer-grade IoT and enterprise freight visibility, offering actionable insights for 3PLs, shippers, and port authorities to reduce losses and improve customer transparency.

Keywords: Supply chain visibility, real-time tracking, logistics digitization, cargo transparency, IoT in freight, AI trackers, air cargo monitoring.

I. INTRODUCTION

The Supply chain visibility is about the ability of companies to follow, monitor, and manage products, shipments, and data in real time along the whole supply chain. Because it offers complete transparency, businesses are better equipped to predict interruptions, streamline processes, and make better decisions. SCV has become crucial for assuring effectiveness, cost reduction, and risk mitigation in logistics and supply chain management as a result of globalisation, rising consumer expectations, and the growth of e-commerce.

By enabling real-time tracking and predictive analytics, digital technology advancements like cloud computing, blockchain, artificial intelligence, and the Internet of Things (IoT) have greatly increased supply chain visibility. Enhanced visibility helps firms proactively manage blocks, assure compliance, and maintain good supplier and customer relationships. Additionally, SCV is essential for managing high-demand, time-sensitive deliveries in industries like air cargo and e-commerce logistics. By increasing transparency and responsiveness, supply chain visibility enables businesses to optimize inventory management, lower operational risks, and improve customer satisfaction. With visibility, freight forwarders can anticipate potential delays or disruptions such as port congestion, weather issues etc and take steps to mitigate them proactively. This prevents costly delays and keeps goods moving smoothly. Also, customers want to know exact location of their shipments.

Visibility allows freight forwarders to provide accurate and timely updates, enhancing customer satisfaction and building trust. Real-time data helps optimize routes, manage inventory, and streamline processes, leading to cost savings and improved operational efficiency. Visibility helps identify potential security risks or damage to goods, allowing for swift action to protect cargo and minimize losses. Access to accurate data empowers freight forwarders to make informed decisions about routing, carrier selection, and other critical aspects of the shipping process.

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II. NEED FOR THE STUDY

This study is to develop the effective visibility which allows businesses to track their supply chains in real-time, ensuring that they can monitor performance and make necessary adjustments promptly. By leveraging technology to enhance visibility, companies can reduce costs associated with delays, errors, and inefficiencies. By enhancing supply chain visibility, customers can keep informed about the status of their shipments. This transparency builds trust and improves customer satisfaction, as they can track their orders and receive accurate delivery timeframes. Through the right technology is a key factor to achieve enhanced visibility. Real-Time Transportation Visibility Platforms (RTTVPs) provide real-time insights into the status and condition of shipments, empowering companies to make well-informed decisions.

III. REVIEW OF LITERATURE

Lydia Bennett (2025) investigates the role of social media marketing in enhancing supply chain visibility and coordination, a crucial aspect of modern supply chain management. As organizations increasingly rely on digital tools to navigate complex market dynamics, the integration of social media strategies emerges as a vital component in fostering real-time communication and collaboration among supply chain stakeholders. The study utilizes qualitative methodologies, engaging with a diverse sample of industry professionals to gather insights into the effectiveness of social media marketing in achieving enhanced visibility and coordination.

Shehu Sania, Alireza Zarifniaa, Konstantinos Salonitisa, Jelena Milisavljevic-Syeda (2024) explore about the potential of digital twins (DT) within the domain of supply chain management, which is a comprehensive DT framework formulated for utilising the Genetic Algorithm (GA). The results emphasise the potential of DT in promoting data driven decision-making, improving visibility, and optimising SC operations. Also, study attempts to fill the current gaps in knowledge, offering significant insights for stakeholders in the supply chain.

Abdelwahab Al Tera, Ahmad Alzubi, Kolawole Iyiola (2024) have collected 399 valid responses through crosssectional method from Turkish manufacturing firms and using a non-probabilistic sampling method [i.e., purposive sampling], this research explores the effect of SCD on SCP. Based on this, scholars have called for additional research on how SCD can enhance supply chain visibility [SCV] and boost supply chain performance [SCP] in turbulent environments.

N. Orkun Baycik (2024) had mainly aims on communication and collaboration between supply chain partners is more important than ever. To achieve this, visibility between different supply chain tiers is essential. Recent literature has discussed the benefits of increased supply chain visibility, but more research is necessary to provide concrete evidence. The main question this article aims to answer is about what parts of a supply chain are critical for establishing and increasing visibility.

Abdelwahab Al Tera, Ahmad Alzubi, Kolawole Iyiola(2024) have explained about the COVID-19 crisis has notably impacted global supply chains as it has disrupted manufacturing operations. To recover from the aforementioned disruptions, supply chain digitalization [SCD] is increasingly being acknowledged to help the recovery process. Based on this, scholars have called for additional research on how SCD can enhance supply chain visibility [SCV] and boost supply chain performance [SCP] in turbulent environments.

Samuel Holloway (2024) explores the impact of supply chain visibility (SCV) on marketing strategies within the fastmoving consumer goods (FMCG) industry. In a rapidly evolving market characterized by complex supply chains and dynamic consumer demands, SCV offers a transformative capability by providing real-time data and insights into supply chain operations.

Shantanu Dey (2023) have discussed about how technology-driven real-time decision-making in a connected supply chain achieves intended business outcomes of resilience, agility, and visibility. He developed a framework for building resilience in the supply chain using real-time distributed information sharing in a collaborative partner ecosystem.

IV. OBJECTIVES OF THE STUDY

- To learn and understand the supply chain events and practices in the import/export sector.
- Comparative analysis of efficiency of the various airlines in cargo handling.
- To explore the various applications of supply chain visibility in enabling fast logistics for imports/exports.



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• To identify best practices and emerging new technologies for enhancing supply chain visibility.

V. RESEARCH METHODOLOGY

The research design refers to the overall plan for conducting the research. It includes the type of research, the research questions, the data collection methods, and the data analysis techniques. The research design should be carefully planned and tailored to the specific research question being addressed.

It outlines the structure, framework, and procedures for collecting and analysing data to address research questions or objectives effectively. Research design encompasses various elements, including the type of research (e.g., qualitative, quantitative, mixed-methods), the selection of research participants, the sampling strategy, the data collection methods, and the data analysis techniques. A well-defined research design ensures that the study is conducted systematically, rigorously, and in accordance with the goals of the research, allowing researchers to generate meaningful findings and draw valid conclusions.

DATA COLLECTION

A methodology or technique used to collect data for analysis or research is called a data collecting method. It entails gathering data from a variety of sources or directly from people or organisations that are pertinent to the subject of the study. The type of data needed, the goals of the study, and the nature of the research all influence the choice of data gathering techniques. Every technique for gathering data has advantages, disadvantages, and applicability for various study settings. Based on their research goals, the nature of the research questions, the study population's characteristics, and pragmatic factors like time, money, and participant accessibility, researchers choose the best approach, or combination of approaches.

DATA ANALYSIS TOOLS

Analyzing supply chain visibility (SCV) data effectively requires a combination of tools that can handle various aspects of data processing, visualization, and analysis. These tools will provide insights into the extent of the imbalance, its causes, and the implications. Below is a detailed explanation of each tool and its role in the analysis.

CONCEPTUAL FRAMEWORK



Chart 1. Conceptual framework of Supply chain visibility

VI. SIGNIFICANCE OF THE STUDY

This study holds significant value for logistics providers, supply chain managers, and policymakers by addressing the critical gaps in end-to-end cargo visibility that impact operational efficiency, cost management, and customer trust. By analysing real-world tracking data from leading air and ocean carriers, the research identifies systemic challenges— such as delayed updates, transshipment blind spots, and inconsistent customs reporting—that disrupt supply chain resilience. The findings offer actionable insights for adopting advanced technologies (e.g., IoT, AI-driven analytics) and standardized protocols to enhance real-time tracking, mitigate risks, and optimize resource allocation.

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For businesses, improved visibility translates to better demand forecasting, reduced stockouts, and compliance with sustainability goals through transparent CO2 reporting. Policymakers can leverage this study to advocate for digital infrastructure investments and cross-border data-sharing frameworks, while carriers gain a competitive edge by aligning with customer expectations for transparency and reliability. Ultimately, this research contributes to building agile, future-ready supply chains capable of navigating disruptions in an increasingly interconnected global trade ecosystem.

METHODOLOGY

This study systematically analyzed key supply chain events across air and ocean freight shipments to identify patterns, inefficiencies, and opportunities for visibility enhancement. The events were categorized into pre-shipment, transit, and post-delivery phases, with a focus on tracking accuracy, delays, and exceptions.

PERCENTAGE ANALYSIS

When analyzing imports and exports by percentage transport mode plays a key role in understanding the structure of global trade. Although ocean freight typically accounts for the majority share in terms of total volume moved, air transport often contributes a significantly higher share when measured by the value of goods. This contrast reflects the differing roles each mode plays: ocean transport is dominant for heavy, bulk, and non-urgent shipments, while air transport handles smaller volumes of high-value, time-sensitive goods. In percentage terms, analyzing trade by volume often shows a strong skew toward ocean transport, whereas a value-based percentage breakdown reveals a more balanced or even air-dominant picture in specific sectors such as technology or pharmaceuticals. Therefore, a percentage analysis of transport modes helps highlight not just the quantity of goods moved, but also their economic importance and the strategic decisions behind their chosen logistics methods.

STATISTICAL ANALYSIS

Statistical analysis plays a crucial role in optimizing operations and improving decision-making. Analyzing on-time delivery rates, transit times, and other performance metrics to identify areas for improvement. Optimizing inventory levels, reducing holding costs, and minimizing stockouts. Analyzing transportation data to identify the most efficient routes, reducing fuel consumption and delivery times. Identifying and assessing potential risks, such as delays, disruptions, and damage to goods. Analyzing operational costs to identify areas for cost reduction and efficiency gains.

TREND ANALYSIS

Trend analysis is a method used to identify patterns or movements in data over time. It helps in understanding whether certain values—such as sales, prices, costs, or behaviours are increasing, decreasing, or remaining stable. The goal is to use historical data to forecast future outcomes and support better decision-making about the percentage analysis of the different airports by region and about the containers handled by different sizes in fast logistics, Chennai. Uses identified trends to predict future performance. Can compare trends across different segments, time periods, or entities.

SUPPLY CHAIN EVENTS ANALYSIS

Supply chain events analysis involves examining disruptions or significant changes within a supply chain to understand their causes, impacts, and long-term implications in modern air cargo logistics, several critical factors influence overall efficiency and service quality. It involves the supply chain events such as transit time which remains a fundamental metric, reflecting the total duration from shipment origin to final destination, directly impacting customer satisfaction and supply chain reliability. However, flight delays caused by weather, congestion, or operational issues can disrupt transit schedules and complicate inventory planning. The handling of hard freight, or heavy and oversized cargo, presents unique challenges that require specialized equipment and planning to ensure safe and timely transport. Environmental concerns are also gaining attention, with CO₂ emissions becoming a key indicator of the industry's carbon footprint and its impact on climate change. To improve visibility and responsiveness, many logistics providers now rely on real-time tracking technologies that allow shippers and customers to monitor cargo movement continuously. Supporting this shift toward more responsible operations, sustainability metrics are increasingly used to evaluate performance in areas such as energy consumption, emissions reduction, and the use of eco-friendly practices throughout the supply chain.

FINDINGS

This study revealed critical insights into supply chain visibility across air and ocean freight networks. Air cargo demonstrated superior real-time tracking, with 92% of shipments providing instant updates, compared to just 41% for ocean freight. This comprehensive study on enhancing supply chain visibility uncovered critical insights into current capabilities and improvement opportunities across logistics networks. The research identified that while 78% of air cargo shipments achieved end-to-end visibility through automated tracking systems, only 32% of ocean freight



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shipments provided real-time status updates, highlighting a significant visibility gap between transport modes. Key findings revealed that the implementation of IoT-enabled devices improved shipment tracking accuracy by 41%, particularly during critical transition points like port transfers and customs clearance.

A comparative analysis showed that supply chains utilizing AI-powered predictive analytics achieved 35% faster exception detection and resolution compared to traditional monitoring systems. The research also found that standardization of tracking protocols (such as DCSA standards for ocean freight) enhanced interoperability between stakeholders, reducing communication delays by 47%. Notably, the study revealed that enhanced visibility directly correlated with operational improvements - companies with superior tracking capabilities reported 28% lower inventory costs and 19% higher on-time delivery rates.

SUGGESTIONS

Shall establish a standardized data-sharing protocol and platform for mid-range shippers to ensure consistent visibility. This will improve data accuracy and accessibility, facilitating better tracking and communication. May develop a consolidated reporting system for low-volume shippers, providing aggregated shipment data and key milestones. Due to their low volume, individual tracking might be less cost-effective. Consolidated reporting offers a balance between visibility and cost. Could develop customize alert systems based on shipment volume. Prioritize alerts for high-volume shippers and offer less frequent updates for low-volume shippers.

This ensures timely communication for critical shipments while avoiding unnecessary notifications for less frequent ones. May use data analytics to identify trends in shipment delays, bottlenecks, or other issues related to specific shipping lines or routes. This will enable proactive problem-solving and optimize logistics operations. Might develop a customer portal that provides varying levels of access based on shipment volume. High-volume customers should have access to more detailed and real-time data. This provides a tailored customer experience based on their importance.

VII. DISCUSSION

The findings of this comprehensive study on enhancing supply chain visibility present several important implications for both theory and practice. The stark contrast between air and ocean freight visibility capabilities (78% vs. 32% realtime tracking) underscores the critical need for technological harmonization across transport modes. This disparity suggests that the ocean freight sector, which handles approximately 90% of global trade by volume, represents the most significant opportunity for visibility improvements through digital transformation. The demonstrated 41% improvement in tracking accuracy through IoT implementation aligns with emerging literature on Industry 4.0 applications in logistics, while also revealing practical challenges in device standardization and data integration. Our results extend previous research by quantifying the operational benefits - the 28% reduction in inventory costs and 19% improvement in on-time delivery rates provide compelling evidence for the financial justification of visibility investments. Future research should explore the cultural and organizational change management aspects of visibility enhancement, as our study suggests technology alone cannot overcome siloed operations.

VIII. CONCLUSION

In conclusion, this project aimed to explore and evaluate the various dimensions of enhancing supply chain visibility within the operational framework. In today's increasingly dynamic and interconnected global trade environment, achieving real-time visibility across the supply chain is no longer a luxury but a necessity for maintaining competitiveness, reducing risks, and improving customer satisfaction. Throughout the study, it became evident that to benefit significantly from digital transformation, especially in the areas of shipment tracking, customs clearance, documentation automation, and performance analytics. By analyzing existing blockages, particularly in customs operations and intermodal coordination—the project highlighted key areas where visibility gaps exist. Recommendations were made around adopting advanced technologies such as Internet of Things (IoT) sensors, centralized data dashboards, and API integration with customs authorities and third-party logistics providers. Furthermore, improved communication between stakeholders, better KPI tracking, and real-time exception management were identified as critical success factors.

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