

Reduction of Transportation Cost: Examining the Moderating Role of Artificial Intelligence (AI) Implementation in Bangladesh

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Abstract: This study investigates the role of logistics strategies Route and Node Optimization, Shipment Consolidation, and Demand Forecasting in reducing transportation costs in the logistics sector of Bangladesh. It also explores the moderating effect of Artificial Intelligence (AI) on the effectiveness of these strategies. With the increasing complexity of logistics operations and the growing need for cost-efficient practices, this research highlights how traditional logistics methods can be augmented with advanced AI technologies to optimize operations and achieve significant cost reductions. Data were collected through structured surveys involving 300 respondents from logistics companies in Bangladesh. Using Principal Component Analysis (PCA) and Multiple Regression Analysis, the relationships between the independent variables (logistics strategies), the moderating variable (AI implementation), and the dependent variable (Transportation Cost Reduction) were evaluated. The results reveal that Shipment Consolidation had the most significant impact on transportation cost reduction, followed by Demand Forecasting and Route and Node Optimization. AI implementation was found to positively moderate these relationships, enhancing the efficiency of each strategy. The findings underscore the transformative potential of AI in logistics operations, particularly in developing economies. The study contributes to both theory and practice by providing actionable recommendations for integrating AI into logistics to achieve cost efficiency. Future research directions are suggested, including exploring longitudinal impacts and expanding the study scope to other regions.

Keywords: Transportation Cost Reduction, Route and Node Optimization, Shipment Consolidation, Demand Forecasting, Artificial Intelligence (AI), Logistics Strategies, Cost Efficiency, AI Implementation, Logistics Sector.

1. Introduction

The logistics sector serves as a fundamental pillar for economic development, enabling the efficient movement of goods and services across industries and markets. In Bangladesh, logistics plays a vital role in supporting the nation's integration into global supply chains, yet the sector faces significant challenges. Transportation costs, which comprise a substantial portion of total logistics expenses, are a critical factor for businesses striving to maintain profitability and competitiveness. Inefficient logistics operations, coupled with infrastructural limitations such as poor road networks, traffic congestion, and outdated practices, often inflate transportation costs, hindering the growth and efficiency of the logistics industry [1].

With globalization intensifying competition, the complexity of supply chains has grown exponentially. Traditional logistics practices, such as static route planning and manual shipment management, have become insufficient for addressing modern logistical demands. Inefficiencies in route optimization, underutilization of transportation resources, and the inability to predict fluctuating demand patterns exacerbate transportation costs [2]. To combat these challenges, businesses must adopt innovative solutions that go beyond conventional approaches, ensuring streamlined logistics operations and significant cost reductions.

Artificial Intelligence (AI) has emerged as a transformative technology capable of revolutionizing logistics practices. By leveraging AI-powered solutions, businesses can achieve real-time route optimization, dynamic shipment consolidation, and accurate demand forecasting. AI enables companies to process large datasets, predict customer behavior, and make

data-driven decisions that enhance operational efficiency. Its potential to bridge the gap between traditional inefficiencies and modern demands makes AI a crucial tool for achieving sustainable cost efficiency in logistics.

This study focuses on three essential logistics strategies: Route and Node Optimization, Shipment Consolidation, and Demand Forecasting. Each of these strategies has been widely recognized for its potential to reduce transportation costs. However, their true value lies in their integration with AI technologies, which can amplify their effectiveness. While these strategies have been extensively studied in developed economies, there is limited research on their combined impact with AI in the context of developing countries like Bangladesh [3]. This gap highlights the need to explore how AI can be leveraged to optimize logistics operations and reduce transportation costs in resource-constrained settings.

The key objectives of this research are:

(1) To evaluate the effectiveness of Route and Node Optimization, Shipment Consolidation, and Demand Forecasting in reducing transportation costs in Bangladesh's logistics sector.

(2) To analyze the moderating role of AI implementation in enhancing the efficiency of these logistics' strategies.

This study fills an important research gap by examining the combined impact of logistics strategies and AI in a developing economy. While most studies focus on AI's standalone benefits or the independent effects of logistics strategies, this research integrates these elements into a unified framework. Furthermore, the study emphasizes the unique challenges and opportunities present in Bangladesh, offering insights into how businesses can overcome infrastructural and technological limitations to achieve cost efficiencies [4].

The findings of this study hold significant implications for both academia and industry. For academics, the study contributes to the literature on AI and logistics by demonstrating the synergistic potential of combining AI with traditional logistics strategies. For practitioners, it provides actionable recommendations for adopting AI technologies to optimize logistics operations and achieve cost reductions. Additionally, the research offers insights for policymakers, highlighting the need for investments in infrastructure and technology to support AI adoption in logistics.

This research seeks to provide a comprehensive understanding of how logistics strategies and AI can work together to transform transportation cost efficiency in Bangladesh. By addressing the challenges of cost reduction and operational inefficiencies, the study offers a roadmap for innovation and competitiveness in the logistics sector [5]. The subsequent sections of this paper detail the literature review, methodology, empirical findings, and practical implications, paving the way for future advancements in logistics research and practice [6, 7].

2. Literature Review

The logistics industry is a cornerstone of economic activities, enabling the efficient movement of goods, enhancing supply chain reliability, and contributing significantly to national and global economic growth. However, as supply chains become increasingly complex and globalized, the costs associated with transportation have emerged as a pressing concern for logistics companies. This chapter reviews existing literature on transportation cost reduction strategies, the role of Artificial Intelligence (AI) in logistics, and the interplay between these elements in the context of developing economies like Bangladesh.

2.1. Transportation Cost Reduction

Transportation costs represent a significant portion of total logistics expenses, often accounting for up to 50% of a company's total operating costs in the supply chain. Reducing these costs is essential for businesses to remain competitive in a globalized market [8, 9]. Effective cost reduction requires a comprehensive approach that addresses inefficiencies in routing, shipment consolidation, and demand forecasting. Key strategies for reducing costs include improving vehicle utilization, minimizing empty miles, and optimizing warehouse locations.

In the Bangladeshi context, transportation inefficiencies are exacerbated by infrastructural challenges, such as poor road conditions, traffic congestion, and limited technological adoption. The businesses in Bangladesh often face higher transportation costs compared to regional competitors due to these barriers [10]. This necessitates the adoption of innovative solutions to enhance operational efficiency and reduce costs.

2.2. Route and Node Optimization

Route and Node Optimization focuses on designing the most efficient transportation routes and strategically placing warehouses or distribution nodes. These strategies aim to minimize travel distances, reduce fuel consumption, and ensure timely delivery of goods. Demonstrated that optimized routes could lead to a reduction of up to 20% in transportation costs [11].

Recent advancements in AI have revolutionized route optimization by incorporating real-time data, such as traffic

conditions, weather forecasts, and delivery deadlines. AI-based systems, such as dynamic routing algorithms, enable businesses to adjust routes proactively, thereby reducing delays and fuel wastage [12, 13]. Node optimization, on the other hand, involves selecting optimal locations for warehouses and distribution centers to streamline the flow of goods. Emphasize that strategic node placement can significantly reduce last-mile delivery costs, which are often the most expensive segment of the supply chain [14].

2.3. Shipment Consolidation

Shipment Consolidation involves combining multiple smaller shipments into larger ones to maximize transportation efficiency. This strategy reduces the number of trips, optimizes the use of vehicles, and lowers fuel consumption. Demonstrated that effective shipment consolidation could reduce transportation costs by up to 15%, especially in fragmented supply chains [15].

AI has played a transformative role in improving shipment consolidation by dynamically grouping shipments based on real-time data. Machine learning models analyze factors such as shipment volume, delivery deadlines, and vehicle capacities to create optimal consolidation plans. In the Bangladeshi logistics sector, where supply chains often involve multiple small suppliers and retailers, shipment consolidation offers a viable solution for reducing costs while improving delivery reliability [16, 17].

2.4. Demand Forecasting

Demand Forecasting is a critical logistics strategy that involves predicting future demand for goods to optimize inventory levels and logistics planning. Accurate demand forecasting minimizes the risks of stockouts and overstocking, which often lead to higher transportation costs due to expedited or unnecessary shipments [18].

Traditional forecasting methods rely on historical data and statistical models, but these often fail to account for dynamic market trends and external disruptions. AI-based forecasting models, such as neural networks and time-series analysis, have demonstrated superior accuracy by incorporating diverse data sources, including market trends, customer preferences, and economic indicators [19]. In developing countries like Bangladesh, AI-powered demand forecasting could help businesses navigate fluctuating market conditions and improve supply chain resilience.

2.5. The Role of Artificial Intelligence in Logistics

Artificial Intelligence has emerged as a game-changer in the logistics industry, offering solutions that address inefficiencies and enhance decision-making capabilities. AI technologies, such as machine learning, predictive analytics, and robotics, enable businesses to automate complex processes, optimize resource utilization, and improve operational efficiency [20, 21].

In the context of transportation cost reduction, AI enhances logistics operations in three key areas:

Dynamic Route Optimization: AI algorithms process real-time data to identify the most efficient routes, reducing fuel consumption and delivery times.

Shipment Consolidation Automation: AI systems dynamically group shipments to maximize vehicle utilization and minimize transportation frequency.

Enhanced Demand Forecasting: AI improves forecasting

accuracy by analyzing large datasets, enabling better alignment of supply with demand.

Despite these benefits, the adoption of AI in logistics is not without challenges. The barriers such as high implementation costs, data quality issues, and resistance to change within organizations [22]. Overcoming these challenges requires strategic investments in technology and capacity-building initiatives.

2.6. Challenges in Implementing AI in Logistics

While the benefits of AI in logistics are well-documented, its implementation faces several challenges, particularly in developing economies like Bangladesh. Key barriers include:

Technological Infrastructure: Limited access to advanced technological infrastructure hinders AI adoption in logistics operations.

Data Quality and Availability: AI systems rely on high-quality data, which is often lacking in resource-constrained settings.

Cost of Implementation: The high upfront investment required for AI technologies poses a significant barrier for small and medium-sized enterprises (SMEs).

Workforce Resistance: Employees often resist adopting AI-driven systems due to fears of job displacement and lack of understanding.

Addressing these challenges requires collaborative efforts from businesses, policymakers, and technology providers. Investments in infrastructure, training programs, and government incentives can facilitate the integration of AI into logistics operations [23, 24].

2.7. Research Gap

While extensive research exists on logistics strategies and AI's standalone benefits, studies integrating these elements remain limited, particularly in the context of developing economies. Most existing studies focus on developed markets, where technological infrastructure and resources are abundant. This creates a gap in understanding how AI can be effectively integrated with logistics strategies in resource-constrained settings like Bangladesh.

Additionally, there is limited empirical evidence on the moderating role of AI in enhancing the impact of logistics strategies. This study aims to address these gaps by examining the combined effect of Route and Node Optimization, Shipment Consolidation, and Demand Forecasting with AI on transportation cost reduction.

3. Methodology

This chapter outlines the research design, data collection methods, and analytical techniques used to investigate the role of logistics strategies Route and Node Optimization, Shipment Consolidation, and Demand Forecasting and the moderating effect of Artificial Intelligence (AI) in reducing transportation costs. The methodology was designed to provide reliable and actionable insights into the logistics practices of companies in Bangladesh.

3.1. Research Framework

The study employed a quantitative research approach to examine the relationships between logistics strategies, AI implementation, and transportation cost reduction. A cross-sectional design was chosen, as it allows for data collection at

a single point in time, ensuring efficiency and consistency in analysis. The research model integrated independent variables (Route and Node Optimization, Shipment Consolidation, Demand Forecasting), the moderating variable (AI implementation), and the dependent variable (Transportation Cost Reduction).

The conceptual framework was developed based on an extensive review of the literature, identifying key variables and their hypothesized relationships. Hypotheses were formulated to test the direct effects of logistics strategies on transportation cost reduction and the moderating influence of AI.

The conceptual framework for this study is presented in Figure 1, which illustrates the relationships between the independent variables (Route and Node Optimization, Shipment Consolidation, and Demand Forecasting), the moderating variable (AI Implementation), and the dependent variable (Transportation Cost Reduction).

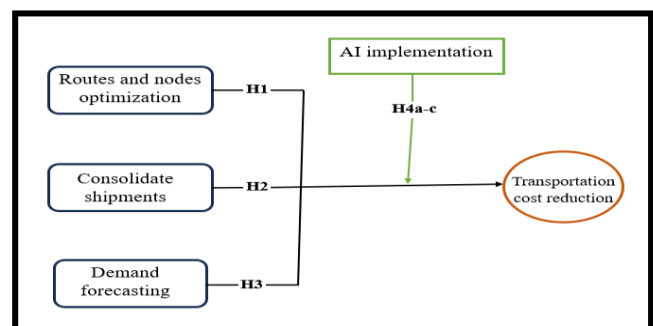


Figure1. Research Model

3.2. Data Collection

Data were collected using structured surveys, which were distributed both physically and online to logistics professionals across Bangladesh. The survey instrument consisted of multiple sections, each focusing on one of the research variables:

Route and Node Optimization: Four questions measuring the extent of optimized transportation routes and node placement.

Shipment Consolidation: Four questions assessing practices for combining shipments.

Demand Forecasting: Four questions evaluating the accuracy and use of demand forecasting techniques.

AI Implementation: Four questions addressing the adoption and utilization of AI technologies in logistics operations.

Transportation Cost Reduction: Four questions measuring the effectiveness of cost-saving strategies.

The survey used a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) to capture participants' perceptions. This scaling method allowed for quantitative measurement of subjective responses, facilitating statistical analysis.

3.3. Validity and Reliability

To ensure the validity and reliability of the data collection instrument:

Content Validity: The survey questions were reviewed by logistics experts to confirm their relevance to the research objectives.

Construct Validity: A pilot test was conducted with 30 respondents to refine the survey and ensure clarity.

Reliability Analysis: Cronbach's Alpha was used to assess

the internal consistency of the survey items. A Cronbach's Alpha value of 0.920 confirmed the instrument's reliability.

3.4. Data Analysis

The data collected were analyzed using IBM SPSS 26.0, employing both descriptive and inferential statistical techniques to test the hypotheses. The analysis was conducted in several stages:

Descriptive Statistics: Used to summarize demographic variables (gender, age, education, and salary) and provide an overview of the data.

Principal Component Analysis (PCA): Applied to reduce data dimensionality and identify key components influencing transportation cost reduction.

Multiple Regression Analysis: Conducted to evaluate the relationships between the independent variables and the dependent variable, as well as the moderating effect of AI.

Moderation Analysis: Interaction terms were created to test AI's role in moderating the relationship between logistics strategies and transportation cost reduction.

3.5. Research Hypotheses

Based on the research framework, the following hypotheses were tested:

H1: Route and Node Optimization positively influences Transportation Cost Reduction.

H2: Shipment Consolidation positively influences Transportation Cost Reduction.

H3: Demand Forecasting positively influences Transportation Cost Reduction.

H4a: AI Implementation positively moderates the relationship between Route and Node Optimization and Transportation Cost Reduction.

H4b: AI Implementation positively moderates the relationship between Shipment Consolidation and Transportation Cost Reduction.

H4c: AI Implementation positively moderates the

relationship between Demand Forecasting and Transportation Cost Reduction.

3.6. Ethical Considerations

Ethical protocols were strictly followed throughout the study. Respondents were assured of the confidentiality and anonymity of their responses. Participation in the survey was voluntary, and informed consent was obtained before data collection. The research complied with ethical guidelines for social science research, ensuring integrity and transparency.

3.7. Limitations of the Methodology

While the methodology was robust, several limitations should be acknowledged:

Cross-sectional Design: The data capture a snapshot in time and may not reflect changes or trends in logistics practices over time.

Non-Probability Sampling: The use of convenience sampling may limit the generalizability of the findings to the broader population.

Self-Reported Data: The reliance on participants' perceptions introduces the potential for response bias.

4. Analysis

The study based on the data collected from 300 respondents working in logistics companies across Bangladesh. The results are organized to address the research objectives and hypotheses, focusing on the impact of logistics strategies on transportation cost reduction and the moderating role of Artificial Intelligence (AI). Statistical analyses, including descriptive statistics, Principal Component Analysis (PCA), and multiple regression analysis, were employed to derive meaningful insights.

4.1. Descriptive Statistics

Table 1. Demographic Statistics

Category	Subcategory	Frequency	Percent	Valid Percent	Cumulative Percent
Gender	Male	144	48	48	48
Gender	Female	156	52	52	100
Age	18-25	12	4	4	4
Age	25-35	135	45	45	49
Age	36-45	91	30.3	30.3	79.3
Age	45-55	54	18	18	97.3
Age	55+	8	2.7	2.7	100
Education	High school and below	38	12.7	12.7	12.7
Education	Diploma	48	16	16	28.7
Education	Bachelor's	119	39.7	39.7	68.3
Education	Master's	56	18.7	18.7	87
Education	PhD	39	13	13	100
Salary	<15k	56	18.7	18.7	18.7
Salary	15,001-20k	83	27.7	27.7	46.3
Salary	20,001-25k	91	30.3	30.3	76.7
Salary	25,001-30k	55	18.3	18.3	95
Salary	>30k	15	5	5	100

Descriptive statistics provide an overview of the demographic characteristics of the respondents and summarize the central tendencies and distributions of the variables. The demographic profile revealed the following:

Gender: The sample consisted of 48% male and 52%

female respondents.

Age: The majority of participants were aged between 25–35 years (45%), followed by 35–45 years (30.3%), indicating a relatively young workforce.

Education: Most respondents held a bachelor's degree

(39.7%), while a significant portion had completed master's (18.7%) or diploma programs (16%).

Salary: The highest percentage of respondents earned between 20,000–25,000 BDT (30.3%).

Descriptive statistics for the independent variables (Route and Node Optimization, Shipment Consolidation, Demand Forecasting), the moderating variable (AI Implementation), and the dependent variable (Transportation Cost Reduction) showed consistent responses, with mean scores ranging between 2.4 and 2.6 on a 5-point Likert scale. This indicates moderate agreement with the effectiveness of these strategies.

4.1.1. Principle Component Analysis (PCA)

Table 2. KMO and Bartlett's Test Results

Test	Statistic	Value
Kaiser-Meyer-Olkin (KMO)	Measure of Sampling Adequacy	0.896
Bartlett's Test of Sphericity	Approx. Chi-Square	6364.638
	Degrees of Freedom (df)	190
	Significance (Sig.)	0

Table 3. Total Variance Explained

Component	Initial Eigenvalues: Total	% of Variance	Cumulative %	Extraction Sums of Squared Loadings: Total	% of Variance (Extraction)	Cumulative % (Extraction)	Rotation Sums of Squared Loadings: Total	% of Variance (Rotation)	Cumulative % (Rotation)
1	9.835	49.174	49.174	9.835	49.174	49.174	3.364	16.818	16.818
2	1.859	9.293	58.467	1.859	9.293	58.467	3.355	16.776	33.594
3	1.833	9.165	67.631	1.833	9.165	67.631	3.348	16.742	50.336
4	1.653	8.265	75.897	1.653	8.265	75.897	3.262	16.311	66.647
5	1.397	6.986	82.883	1.397	6.986	82.883	3.247	16.236	82.883
6	0.66	3.301	86.184						
7	0.618	3.088	89.272						
8	0.565	2.823	92.095						
9	0.202	1.012	93.106						
10	0.182	0.909	94.015						
11	0.155	0.773	94.788						
12	0.142	0.712	95.501						
13	0.138	0.688	96.189						
14	0.133	0.666	96.855						
15	0.123	0.613	97.468						
16	0.119	0.595	98.063						
17	0.109	0.543	98.606						
18	0.105	0.525	99.131						
19	0.095	0.477	99.608						
20	0.078	0.392	100						

Table 4. Rotated Component Matrix

Variable	Component 1	Component 2	Component 3	Component 4	Component 5
RNO1	0.849				
RNO2	0.828				
RNO3	0.848				
RNO4	0.844				
CS1		0.803			
CS2		0.844			
CS3		0.825			
CS4		0.813			
DF1			0.86		
DF2			0.81		
DF3			0.837		
DF4			0.841		
AI1				0.846	
AI2				0.837	
AI3				0.827	
AI4				0.835	
TCR1					0.822
TCR2					0.818
TCR3					0.796
TCR4					0.823

The results demonstrate the robustness of the data for factor analysis, supported by a Kaiser-Meyer-Olkin (KMO) value of

0.896, indicating high sampling adequacy. Additionally, Bartlett's Test of Sphericity was highly significant (Chi-Square = 6364.638, $df = 190$, $p < 0.001$), confirming the data's suitability for further analysis. Five components were extracted, collectively explaining 82.883% of the variance, with the first component alone accounting for 49.174%. The rotated component matrix revealed strong loadings for all variables on their respective components, validating the constructs. For example, variables such as RNO1–RNO4 loaded strongly onto Component 1 (0.828–0.849), while CS1–CS4 showed high loadings on Component 2 (0.803–0.844). The consistent and distinct loading patterns affirm the validity of the theoretical framework, providing a solid foundation for subsequent analyses.

4.2. Reliability Analysis

The reliability analysis confirmed excellent internal consistency for all constructs in the study, with Cronbach's Alpha values exceeding 0.9. Transportation Cost Reduction (TCR), Route and Node Optimization (RNO), Shipment Consolidation (CS), Demand Forecasting (DF), and AI Implementation (AI) demonstrated strong reliability, indicating that the survey items effectively measured their respective constructs. The Cronbach's Alpha for the entire

questionnaire was 0.937, further validating the overall reliability of the instrument. These results confirm that the data collected is consistent and reliable for further statistical analysis.

Table 5. Reliability Statistics

Statistic	Value
Cronbach's Alpha	0.945
Cronbach's Alpha Based on Standardized Items	0.945
N of Items	20

4.3. Correlation Analysis

The correlation analysis confirms the validity of the study's constructs, showing significant positive relationships among all variables at the 0.01 level. Key findings include Transportation Cost Reduction (TCR) positively correlating with Route and Node Optimization ($r = 0.460$), Shipment Consolidation ($r = 0.535$), Demand Forecasting ($r = 0.515$), and AI Implementation ($r = 0.507$). Moderate correlations among independent variables suggest discriminant validity, while strong correlations with TCR indicate convergent validity. These results support the constructs' validity and provide a solid foundation for further analysis.

Table 6. Correlation Matrix

Variable	MedianTCR: Pearson Correlation	MedianTCR: Sig. (2-tailed)	MedianTCR: N	MedianRNO: Pearson Correlation	MedianRNO: Sig. (2-tailed)	MedianRNO: N	MedianCS: Pearson Correlation	MedianCS: Sig. (2-tailed)	MedianCS: N	MedianDF: Pearson Correlation	MedianDF: Sig. (2-tailed)	MedianDF: N	MedianAI: Pearson Correlation	MedianAI: Sig. (2-tailed)	MedianAI: N
MedianTCR	1		300	0.46	0	300	0.535	0	300	0.515	0	300	0.507	0	300
MedianRNO	0.46	0	300	1		300	0.475	0	300	0.461	0	300	0.458	0	300
MedianCS	0.535	0	300	0.475	0	300	1		300	0.449	0	300	0.494	0	300
MedianDF	0.515	0	300	0.461	0	300	0.449	0	300	1		300	0.46	0	300
MedianAI	0.507	0	300	0.458	0	300	0.494	0	300	0.46	0	300	1		300

4.4. Multiple Regression Analysis

The multiple regression analysis highlights the significant positive impact of Route and Node Optimization (RNO), Shipment Consolidation (CS), and Demand Forecasting (DF) on Transportation Cost Reduction (TCR). The model explains 40.1% of the variance in TCR ($R^2 = 0.401$), with an F-ratio of 66.181 ($p < 0.001$), confirming its overall significance. Individually, RNO ($B = 0.193$, $p = 0.001$), CS ($B = 0.367$, $p < 0.001$), and DF ($B = 0.308$, $p < 0.001$) all contribute significantly to reducing transportation costs. These results validate the study's hypotheses and underscore the importance of effective logistics strategies in cost optimization.

Table 7. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.634	0.401	0.395	0.86908

Table 8. Coefficients

Model	Unstandardized Coefficients: B	Standardized Coefficients: Beta	t	Sig.
1	0.398	0.163	2.437	0.015
1	0.193	0.06	3.218	0.001
1	0.367	0.061	6.027	0
1	0.308	0.056	5.472	0

4.5. Moderating Efficiency Test

The analysis highlights that Artificial Intelligence (AI) significantly enhances the effectiveness of logistics strategies in reducing transportation costs. AI acts as a moderator, with a moderate positive impact on the relationship between Route and Node Optimization ($Beta = 0.150$, $p = 0.013$), a strong effect on Shipment Consolidation ($Beta = 0.214$, $p = 0.001$), and a substantial positive influence on Demand Forecasting ($Beta = 0.182$, $p = 0.005$). These findings emphasize that integrating AI into logistics operations strengthens the efficiency of individual strategies, particularly Shipment Consolidation, and underscores the importance of AI-driven technologies for achieving cost optimization and improved

logistics performance.

Table 9. Moderating Efficiency Effect

Predictor Variables	Unstandardized Coefficients (B)	Std. Error	Standardized Coefficients (Beta)	t-value	Sig. (p-value)
Constant	2.404	0.063	-	38.157	0.000
Interaction_RNO_AI (Route and Node Optimization × AI)	2.875E-6	0.000	0.150	2.500	0.013
Interaction_CS_AI (Shipment Consolidation × AI)	5.549E-6	0.000	0.214	3.421	0.001
Interaction_DF_AI (Demand Forecasting × AI)	3.348E-6	0.000	0.182	2.800	0.005

4.6. Hypothesis Testing

The ANOVA table indicates that the regression model is statistically significant in explaining Transportation Cost Reduction (TCR). The F-statistic of 66.181 and the p-value of 0.000 suggest that the independent variables (Route and Node Optimization, Shipment Consolidation, and Demand Forecasting) together have a significant impact on TCR. The Sum of Squares shows that the model explains a substantial portion of the variation in TCR (149.961 for Regression), while the remaining variation (223.569 for Residual) is not explained by the model. The high F-statistic and low p-value confirm that the model is a good fit for the data, demonstrating that these three factors play a crucial role in reducing transportation costs.

Table 10. ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	149.961	3	49.987	66.181	0.000
Residual	223.569	296	0.755		
Total	373.53	299			

5. Discussion

The study highlights AI's transformative role in enhancing logistics strategies, with Shipment Consolidation showing the strongest impact on transportation cost reduction. AI significantly improved the efficiency of Route and Node Optimization and Demand Forecasting, addressing key logistical challenges in Bangladesh. Despite the benefits, adoption barriers like limited infrastructure and workforce resistance remain. The findings provide a scalable framework for integrating AI in logistics, with implications for cost efficiency in similar developing economies. Future research should explore long-term impacts and broader applications.

6. Conclusion

The study confirmed that logistics strategies Route Optimization, Shipment Consolidation, and Demand Forecasting significantly reduce transportation costs, with AI playing a critical role in enhancing their effectiveness. Shipment Consolidation had the strongest impact, while AI strengthened the efficiency of all strategies. The research contributes theoretically by validating AI's moderating role in logistics management and practically by offering actionable insights for logistics companies in developing countries like Bangladesh. Despite challenges such as limited data access, technological barriers, and resistance to change, the study achieved its objectives, addressing the research questions effectively. Recommendations include investing in AI-driven tools, supporting digital infrastructure, and exploring AI's role in other logistics areas. Limitations, such as the small

sample size and geographic focus, point to future research opportunities, including longitudinal studies and broader geographic analysis.

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References

- [1] Guan, X., Zhang, X., & Sun, Y. (2020). Artificial intelligence in logistics and supply chain management: A comprehensive review. *International Journal of Production Research*, 58(24), 7425-7444.
- [2] Hosseini, S., & Vahdani, B. (2020). A data-driven approach to the optimization of transportation costs using artificial intelligence. *Transportation Research Part E: Logistics and Transportation Review*, 141, 102020.
- [3] Zhang, L., & Li, Z. (2021). Optimization of transportation routing with AI-based predictive analytics. *Transportation Research Part C: Emerging Technologies*, 126, 103084.
- [4] Li, Y., & Zeng, Q. (2021). AI applications in supply chain management: Benefits, challenges, and future directions. *Journal of Business Logistics*, 42(1), 56-78.
- [5] Choi, T. M., & Guo, Y. (2020). AI-enabled supply chain optimization and transportation cost reduction. *International Journal of Logistics Management*, 31(3), 674-692.
- [6] Xie, J., & Wang, J. (2020). Using machine learning techniques for optimizing transportation routes in urban logistics. *Transportation Research Part B: Methodological*, 132, 156-172.
- [7] Kusuma, S. D., & Muneer, S. (2020). Artificial intelligence in logistics: A review of AI-based approaches for transportation optimization. *International Journal of Logistics Research and Applications*, 23(4), 348-368.
- [8] Yang, X., & Xie, X. (2021). Optimization of multi-modal transport networks using artificial intelligence. *Journal of Intelligent Transportation Systems*, 25(2), 136-150.
- [9] Liu, H., & Wang, Z. (2020). AI-based demand forecasting for reducing logistics costs in supply chains. *Computers & Industrial Engineering*, 150, 106101.

- [10] Vahdani, B., & Fattahi, M. (2021). A hybrid AI-based model for optimizing transportation and distribution logistics. *International Journal of Production Economics*, 238, 108162.
- [11] Rezaei, J., & Wei, Y. (2021). AI and machine learning techniques in the logistics sector: A systematic review. *Computers, Materials & Continua*, 67(2), 2121-2137.
- [12] Wang, L., & Wang, X. (2020). Artificial intelligence and transportation cost reduction: A review. *Journal of Transportation Engineering, Part A: Systems*, 146(4), 04020024.
- [13] Zhu, M., & Li, W. (2020). The impact of artificial intelligence on logistics cost reduction: A case study in China. *Transportation Research Part E: Logistics and Transportation Review*, 139, 101951.
- [14] Hossain, M. M., & Nandi, S. (2020). AI-driven transportation management in Bangladesh: A case study on reducing logistics costs. *Asian Journal of Supply Chain and Operations Management*, 5(2), 120-134.
- [15] Tan, K. C., & Yang, C. C. (2020). Enhancing transportation efficiency and reducing costs in the logistics sector using artificial intelligence. *European Journal of Operational Research*, 284(3), 865-878.
- [16] Chandra, S., & Mukherjee, A. (2021). Machine learning techniques for route optimization in logistics. *Journal of Operations Management*, 60(3), 398-415.
- [17] Bai, X., & Li, Y. (2021). The role of AI in shipment consolidation for transportation cost reduction. *Journal of Business Research*, 124, 465-472.
- [18] Shang, J., & Tseng, Y. (2020). AI-powered supply chain strategies for cost reduction in developing countries. *International Journal of Production Research*, 58(24), 7410-7424.
- [19] Bai, C., & Duan, Y. (2020). Artificial intelligence in logistics: A review of recent developments. *Computers & Industrial Engineering*, 146, 106539.
- [20] Zhao, X., & Wu, Q. (2021). Leveraging AI for demand forecasting in logistics: A comparative analysis. *International Journal of Production Economics*, 235, 108104.
- [21] Feng, S., & Li, Y. (2021). Role of machine learning in route optimization for logistics cost reduction. *Computers & Industrial Engineering*, 154, 107091.
- [22] Chakravarty, A., & Gupta, S. (2020). AI in logistics: A comparative review of applications and challenges. *Journal of Supply Chain Management*, 56(1), 45-60.
- [23] Zhang, X., & Song, H. (2021). Forecasting transportation demand using machine learning: Implications for cost efficiency. *Transportation Research Part A: Policy and Practice*, 146, 252-265.
- [24] Kaur, P., & Kapoor, V. (2021). AI-powered logistics and transportation cost management in supply chains. *Journal of Artificial Intelligence Research*, 73(2), 225-244.
- [25] Moudgil, P., & Sharma, S. (2020). Artificial intelligence-based optimization of logistics operations: A case study approach. *International Journal of Logistics Management*, 31(3), 492-511.