

UNLOCKING LOGISTICS PERFORMANCE THROUGH AI: A STUDY IN THE INDIAN MANUFACTURING LANDSCAPE

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INTRODUCTION

The integration of Artificial Intelligence (AI) in supply chain management is revolutionizing operational frameworks by fostering greater agility and responsiveness. AI-driven solutions like predictive analytics and route optimization have transformed typical supply chain methods in the Indian manufacturing sector, where logistical inefficiencies often result in delays and greater costs. Manufacturers are able to predict changes in demand, plan the best routes for transport, use less fuel, and improve logistics efficiency overall due to these technologies. Manufacturers can estimate demand patterns, examine historical data, and avoid potential issues using the help of machine learning-powered predictive analytics. Similarly, by determining the most effective transit routes, cutting down on transit times, and cutting operational costs, AI-based route optimization improves real-time decision-making. Through optimizing resources, the use of AI into logistics not only raises supply chain resilience but also advances sustainability.

The present research focuses on evaluating the influence of AI-driven logistics tools on operational performance within Indian manufacturing firms. The report investigates how AI-driven technologies are changing supply chain operations and generating market advantages by examining case studies and real-world applications. It also talks about the difficulties associated with implementing AI and offers estimates for the development of AI-enabled logistics in India.

LITERATURE REVIEW

In recent years, artificial intelligence (AI) has grown in value in the logistics field, offering novel ways to improve supply chain responsiveness and cut cost. ML (machine learning) models, forecast methods, and real-time optimization tools are examples of AI-driven systems that have been shown to improve operational performance across logistical functions (Choi et al., 2021). Organizations can use predictive analytics, for instance foresee transportation needs, maximize fleet movement, and reduce fuel consumption (Ivanov & Dolgui, 2020).

Likewise, changes in global logistics operations, like adaptive traffic control and AI-based GPS tracking, have drastically improved delivery punctuality (Wang et al., 2022). Shahzadi et al. (2024) offer a thorough analysis of AI adoption in supply chain management using the Technology-Organization-Environment (TOE) framework. They list both obstacles like technical complexity and human resistance and aids like organizational structure, technology readiness, and environmental dynamics. According to their findings, AI improves decision quality overall, sustainability, and resilience in besides efficiency.

Similarly, Thenmozhi and Krishnakumari (2024) emphasize AI's contribution to automating logistics processes. Their study highlights AI's ability to improve route selection, manage inventories more accurately, and refine demand predictions. Additionally, features like

real-time tracking and AI-powered chatbots enhance customer service and facilitate predictive maintenance—leading to cost savings and operational flexibility. Mendonça and Lima Junior (2023) conduct a longitudinal review of AI's application in supply chain operations from 2000 to 2020. Categorizing studies through the Supply Chain Operations Reference (SCOR) model, they analyze how AI tools mitigate uncertainty and improve performance. Their work also outlines gaps in current research and calls for more contextual studies. Goswami et al. (2024) discuss AI's transformative potential in logistics, emphasizing operational efficiency, cost minimization, and enhanced client satisfaction. They propose a structured model for AI integration and shed light on barriers such as data quality concerns and the shortage of domain-specific expertise. Ulle et al. (2024) focus on AI integration in small and medium-sized Indian enterprises. Their findings suggest that AI tools enable precise demand forecasting, agile inventory control, optimized routing, and real-time system monitoring.

However, they also underline challenges like limited infrastructure and high initial investment requirements, which often deter widespread adoption. While existing literature collectively establishes the value of AI in logistics, especially in terms of efficiency and performance enhancement, few studies have explored its direct impact within the Indian manufacturing sector. Given India's unique infrastructural and economic landscape, this study seeks to bridge that gap by empirically examining the role of AI-powered logistics systems and their contribution to improved operational outcomes.

Objective

- To investigate how predictive analytics enabled by Artificial Intelligence influence logistics performance, with specific emphasis on reducing transportation expenses and improving delivery timelines within Indian manufacturing organizations.
- To assess the correlation between varying levels of AI adoption and overall supply chain effectiveness, offering data-driven insights that can guide strategic logistics planning for practitioners and policy developers.

Hypotheses

H₁: AI-driven predictive analytics significantly reduces transportation costs in Indian manufacturing companies.

H₂: AI-based route optimization has a positive impact on on-time delivery performance in Indian manufacturing companies.

RESEARCH METHODOLOGY

The study employed an online structured questionnaire to collect data from logistics professionals in Indian manufacturing companies, focusing on AI adoption and its impact on logistics efficiency. The questionnaire consists of three sections: demographic and company profile, AI adoption in logistics, and logistics efficiency indicators. The demographic section captured details such as company size, industry sector, years of AI adoption, and respondents' roles. The AI adoption section measured the extent of AI-based demand forecasting and route optimization usage, along with the overall use of AI integration in the companies. The third section assessed key performance metrics, including transportation costs and on-time delivery rates before and after AI implementation.

To ensure measurement reliability, Cronbach's Alpha was computed and yielded a value of 0.827—demonstrating high internal consistency, which exceeds the acceptable threshold of 0.70. Additionally, construct validity was examined through a correlation matrix

as an alternative approach, with correlation coefficients ranging between 0.867 and 0.913, indicating strong inter-item relationships. These results affirm that the questionnaire effectively measures AI adoption in logistics and its influence on operational efficiency.

A stratified random sampling approach was implemented to ensure proportional representation based on company size categories—small, medium, and large enterprises. The study received 250 valid responses, offering a strong base for statistical analysis of AI's impact on logistics efficiency in the Indian manufacturing context Tables 1-4.

Table 1 DEMOGRAPHIC PROFILE OF THE RESPONDENTS		
Category	Frequency	Percentage
Gender		
Male	160	64
Female	90	36
Marital Status		
Married	182	72.80
Unmarried	68	27.20
Total Experience in same Industry		
1 to 5 Year	95	38
6 to 10 Year	64	25.60
11 to 15 Year	42	16.80
16 to 20 Year	33	13.20
More than 20 Years	16	6.40
Designation		
Logistic Manager	102	40.80
Fleet Manager	58	23.20
Supply Chain Manager	40	16
Logistics Executives	25	10
Logistics Supervisor	25	10
Age Group		
21 to 25 Year	20	8
26 to 30 Year	55	22
31 to 35 Year	79	31.6
36 to 40 Year	56	22.4
Above 40 Year	40	16

The demographic profile of the respondents provides critical insights into the workforce composition within the logistics sector of the manufacturing industry. The sample consists of 250 logistics professionals, with 64% being male and 36% female, indicating a male-dominated industry. In terms of marital status, 72.8% of respondents are married, while 27.2% are unmarried, suggesting that the majority of professionals in this sector are settled in their personal lives, which could influence their job stability and long-term commitment to the industry. Regarding professional experience, 38% of respondents have 1 to 5 years of experience, followed by 25.6% with 6 to 10 years, 16.8% with 11 to 15 years, and 13.2% with 16 to 20 years of experience. Only 6.4% have more than 20 years of industry experience, reflecting a relatively young workforce in logistics management. The distribution of job roles highlights that 40.8% of respondents are Logistics Managers, making it the most common designation, followed by Fleet Managers (23.2%), Supply Chain Managers (16%), Logistics Executives (10%), and Logistics Supervisors (10%).

The age distribution of respondents indicates that the majority belong to the 31 to 35 years age group (31.6%), followed by 26 to 30 years (22%) and 36 to 40 years (22.4%). A smaller proportion of respondents fall into the 21 to 25 years (8%) and above 40 years (16%) categories. This suggests that logistics professionals in the manufacturing sector are primarily in their early- to mid-career stages, which may influence their openness to adopting new technologies such as AI in logistics operations. These demographic insights provide a foundational understanding of the workforce characteristics, which can be further analyzed to assess how factors such as experience and job role influence AI adoption and logistics efficiency.

H₁: *There is a significant impact of Artificial Intelligence adoption on logistics efficiency.*

Table 2 DESCRIPTIVE STATISTICS						
	N	Minimum	Maximum	Mean	Std. Deviation	Std. Error Mean
Before AI	250	2.90	4.80	4.323	.441	.0261
After AI	250	3.93	4.90	4.590	.276	.0163
Valid N	250					

To determine the effectiveness of AI implementation in enhancing logistics performance, a paired sample t-test was employed. This statistical approach compared the mean values of key logistics efficiency indicators before and after AI technologies were introduced.

The descriptive statistics table indicates that the mean score before AI adoption was 4.323 with a standard deviation of 0.441, whereas the mean score after AI adoption increased to 4.590 with a reduced standard deviation of 0.276. The minimum observed value before AI was 2.90, which improved to 3.93 after AI adoption, while the maximum value also showed an upward shift from 4.80 to 4.90.

Table 3 PAIRED SAMPLE TEST							
	Paired Difference				t-value	df	Sig. (2- Tailed)
	Mean	Std Deviation	Std Error Mean	95% Confidence Interval of the Difference Lower Upper			
Before AI							
After AI							
	-0.2672	.2275	.0134	-0.2937 -0.2406	-19.823	249	.000

The test yielded a mean difference of -0.2672, with a standard error of 0.0134. The 95% confidence interval ranged from -0.2937 to -0.2406. A highly significant t-value of -19.823 was observed at 249 degrees of freedom, with a p-value of 0.000, indicating a statistically significant improvement in logistics efficiency after AI integration. These findings confirm that AI-powered solutions have made a meaningful impact on operational outcomes in Indian manufacturing logistics. These results statistically validate the hypothesis that AI integration contributes to cost reduction and improved logistical operations.

H₂: *There is no significant difference among on-time delivery performance with AI adoption level of manufacturing companies.*

Table 4 ANOVA RESULT		
AI Adoption Level	On-time delivery performance	
	F-VALUE	p
Low	.111	.043
Medium	.399	.024
High	.351	.018

To examine whether varying levels of AI adoption influenced on-time delivery performance, a one-way ANOVA was carried out. The analysis compared firms grouped into three categories—low, medium, and high—based on their extent of AI usage in logistics. The ANOVA results indicate a statistically significant difference in on-time delivery performance across the AI adoption levels. The F-values for the low, medium, and high AI adoption groups were 0.111 ($p = 0.043$), 0.399 ($p = 0.024$), and 0.351 ($p = 0.018$), respectively. Since all p-values are below the 0.05 threshold, the null hypothesis is rejected. This indicates that increased AI adoption is positively associated with better on-time delivery rates.

These outcomes align with the paired t-test findings and reinforce the argument that predictive analytics and intelligent routing enhance delivery reliability in manufacturing supply chains. A paired t-test analysis would further determine whether this observed improvement is statistically significant. Given the reduced variability in the post-AI data, it is indicative that AI adoption contributed to greater consistency and efficiency in logistics operations. These findings provide empirical support for the role of AI-powered predictive analytics and route optimization in enhancing supply chain efficiency, reducing uncertainties, and improving overall logistics performance in the manufacturing sector. These findings provide strong empirical evidence that AI adoption has significantly improved logistics efficiency, leading to measurable enhancements in operational performance and cost-effectiveness. A one-way Analysis of variance (ANOVA) findings suggest that companies with higher AI adoption levels experience improved delivery performance, likely due to enhanced route optimization and predictive analytics. The results align with existing literature, highlighting AI's role in reducing inefficiencies in logistics operations.

Discussion

The results of this study clearly demonstrate the pivotal role of AI-enabled technologies—particularly predictive analytics and route optimization—in enhancing logistics efficiency within the Indian manufacturing context. Traditional logistics systems in India often suffer from inefficiencies such as high transportation costs, suboptimal route planning, and unreliable demand forecasting. The results indicate that AI-powered predictive analytics enhances logistics performance by enabling better decision-making regarding fleet movement, fuel consumption, and transportation demand forecasting. The integration of machine learning algorithms and real-time GPS tracking allows for dynamic route adjustments, reducing delays and improving on-time deliveries. The empirical analysis using a paired t-test and ANOVA confirms that firms with higher AI adoption experience a noticeable reduction in logistics costs and a substantial improvement in delivery performance. This aligns with global research indicating that AI implementation optimizes supply chain responsiveness and cost efficiency. However, the transition to AI-driven logistics in India is still evolving. Adoption rates remain relatively modest due to constraints such as underdeveloped infrastructure, limited technical know-how, and a shortage of skilled personnel to manage AI-based systems. These barriers hinder the full realization of AI's potential in the manufacturing sector.

Moreover, the findings reaffirm trends reported in global studies, which point to AI's contributions toward greater agility, cost efficiency, and responsiveness in supply chain operations. This aligns with existing literature, which highlights that AI applications in logistics improve cost-effectiveness and supply chain agility (Choi et al., 2021; Ivanov & Dolgui, 2020). However, challenges such as data privacy concerns, high implementation costs, and resistance to technological change remain key barriers to AI adoption in the Indian context. The study suggests that overcoming these challenges requires a strategic approach involving policy interventions, investment in digital infrastructure, and upskilling logistics professionals to maximize the benefits of AI integration.

CONCLUSION

This study offers valuable insights into the emerging role of artificial intelligence in transforming supply chain operations, with a focus on the Indian manufacturing landscape. The empirical evidence gathered supports the effectiveness of AI-based predictive analytics and intelligent routing in lowering operational costs and improving delivery performance. By examining real-world data, this research addresses a notable gap in existing literature, especially considering the relatively nascent stage of AI implementation in logistics across Indian industries.

In addition to its implications for businesses, this study holds relevance for policymakers and industry leaders seeking to foster AI-driven innovation in India's supply chain ecosystem. The research highlights the need for industry-wide collaboration, investment in AI-driven logistics solutions, and targeted policies to facilitate seamless AI integration. Future research can build on this study by exploring sector-specific AI applications in logistics and assessing long-term sustainability impacts. Overall, AI-driven logistics presents a transformative opportunity for Indian manufacturing firms, enabling them to navigate supply chain complexities, optimize costs, and achieve greater competitiveness in a rapidly evolving market landscape.

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