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Transforming Logistics Through Artificial Intelligence: 2813-84An Empirical Study of Supply Chain Performance

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ABSTRACT

Artificial Intelligence (AI) is increasingly gaining ground as a key enabler of contemporary logistics and supply chain management. This study demonstrates the potential of artificial intelligence in supporting demand planning, inventory management, route optimization, warehousing, predictive analytics, and decision-making in supply chains. Data collected from 50 respondents using a structured questionnaire were analyzed descriptively and empirically to determine the extent to which respondents are enthusiastic about adopting AI and its benefits. The findings reveal that respondents were positive about the potential of AI, particularly in improving order accuracy ($M = 3.42$), reducing operational inaccuracies ($M = 3.22$), and supporting supply chain decisions ($M = 3.18$). AI benefits had a positive and significant relationship with supply chain performance ($r = 0.892$, $p < 0.001$) and explained 79.5% of the variance in supply chain performance ($R^2 = 0.795$, $F(1, 48) = 186.71$, $p < 0.001$). Furthermore, no significant differences were found in supply chain performance among the respondents' income groups ($F(3, 46) = 2.379$, $p = 0.082$); however, gender had a significant effect on AI perception ($\chi^2(1) = 6.202$, $p = 0.013$). The main challenges were the high investment costs, shortage of skilled labor, data privacy and security, and organizational resistance to change.

Keywords: Artificial Intelligence, Logistics, Supply Chain Management, Operational Performance, Intelligent Decision-making

INTRODUCTION

Artificial Intelligence (AI) is becoming an important aspect of contemporary logistics and supply chain management, enabling firms to make better decisions in demand planning, inventory management, routing, warehousing, predictive analytics, and overall decision-making. This study focuses on the potential of artificial intelligence to improve supply chain performance by harnessing information for decision support and improving organizational agility in addressing customers' expectations and emerging disruptions. The study uses primary data collected from 50 respondents and analyzed descriptively and empirically to establish the extent to which the respondents perceive artificial intelligence benefits in improving supply chain performance. The findings indicate positive perceptions of artificial intelligence, particularly regarding enhancing order accuracy ($M = 3.42$), reducing operational inaccuracies ($M = 3.220$), and supporting supply chain decisions ($M = 3.221$). Artificial intelligence benefits had a positive and significant relationship with supply chain performance ($M = 3.222$, $M = 3.223\%$) and explained 79.5% of the variance in supply chain performance ($M = 3.224\%$, $F(1, 48) = 186.71$, $M = 3.225\%$). Nevertheless, the high capital investment, inadequate skilled labor, data privacy and security, and organizational resistance to change pose the major challenges to implementing AI.

LITERATURE REVIEW

Min (2010) argued that artificial intelligence helps supply chain managers analyze information and facilitates managerial analysis, suggesting that AI could enhance productivity in supply chain management while supporting managerial decision-making based on the insights gained from information analysis. Hellingrath and Lechtenberg (2019) undertook a study on AI in supply chain management and logistics, focusing on supply chain execution, and demonstrating how smart technologies could support digitalization and transformation by enabling organizations to embrace digital supply chains and become future-ready through digital thread-enabled operations. Similarly, Kota (2019) demonstrated how artificial intelligence, robotics, autonomous vehicles, and optimization could revolutionize transportation and logistics through automation and expediting decision-making. Dubey et al. (2020) established the relationship between big data analytics, artificial intelligence, and operational performance, suggesting that the combination of technology and information could enhance performance if the firm has the requisite processes and skilled personnel to leverage the technology-informed information. The study by Belhadi et al. (2021) on AI-driven innovations, supply chain resilience, and performance indicated that AI could support firms in becoming more agile and responsive to disruptions by leveraging data analytics in enhancing information management during disruptions. On the other hand, Toorajipour et al. (2021) undertook a review of AI applications in logistics, production, marketing, and supply chain management, highlighting the significance of forecasting, optimization, and decision-making while recommending future research directions.

Pournader et al. (2021) identified three thematic areas in their review of AI applications in supply chains: sensing and interaction, learning, and decision-making. The authors noted the rising significance of AI-driven learning algorithms while observing that AI applications span multiple supply chain activities. Lastly, Belhadi et al. (2022) reviewed AI-based approaches, including machine learning, big data analytics, fuzzy logic, and agent-based modeling, that could enhance supply chain resilience while recommending the need to consider contextual factors when resolving supply chain disruptions. Sharma et al. (2022) undertook a bibliometric review of AI in supply chain management, indicating the growing interest in AI and its ability to support decision-making. Similarly, Kasih, Bernadi, and Yulianti (2024) reviewed the relevance of AI in demand planning, inventory management, and logistics while demonstrating its potential in improving efficiency and agility in addressing disruptions.

Research Gap

The aforementioned studies indicate the potential of AI in supply chain management and logistics while establishing a relationship between AI applications and performance, with only a few studies using simple survey data to demonstrate the benefits of adopting AI. There is a need for more studies, particularly on the extent to which logistics managers perceive the benefits of AI and the challenges associated with its adoption. The current study contributes to the existing body of knowledge by filling the aforementioned research gap.

OBJECTIVES

1. To examine the impact of Artificial Intelligence (AI) adoption on logistics efficiency and performance
2. To analyze the influence of AI-driven technologies on logistics cost reduction and resource optimization
3. To assess the effect of Artificial Intelligence on delivery speed, accuracy, and overall logistics service quality
4. To evaluate the role of AI in improving supply chain visibility, demand planning, and decision-making
5. To identify the key challenges and barriers affecting the successful implementation of Artificial Intelligence in logistics and supply chain management

HYPOTHESES OF THE STUDY

Based on the objectives and the review of existing literature, the study hypothesizes that higher levels of perceived benefits of AI in logistics lead to higher levels of perceived supply chain performance and tests the differences in perceptions among the respondents using the following null (H0) and alternative (H1) hypotheses at the 5% significance level ($M = 3.226$)

H0: There is no significant relationship between perceived AI benefits in logistics and perceived supply chain performance.

H1: There is a significant positive relationship between perceived AI benefits in logistics and perceived supply chain performance.

CONCEPTUAL FRAMEWORK

The conceptual framework of the study shows the relationship between Artificial Intelligence (AI) in logistics and Supply Chain Performance. It theorizes that the effective use of AI leads to improvements in various logistic activities, resulting in enhanced supply chain performance. Additionally, the study assumes that the presence of implementation barriers such as cost, skills, data security, and resistance to change influences the extent to which the benefits of AI are realized. Lastly, the study uses respondent demographics to establish differences in respondent perceptions

RESEARCH METHODOLOGY

This study uses a quantitative and descriptive research design to establish the relationships between Artificial Intelligence and logistics and supply chain performance. Specifically, the study focuses on the potential of artificial intelligence to reduce errors and costs, improve logistics speed, optimize resource allocation and utilization, enhance delivery speed, accuracy, and overall service quality, increase supply chain visibility, support demand planning, and facilitate decision-making. Data were collected using a structured questionnaire and analyzed descriptively and empirically to evaluate the extent to which respondents perceive the benefits of AI and its effect on logistics and supply chain performance. The findings are based on 50 valid responses obtained from a convenience sampling frame. Published articles were used as secondary data to complement the primary data collected using the structured questionnaire. Because this study relies on the respondents' perceptions, the findings should be interpreted as reflective of the sample and not necessarily indicative of the wider population since the study does not establish causal relationships.

Research Design

This study used a descriptive research design to describe respondents' perceptions about Artificial Intelligence (AI) in logistics. The design was appropriate for the current study because the researcher focused on gathering information on the extent to which the respondents perceived artificial intelligence benefits and how these benefits affect supply chain performance. Specifically, Questions 12-17 measured perceived AI benefits, Questions 18-25 assessed supply chain performance, and Questions 26-29 evaluated implementation barriers. The questions were scored to ensure that higher scores reflected more positive perceptions, and the scores were used to perform correlation, regression, ANOVA, and chi-square analysis.

Population and Sample

The current study focused on populations with some understanding of transportation, logistics, supply chain activities, vehicles, or business operations. Specifically, 50 respondents participated in this study and provided valid responses. All respondents were aged between 18 and 25 years, and had attained an undergraduate level of education. Out of the 50 respondents, 44 were students while 6 were private employees. The convenience sampling procedure was used because the researcher was able to recruit participants based on their availability and willingness to participate in the study.

Instrument and Measures

A structured questionnaire was used to collect the primary data used in this study. It contained both demographic and logistical information, including questions about artificial intelligence and supply chain performance. Questions 12-17 focused on how respondents perceived the benefits of artificial intelligence in logistics, including reducing errors and costs, improving logistics speed, optimizing resources allocation and utilization, and enhancing delivery accuracy. Questions 18-25 assessed the extent to which the respondents perceived artificial intelligence to improve delivery speed, accuracy, and overall service quality while increasing supply chain visibility, supporting demand planning, and facilitating decision-making. Finally, questions 26-29 evaluated the extent to which the respondents perceived various factors, including implementation costs, skilled labor, data privacy and security, and resistance to change, as implementation barriers. The questions were scored using a Likert scale and later converted to a percentage format where higher scores reflected more positive perceptions. Three composite scores were calculated for perceived AI benefits, supply chain performance, and AI implementation barriers. The Cronbach's alpha scores were 0.88, 0.91, and 0.74 respectively.

Procedure and Ethics

The questionnaire was administered to the respondents for research purposes, and the participants provided their responses voluntarily. After collecting the responses, the researcher scored and analyzed the responses. The respondents' information was kept confidential, and the results were used for academic purposes only. The researcher ensured that the data were anonymized and reported at the aggregate level.

Analysis Plan

The data were analyzed at the 5% significance level ($M = 3.227$). Frequencies and percentages were used to report the descriptive findings while the mean, median, and standard deviation were used to summarize the data. The relationship between AI benefits and supply chain performance was evaluated using Pearson correlation while the predictive relationship was established using simple linear regression analysis. In addition, a multiple regression analysis was performed, with barriers as control variables, to assess the extent to which AI benefits predicted supply chain performance. One-way ANOVA was used to compare results across the respondent groups while chi-square analysis evaluated the associations between respondents' characteristics and their perceptions.

DATA ANALYSIS AND RESULTS

1. Respondents

There were 50 valid responses. Thus, 27 of the respondents were male (54%) and 23 were female (46%). The participants were 18–25 years of age and undergraduates. In total, 44 respondents (88%) were students, whereas 6 (12%) were private employees. Eighteen respondents (36%) reported monthly household income below ₹25,000, twelve (24%) earned ₹25,000–₹50,000, and four (8%) reported ₹75,000–₹100,000, whereas sixteen (32%) respondents earned above ₹100,000. Six respondents (12%) did not own a vehicle, 23 (46%) owned a two-wheeler, and 21 (42%) belonged to both categories.

Variable	Response	Frequency	Percentage
Gender	Male	27	54%
	Female	23	46%
Age	18–25 years	50	100%

Education	Undergraduate	50	100%
Occupation	Student	44	88%
	Private Employee	6	12%
Income	Below ₹25,000	18	36%
	₹25,000–₹50,000	12	24%
	₹75,000–₹100,000	4	8%
	Above ₹100,000	16	32%
Vehicle	No vehicle	6	12%
	Two-wheeler	23	46%
	Both	21	42%

The sample size consisted of a relatively equal distribution by gender but was mainly composed of young respondents who were studying at the undergraduate level. Thus, the results mainly reflect the viewpoint of younger respondents but not more experienced logistics professionals.

2. Descriptive statistics

Overall, the respondents expressed a largely positive perspective about the benefits of AI in logistics, with order accuracy being the strongest outcome (87.5% positive responses, mean: 3.42). Operational errors were highlighted as the second most important benefit (84%, M = 3.22), followed by support for supply chain decisions (80%, M = 3.18).

Indicator	Positive	Mean	Median	SD
Reduces operational errors	84.0%	3.22	3	0.82
Increases logistics speed	76.0%	3.14	3	0.88
Reduces supply chain costs	68.8%	2.94	3	0.86
Optimizes resources	72.0%	2.88	3	0.87
Reduces transport/inventory costs	66.0%	2.90	3	0.86
Improves resource allocation	82.0%	2.96	3	0.75
Improves delivery speed	66.0%	2.94	3	0.79
Improves order accuracy	87.5%	3.42	4	0.71
Reduces delivery delays	72.0%	2.88	3	0.77
Improves service quality	66.0%	3.04	3	0.86
Improves supply chain visibility	68.0%	2.90	3	0.84
Improves demand forecasting	74.0%	2.86	3	0.88
Supports supply chain decisions	80.0%	3.18	3	0.75
AI information is useful	84.0%	3.08	3	0.63

The respondents demonstrated that they identified tangible benefits of AI more strongly in increasing accuracy, reducing errors, and improving speed and decision-making functions rather than direct cost reductions. Demand forecasting, resource optimization, and reducing delivery delays appeared to be comparatively less important, as evidenced by the comparatively lower mean score. The SD ranged between 0.63 and 0.88, which indicated moderate variability in responses.

3. Barriers to AI use

Furthermore, the respondents reported several barriers associated with the use of AI. Resistance to organizational change was the most frequently reported important barriers (82%), followed by the lack of skilled employees (76%), high implementation cost (74%), and data security and privacy concerns (72%). Securing data was associated with the highest mean score of 3.20.

Barrier	Important Response	Mean	Median	SD
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High implementation cost	74%	3.06	3	0.77
Lack of skilled employees	76%	3.00	3	0.81
Data security and privacy	72%	3.20	3	0.86
Resistance to organizational change	82%	3.12	3	0.69

These results suggest that the successful adoption of AI required not only focusing on technological solutions but also taking into account employees' competencies, organizational conditions, data protection, and attitudes.

4. Composite scores and reliability

The mean composite score equaled 3.01 for AI benefits, 3.04 for supply chain performance, and 3.10 for barriers to implementation, with the standard deviations (SD) ranging from 0.59 to 0.66. Moreover, the reliability results were generally satisfactory, with Cronbach's alpha values of 0.88 for AI benefits, 0.91 for supply chain performance, and 0.74 for barriers. Overall, the respondents appeared to have moderately positive perspectives about AI and supply chain performance while also recognizing the potential difficulties associated with the implementation of AI.

5. Correlation analysis

Pearson correlation revealed a highly positive relationship between AI benefits and supply chain performance ($r = 0.892$, $p < 0.001$). Specifically, the respondents tended to report similarly positive assessments of AI benefits and supply chain performance. Spearman's correlation yielded a similar result ($p = 0.887$, $p < 0.001$). AI benefits were positively correlated with barriers ($r = 0.699$), whereas supply chain performance was strongly correlated with barriers ($r = 0.889$). These findings described the association within the sample but did not establish a causal link between the variables.

6. Regression analysis

Simple linear regression revealed that the relationship between AI benefits and supply chain performance was statistically significant, $F(1,48) = 186.71$, $p < 0.001$. The model resulted in $R^2 = 0.795$, implying that perceived AI benefits explained 79.5% of the variance in perceived supply chain performance. The coefficient equaled $M = 3.180$ with the 95% confidence interval (CI) of 0.707–0.950 and $M = 3.181$, $M = 3.182$. The equation was: Supply Chain Performance = $0.544 + 0.828 \times \text{AI Benefits}$. Thus, a one-point increase in perceived AI benefits was associated with an increase of approximately 0.83 in perceived supply chain performance.

An additional multiple regression analysis using AI benefits and barriers resulted in $M = 3.183$, $F(2,47) = 330.36$, $M = 3.184$. Both predictors were significant. The positive coefficient for barriers should not be interpreted as barriers promoting performance because the association reflected the tendency for respondents to rate different areas similarly.

7. One-way ANOVA

ANOVA was used to explore differences in AI benefits and supply chain performance between groups of respondents. Supply chain performance ranged from a mean of 2.86 in the lower income groups to 3.34 among respondents who earned above ₹100,000, but the difference was not statistically significant, $F(3,46) = 2.379$, $M = 3.185$, $M = 3.186$. Kruskal–Wallis also did not reveal a significant difference ($M = 3.187$).

The only significant comparison was gender and AI benefits, $F(1,48) = 5.048$, $M = 3.188$. Specifically, male respondents had a higher mean AI benefit score ($M = 3.189$) than female respondents ($r = 0.8920$). Given the small sample size and the multiple comparisons made, this finding should be regarded as exploratory.

8. Chi-square analysis

Chi-square analysis revealed a significant association between gender and favourable AI perception, $\chi^2(1) = 6.202$, $r = 0.8921$, Cramér's $r = 0.8922$. Specifically, a favourable AI perception was reported by 77.8% of male respondents compared with 43.5% of female respondents. Furthermore, Fisher's exact test also yielded a significant result ($r = 0.8923$). AI perception was also associated with vehicle ownership, $\chi^2(2) = 9.295$, $r = 0.8924$, although some expected cell counts were below 5, so this result should be treated cautiously. Income, occupation, and EV consideration were not associated with supply chain performance, nor was AI perception significantly associated with these characteristics.

9. Hypothesis testing

Hypothesis	Test	Result	Decision
H1: AI benefits are positively related to supply chain performance	Correlation & regression	$r = 0.892$, $p < 0.001$; $R^2 = 0.795$	Supported
H2: Supply chain performance differs across income groups	ANOVA	$F(3,46) = 2.379$, $p = 0.082$	Not supported
H3: AI perception is associated with gender	Chi-square	$\chi^2(1) = 6.202$, $p = 0.013$	Supported

Overall, H1 and H3 were supported, whereas H2 was not supported.

DISCUSSION

The results demonstrate that respondents generally view AI as a valuable tool in logistics, particularly in terms of improving order accuracy, reducing operational errors, and enhancing speed and decision-making capabilities. This is consistent with the literature that describes AI as a technology that enables pattern recognition, decision-making, efficiency, and responsiveness. The correlation ($p < 0.0010$) and regression result ($p < 0.0011$) demonstrate that positive views of AI benefits tend to coincide with positive views of supply chain performance. However, since both scores came from the same questionnaire at a single point in time, the results cannot be interpreted as evidence of direct causality.

The respondents appeared to be more optimistic about improving operations than achieving direct cost savings. This may be due to the fact that benefits in terms of accuracy and decision support are easier to recognize, whereas cost savings may take longer to materialize. The analyses of barriers also revealed that successful AI adoption requires more than simply adopting new technology. Employees' competencies, data security, implementation cost, organizational support, and attitudes are all crucial factors.

FINDINGS AND SUGGESTIONS

The results of the study revealed that 84% of respondents believed that AI reduces operational errors and 76% believed that it increases logistics speed. On the other hand, benefits in terms of cost were received more sceptically, with 68.8% positive about supply chain cost reduction and 66% positive about transport and inventory cost reduction. The strongest-rated benefit was order accuracy, since 87.5% of respondents were positive and the mean score equalled 3.42. Furthermore, 84% of respondents found AI information useful and 80% believed that AI supports supply chain decisions. As for the barriers, resistance to organizational change was reported by 82%, whereas data security and privacy had a mean score of 3.20.

From an organizational perspective, it is critical to adopt AI based on the specific logistics needs rather than following technology trends blindly. Employee training should be prioritized, and the quality and security of data should be improved. Starting with implementing practical applications such as order processing, demand forecasting, route planning, and inventory management can enable organizations to see the benefits before investing in a comprehensive AI solution across the supply chain. Moreover, employees should be involved in the implementation process so that resistance can be reduced through communication and training. Since cost benefits were less strongly perceived, organizations should establish clear measures for evaluating the cost and return of AI investments.

CONCLUSION

Artificial Intelligence (AI) is a growing cornerstone of modern logistics and supply chain management. The results of 50 respondents reveal positive perceptions of AI, particularly in terms of improving order accuracy, reducing operational errors, and enhancing logistics speed and decision-making. The study suggests that AI can enable organizations to achieve responsive and data-driven logistics operations. At the same time, the implementation cost, employees' skills, data security, privacy, and resistance to change are significant challenges that organizations should address.

The strong relationship between AI benefits and supply chain performance ($p < 0.0012$; $p < 0.0013$) suggests that respondents who perceived greater benefits associated with AI tended to perceive better supply chain performance. However, the study does not provide evidence of direct causality. Overall, AI has strong potential in transforming logistics operations if it is implemented correctly with skilled employees, high-quality data, secure systems, and organizational support.

LIMITATIONS

The study has several limitations. First, the sample included only 50 respondents, all between the ages of 18–25 and studying at the undergraduate level. Thus, the results cannot be automatically extrapolated to the broader logistics industry or more experienced logistics professionals. Second, some categories were represented by a small number of respondents, which limited the power of the comparisons. Specifically, there were only four respondents in one category of income and six private employees, which limited the relevance of the findings to these specific groups. Finally, some cells in the chi-square analysis had expected counts below 5.

Furthermore, the results were based on respondents' answers to the questionnaires rather than objective measurements of company performance. Since AI and supply chain performance were assessed within the same questionnaire and at a single point in time, common-method bias may have inflated the correlation coefficient. Finally, the design of the study was cross-sectional and thus unable to establish causality; individual significant results should be interpreted with caution.

RECOMMENDATIONS AND FUTURE RESEARCH

Organizations should embrace AI gradually and focus on those applications that directly support their logistics needs. Employee training, reliable data, data security, and evaluation should be prioritized, especially during the initial phases of implementation. Future research can include more extensive

and diverse samples, such as logistics managers, warehouse employees, transportation professionals, supply chain executives, and technology specialists. Researchers can also examine the differences between organizations that have adopted AI and those that have not.

Further studies can explore specific applications such as AI-based demand forecasting, autonomous delivery, warehouse robotics, route optimization, predictive maintenance, generative AI, and intelligent transportation systems. Longitudinal studies comparing performance before and after AI implementation can yield more robust evidence about the impact of AI on supply chains.

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