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Reducing Perishable Goods Lead Time in Air Cargo Logistics

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I. Introduction

Air cargo logistics is a critical enabler of global trade, particularly for high-value and time-sensitive perishables. The COVID-19 pandemic prompted airlines to expand cargo operations, exposing inefficiencies in air freight systems in developing economies like Sri Lanka. Delay in lead time can result from communication delays, connectivity issues, imprudent handling which is careless handling and weak technological integration, and prolonged verification and frisking procedures, leading to spoilage, financial losses, and reduced customer satisfaction. This study investigates mainly these four factors that affect most and proposes strategic interventions to enhance perishable cargo supply chain responsiveness and overall operational efficiency.

II. Study

A. Background of the Study

The transportation of perishable goods by air involves complex logistics, stringent quality controls, and precise timing. Key concepts central to this study include:

- Air cargo logistics: The coordination of freight movement via aircraft, encompassing handling, documentation, and intermodal connectivity.
- Perishable supply chain: A network of stakeholders managing goods with limited shelf life, requiring temperature control and rapid transit.
- Lead time reduction: Minimizing the time between order placement and delivery to preserve product quality.
- Transportation efficiency: Optimizing resources and processes to ensure timely, cost-effective, and sustainable delivery.

Sri Lanka's strategic location and growing agricultural exports make air cargo a vital component of its logistics infrastructure. However, inefficiencies in handling, communication, and inspection processes have hindered performance, especially for perishables.

B. Problem Statement

Despite the increasing reliance on air cargo for perishables, Sri Lanka faces persistent challenges in managing lead time. Delays caused by poor coordination, inadequate infrastructure, and outdated verification protocols compromise product quality and economic returns. The study addresses the following research questions:

- What are the key factors affecting air transportation lead time for perishable goods in Sri Lanka?
- Which of these factors contribute most significantly to delays?
- What measures can be implemented to reduce lead time and improve supply chain performance?

Research objectives:

- To identify the factors affecting Perishable Goods lead time.
- To analyze the significance of lead time occurring delays.
- To propose actionable strategies for lead time reduction.

C. Literature review

Air transportation plays a crucial role in global logistics by supporting economic growth and enabling rapid delivery of high-value and time-sensitive goods, particularly perishables [1]. Service quality remains essential in both passenger and cargo operations, as delays and poor handling can undermine customer confidence [2]. Shelf-life deterioration is a critical issue in perishable logistics, with environmental conditions such as temperature and humidity accelerating spoilage, thereby requiring fast and controlled transport systems [3]. Technologies including RFID and time-temperature indicators (TTIs) help monitor freshness and track cargo in real time [4], while TTIs also support shelf-life prediction based on temperature history [5].

Various mathematical models contribute to forecasting quality degradation. Markov chain models have been applied to analyses spoilage stages in products like salmon [6], whereas artificial neural networks have shown effectiveness

in predicting milk shelf-life [7]. Broader digital integration through enterprise systems and IoT enhances traceability and responsiveness in supply chains [8], though such advancements remain limited in many developing contexts.

Research further shows that increases in lead time significantly escalate operational costs due to disruptions in scheduling, storage, and handling processes [9], highlighting the economic consequences of air cargo delays [10]. However, limited empirical work examines the specific operational and procedural factors causing lead-time inefficiencies in Sri Lanka's perishable air cargo sector, creating a clear research gap.

D. Research Framework

Fig. 1 illustrates the conceptual research framework of the study, outlining all key variables, steps, and analytical procedures employed in achieving the research objectives.

E. Materials and Methods

A quantitative research methodology was adopted. A structured questionnaire was distributed to 100 professionals in Sri Lanka's air cargo sector, including airline staff, logistics managers, and customs officers. Each variable was measured using a 5-point Likert scale. The questionnaire was based on validated scales from prior air cargo and perishable logistics research and refined through expert feedback. It captured four key factors: Communication Delay, Connectivity, Imprudence, and Verification/Frisking covering operational, infrastructural, and behavioral aspects, with demographic questions included to contextualize responses.

Data were analyzed using SPSS, employing:

- Reliability testing (Cronbach's Alpha) & Validity checks (KMO and Bartlett's Test)
- Factor analysis was conducted separately for each of the four key dimensions to identify the underlying variables contributing most to lead time inefficiencies in perishable air cargo logistics.

The study adhered to ethical guidelines, ensuring respondent anonymity and informed consent.

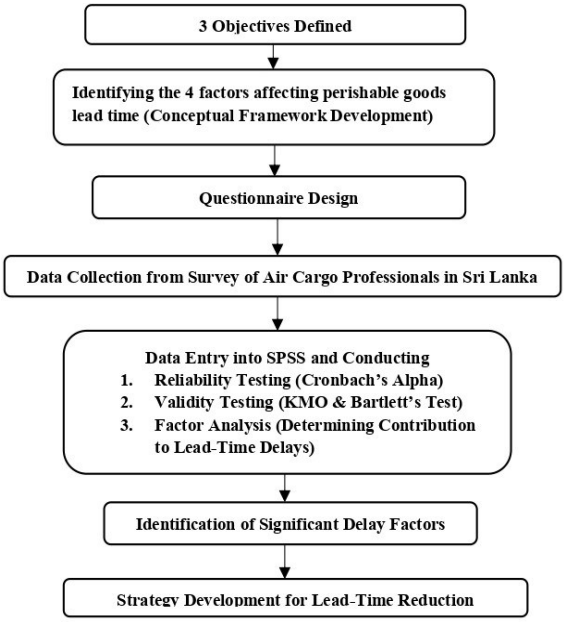

Fig. 1. Research framework

TABLE 1. FACTOR ANALYSIS SUMMARY

Factor	Variance Explained (%)	Key Variables	Factor Loadings
Communication Delay	60.6	Real-time information flow	0.895
		Teamwork-related communication	0.721
Connectivity	47.2	Congestion-related delays	0.926
		Route optimization	0.841
Imprudence	48.1	Modernized system adoption	0.824
		Real-time data use	0.827
Verification & Frisking	61.2	Administrative reporting inefficiencies	0.902
		Complaint-handling processes	0.725

F. Results and Discussion

All four factors demonstrated strong reliability ($\alpha > 0.7$) and validity (KMO > 0.5, $p < 0.001$). Factor analysis revealed several important insights into the determinants of perishable cargo lead-time inefficiencies. Table 1 presents the key variables with the highest factor loadings, indicating those that contribute most significantly to each extracted factor. The demographic profile of respondents shows a higher participation of females (55%) compared to males (45%), with the majority of respondents falling within the 36–45 age group (37%). Collectively, these findings highlight systemic operational and procedural constraints that prolong perishable cargo lead time in Sri Lanka's air cargo logistics sector.

These results address the literature gap by empirically identifying communication, connectivity, imprudence, and verification delays as key drivers of lead-time inefficiencies in Sri Lanka's perishable air cargo sector. The findings offer evidence-based priorities for improvement, highlighting the need for coordinated action through digital communication upgrades, better infrastructure, staff training, and streamlined verification processes.

G. Conclusion

This study shows that communication delays, weak connectivity, imprudent handling, and verification bottlenecks significantly extend lead times in Sri Lanka's perishable air cargo. Improving coordination, infrastructure, and inspections supported by real time monitoring and digital tools can enhance efficiency. Future research should examine regional systems and emerging technologies.

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