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ARTIFICIAL INTELLIGENCE IN OVER-DIMENSIONAL CARGO LOGISTICS: CHALLENGES AND FUTURE PROSPECTS IN INDIA

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ABSTRACT
This study examines the role of Artificial Intelligence (AI) in optimizing Over-Dimensional Cargo (ODC) logistics operations in India. It analyzes how AI applications such as route optimization, real-time tracking, predictive maintenance, and resource allocation improve operational efficiency and cost effectiveness. The research also identifies key challenges in AI adoption, including infrastructure limitations, data management issues, and employee adaptability. Statistical analysis highlights the relationship between AI implementation and operational performance. The study concludes that effective integration of AI can enhance safety, compliance, and long-term competitiveness in the ODC logistics sector.
KEYWORDS: *Artificial Intelligence, Over-Dimensional Cargo (ODC), Logistics Optimization, Operational Efficiency*

1. INTRODUCTION

Over-Dimensional Cargo (ODC) is a niche segment of the Indian logistics and transportation industry, which deals with the transportation of goods that are above the standard size and weight. These goods include heavy machinery, equipment, and infrastructure. Transportation of such goods is a complex and challenging task due to several issues, such as route planning, clearances, infrastructure, and safety. In today's world, where there is a rapid development and implementation of Artificial Intelligence (AI), the Indian logistics and transportation industry is going through a paradigm shift in terms of adopting AI-based decision-making processes. In this context, this study aims to focus on the major challenges of implementing AI in the Indian ODC logistics and transportation industry, and the future scope of AI in the Indian heavy cargo transportation and logistics industry.

2. REVIEW OF LITERATURE

AI Integration in SME Logistics: Challenges, Opportunities, and Practical Solutions – International Journal of Scientific Research in Science and Technology (2024) This paper explains how AI improves demand forecasting and route optimization in SME logistics. It highlights challenges like high implementation costs and data limitations. The study recommends a scalable and modular approach for successful AI adoption.

On Fulfilling the Exigent Need for Automating and Modernizing Logistics Infrastructure in India–arXiv (2023). The article emphasizes the need for AI-driven automation to modernize India's logistics infrastructure. It suggests establishing Smart Industrial Parks and strengthening government policies to enhance efficiency. Collaboration between government and industry is considered essential for AI integration.

AI-Supported Assessment of Load Safety – arXiv (2023). This study develops an AI-based system using CNNs and ANNs to assess cargo load safety through image analysis. It reduces human error and improves compliance with safety standards. The research shows AI can significantly enhance transportation safety.

The Impact of Artificial Intelligence on the Freight Industry: A Comprehensive Analysis International Journal of Computer Engineering and Technology (IJCET) (2024) The paper discusses AI applications such as predictive analytics, fleet management, and route optimization in freight operations. It finds that AI reduces fuel costs and improves scheduling efficiency. The study concludes that AI increases overall operational performance in logistics.

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3. OBJECTIVE OF STUDY

3.1 Primary Objective

To examine the interrelationship among the key factors of Artificial Intelligence in optimizing Over-Dimensional Cargo (ODC) logistics.

3.2 Secondary Objectives

- To identify the major challenges in ODC logistics and analyze suitable AI-based solutions to address them.
- To study whether there is a significant difference between the departments in which employees currently work and their perceptions of the role of Artificial Intelligence in optimizing Over-Dimensional Cargo logistics.
- To suggest effective measures for improving the optimization of Over-Dimensional Cargo (ODC) logistics through the application of Artificial Intelligence.

4. SCOPE OF THE STUDY

This study aims to discuss the application of Artificial Intelligence in optimizing the logistics of Over-Dimensional Cargo movements in India. The study will cover various applications of Artificial Intelligence in optimizing the logistics of ODC movements.

5. LIMITATIONS OF THE STUDY

This study is based on the availability of data on the application of Artificial Intelligence in ODC logistics, which is a specialized field in the logistics industry. The study is based on secondary data, and insights into the application of Artificial Intelligence in ODC movements are limited in nature. The study is based on the Indian market, and the applicability of the study to a broader market is limited in nature.

6. THEORATICAL BACKGROUND

6.1 CONCEPTUAL MODEL

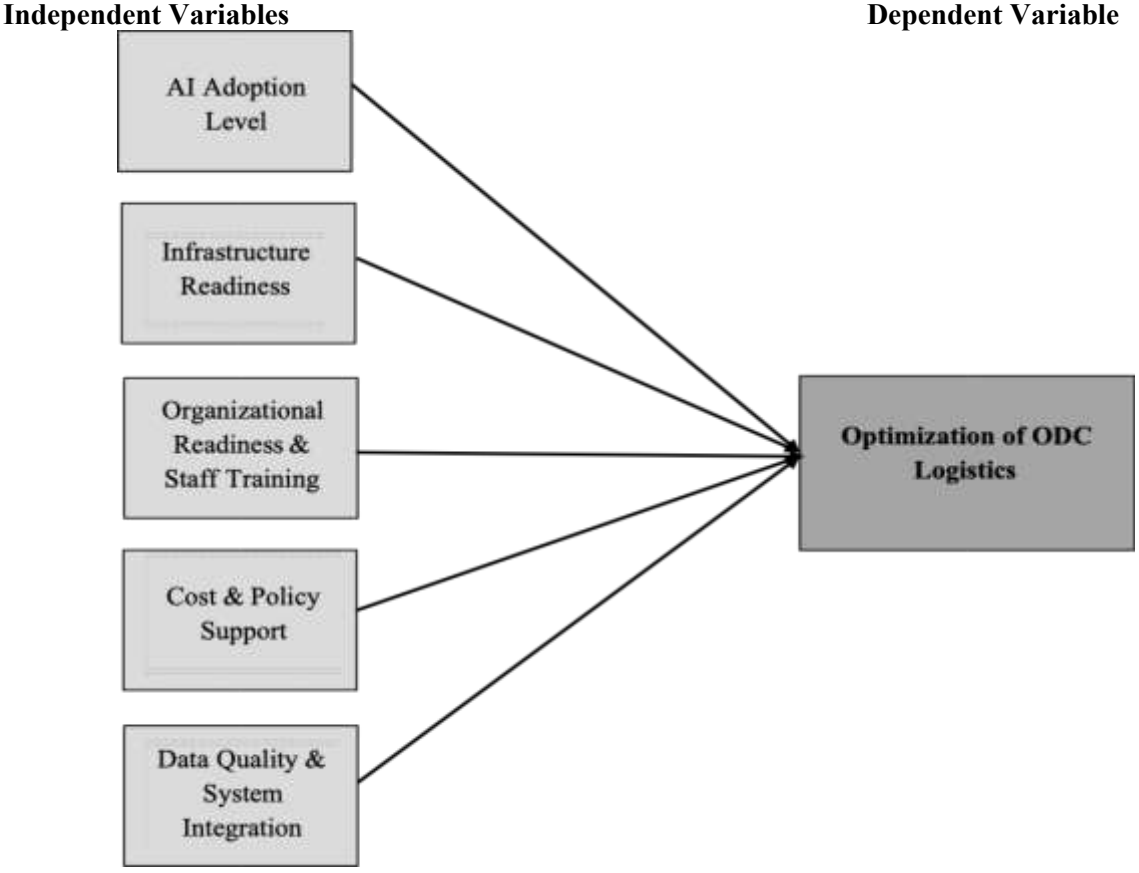

Figure 1

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6.1 AI Adoption Level
AI Adoption Level refers to the extent and sophistication with which artificial intelligence technologies are implemented in ODC logistics operations.

6.2 Infrastructure Readiness
Infrastructure Readiness represents the availability and adequacy of both physical infrastructures, such as roads, ports, and warehousing facilities, and digital infrastructure, including internet connectivity and IoT devices.

6.3 Organizational Readiness & Staff Training
Organizational Readiness & Staff Training reflects how prepared a company is to integrate AI into its operations, including the adaptability of its workflows, decision22 making processes, and employee skills.

6.4 Cost & Policy Support
Cost & Policy Support covers the financial resources and incentives available for AI implementation, as well as the presence of supportive regulations, industry guidelines, and government policies.

6.5 Data Quality & System Integration
Data Quality & System Integration focuses on the accuracy, reliability, and timeliness of logistics data, as well as the seamless connection between different operational systems.

7. RESEARCH DESIGN
The Study follows a descriptive and exploratory design that integrates qualitative insights with quantitative analysis. Surveys and case studies form the core tools of investigation of (ODC), allowing the study to measure trends numerically while also delving deeper into contextual and operational details that numbers alone may not reveal.

8. DATA ANALYSIS
8.1 Demographic Variable
TABLE 1 – The table shows the demographic variable of the study

VARAIABLE	CATEGORY	FREQUENCEY	PERCENTAGE
AGE	Below 25	4	3.3
	25 to 35	63	52.5
	36 to 45	37	30.8
	Above 45	16	13.3
	Total	120	100
GENDER	Male	95	79.2
	Female	22	18.3
	Others	3	2.5
	Total	120	100
EDUCATIONAL LEVEL	Diploma	2	1.7
	Undergraduate	37	30.8
	Postgraduate	80	66.7
	Others	1	.8
	Total	120	100
DEPARTMENT	PGT	113	94.2
	Renewable	4	3.3
	IFF & CHA	3	2.5
	Total	120	100
AI TOOLS	Yes	73	60.8
	No	44	36.7
	Partially	3	2.5
	Total	120	100

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INTERPRETATION

The data indicates that the majority of respondents are young, well-educated professionals, mainly from the PGT department. Most participants are male, showing gender imbalance in the workforce. Additionally, more than half of the respondents use AI tools, suggesting growing adoption of Artificial Intelligence in ODC logistics operations.

8.2 CORRELATION BETWEEN CHALLENGES OF AI IN ODC AND OVERALL PERCEPTION SCORE

Table 2 - Correlation between Challenges of AI in ODC and Overall Perception Score

Correlation		AI in ODC Logistics	Cost Efficiency & Resource Utilization	Operational Efficiency & Tracking	Challenges of AI in ODC	Future Prospects & Support
Challenges of AI in ODC	Pearson Correlation	.323**	.529**	.925**	1	.529**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	120	120	120	120	120

INTERPRETATION

The correlation analysis shows a positive and statistically significant relationship between Challenges of AI in ODC and all other variables (p = .000). There is a moderate positive correlation with AI in ODC Logistics (r = .323) and Cost Efficiency & Resource Utilization (r = .529). A very strong positive correlation is observed with Operational Efficiency & Tracking (r = .925), indicating that operational factors are closely linked with AI challenges. Additionally, Challenges of AI also have a moderate positive relationship with Future Prospects & Support (r = .529). Overall, the results suggest that as AI implementation increases, associated challenges also influence efficiency and future development in ODC logistics.

9. MANAGERIAL IMPLICATIONS

- Management should adopt a structured and phased approach while investing in AI to ensure cost control and maximum operational benefit.
- Greater focus must be given to improving operational efficiency through AI-based route planning, tracking systems, and predictive maintenance.
- Regular training programs should be conducted to enhance employees' understanding and acceptance of AI technologies.
- Managers need to address implementation challenges such as data security, infrastructure gaps, and resistance to technological change.
- AI systems must be integrated with regulatory and safety standards to ensure smooth and compliant ODC operations.
- Leadership should encourage innovation and digital transformation to maintain long-term competitiveness in the logistics sector.

10. CONCLUSION

The study shows that Artificial Intelligence is an important factor in the optimization of Over-Dimensional Cargo logistics in terms of cost efficiency, operational efficiency, and tracking. This shows that there is a strong relationship between the implementation of Artificial Intelligence and operational efficiency. At the same time, there are notable challenges that are associated with the implementation of Artificial Intelligence. Despite these challenges, such as infrastructure and cost of implementation, Artificial Intelligence has a great potential to improve safety, compliance, and efficiency. Managerial strategies and employee readiness are important in the implementation of Artificial Intelligence. In general, the implementation of Artificial Intelligence is likely to improve the competitiveness of the Over-Dimensional Cargo logistics.

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