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A study on optimizing inbound logistics network structures for minimizing cost and lead time

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Abstract
This study examines methods to optimize inbound logistics network structures in order to reduce transportation cost and lead time. The research analyzes important factors such as route optimization, vehicle utilization, mode of transportation, traffic congestion, and warehouse location. Primary data were collected from 120 respondents involved in logistics activities using structured questionnaires and observations. The findings indicate that most variables have a positive relationship with each other, showing that improvements in logistics planning can enhance overall efficiency. Secondary data analysis also helped identify cost-effective transportation options for material movement. The study highlights the importance of technology, data analytics, and strategic planning in logistics operations. Implementing these improvements can support faster deliveries, lower operational expenses, and better supply chain performance.

Keywords: Inbound logistics, transportation network optimization, cost reduction, lead time, route optimization, supply chain efficiency

Introduction

Transportation networks play a crucial role in economic growth by enabling efficient movement of goods and passengers, particularly in India where road transport dominates freight operations. However, congestion, rising operational costs, and infrastructure inefficiencies limit their overall performance. Strategic optimization of transportation systems can significantly reduce transit time and logistics expenses while improving service reliability and sustainability. Advanced models such as routing optimization and minimum-cost flow techniques support data-driven decision-making in logistics planning. The integration of technologies like real-time tracking and digital analytics further enhances operational efficiency and resilience. This study focuses on analysing transportation networks to identify inefficiencies and propose cost-effective, time-saving optimization strategies.

1. Objective of The Study

Primary Objective

To analyse and optimize the transportation network for achieving significant time savings and cost reduction on Inbound logistics.

Secondary Objective

- To find the inter relationship between the key factors determining the transportation network for time saving and cost reduction
- To find the correlation between the factors determining the cost reduction and time saving

2. Scope of The Study

The study focuses on improving inbound logistics network structures to reduce overall transportation cost and lead time. It examines route planning and network efficiency to identify delays and operational inefficiencies. The study also evaluates different cost elements such as fuel, labour, maintenance, and infrastructure usage. In addition, it considers sustainable logistics practices to minimize environmental impact. Further, the study reviews the role of modern technologies and policies in enhancing logistics performance and supporting efficient inbound supply networks.

3. Limitations of The Study

- The study depends on the availability and accuracy of data; incomplete or incorrect data may affect the results.
- Optimization models use certain assumptions and may not fully reflect real-world conditions such as traffic changes or human behavior.
- Implementing the suggested strategies may face practical challenges like system integration, organizational resistance, and changing logistics environments.

4. Review of Literature

Optimization of Transportation Networks for Cost Efficiency and Speed authored by Hasmukh Panchal (2025) examined the integration of data-driven AI and machine learning techniques with traditional mathematical models to enhance transportation network performance. The study aimed to minimize transit costs and travel times while balancing environmental emissions and demand forecasting.

A Review on Transportation Network Based on Complex Network Approach authored by Nur Umaisara Rashid and Chan Kar Tim (2023) [2] provided an overview of the application of complex network theory to transportation systems. The objective of the study was to understand the structure, dynamics, node significance, and evolution of transportation networks through this theoretical lens.

Transportation Cost and Benefit Analysis – Travel Time Costs authored by Todd Litman (2023) [3] offered a detailed framework for assessing the economic implications of travel time across different transportation modes. The study emphasized that travel time costs differ depending on trip purpose, traveler characteristics, and conditions.

Optimisation Models for Transportation Network Design Under Uncertainty: A Literature Review (arXiv preprint, 2022) presented a comprehensive review of optimization models applied to transportation network design in uncertain environments. The authors categorized existing models into

mathematical and geometrical approaches, analyzing their use in routing and districting problems.

Travel Time Reliability in Transportation Networks: A Review of Methodological Developments authored by Zhaoqi Zang, Xiangdong Xu, Kai Qu, Ruiya Chen, and Anthony Chen (2022) explored methodological advancements in analyzing travel time reliability (TTR) within transportation systems. The study categorized TTR research into three main areas: characterization, evaluation, and traffic assignment. It emphasized the importance of addressing uncertainty propagation across spatial levels and incorporating emerging data technologies.

Theoretical Background

The theoretical background of this study is based on logistics and supply chain management concepts that focus on improving transportation efficiency. Factors such as route optimization, vehicle utilization, and mode of transportation help organizations reduce travel time and operational costs. Traffic congestion and warehouse location also influence delivery speed and transportation expenses. Efficient coordination of these factors helps in better planning of logistics activities. Therefore, improving these variables can lead to significant time savings and cost reduction in inbound logistics networks.

Independent Variables Dependent Variable

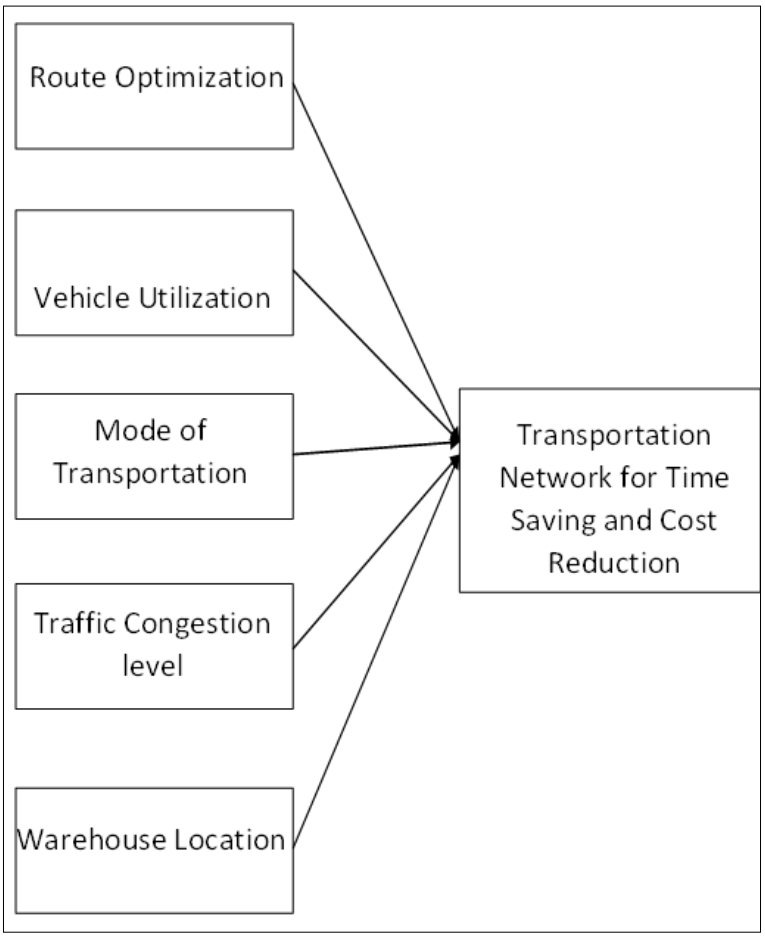

Fig 1: Conceptual Model

Research Design

The study adopts a descriptive research design to examine the transportation network and identify factors affecting time efficiency and cost reduction. A quantitative approach was used, where primary data were collected through structured questionnaires, interviews, and observations from logistics staff, drivers, managers, and distribution partners. Secondary data were gathered from transportation records, delivery logs, and industry reports to support the study. The research used a convenience sampling method under non-probability sampling, with a sample size of 120 respondents involved in logistics and transportation activities.

Data Analysis

The descriptive analysis of all categorical variables, as presented in the table below, highlights the major findings of the study.

Table 1: Demographic Profile of Respondents

Variable	Category	Frequency	Percentage (%)
Age	Below 30	70	58.3
	30 to 45	27	22.5
	46 to 50	11	9.2
	Above 50	11	9.2

	Total	120	100.0
Gender	Male	60	50.0
	Female	57	47.5
	Others	3	2.5
	Total	120	100.0
Education Level	Diploma	54	45.0
	Undergraduate	52	43.3
	Postgraduate	8	6.7
	Others	6	5.0
	Total	120	100.0
Job Role	Owner	52	43.3
	Manager	37	30.8
	Driver	21	17.5
	Others	10	8.3
	Total	120	100.0
Experience	Less than 1 year	40	33.3
	1 to 3 years	57	47.5
	4 to 6 years	19	15.8
	More than 7 years	4	3.3
	Total	120	100.0
Mode Of Transport	Rail	22	18.3
	Road	94	78.3
	Sea	3	2.5
	Air	1	.8
	Total	120	100.0

The table shows that most respondents are below 30 years of age (58.3%)**,** indicating a young workforce in the transportation sector. The gender distribution is almost equal, with 50% male and 47.5% female respondents. In terms of education, the majority have a Diploma (45%) or are Undergraduates (43.3%)**.** Most respondents are Owners (43.3%) and Managers (30.8%)**,** with 1 to 3 years of experience (47.5%)**.** The data also shows that road transport (78.3%) is the most commonly used mode of transportation.

1. Secondary Data Analysis

Table 2: Secondary Data Analysis

S No	Name of transport	Amount(kg)	Duration
1	Government Railway	9.50Rs	48Hrs
2	Value Expess International (Flight)	190Rs	48Hrs
4	Value Expess International (Train)	30Rs	7Days
5	Jmk Cargo (Train)	22Rs	48Hrs
6	Satender Cargo (Train)	28Rs	48Hrs
7	Oscar Expess Worldwide	125Rs	10Days
8	Legend Express	100Rs	8Days
9	Indian International Express	150RS	9Days
10	Dutch Associates	120Rs	6Days
11	Atlantic Courier	110Rs	9Days
12	Avani Enterprises	100Rs	10Days
13	Professional Courier	120Rs	8Days
14	Trackon Courier	130Rs	12Days
15	Dtdc Courier	120Rs	6Days
16	Abt Parcel	130Rs	6Days
17	Akr Express	120Rs	8Days
18	Kaveri Cargo	120Rs	10Days
19	Dart International	140Rs	8Days
20	Garudavega International	120Rs	7Days
21	Porter Intercity	120Rs	10Days
22	Courierbook	110Rs	7Days
23	Sri Murugan Courier	120Rs	9Days
24	Rivigo Logistics	120Rs	10Days
25	Maakeena Logistics	110Rs	8Days

These are the courier services which is identified for importing the raw materials from New Delhi to Coimbatore through the train transport. The JMK Cargo courier is selected for the transportation which is comparatively with low cost and less time duration. This transportation will be more suitable for the company.

2. Correlation analysis

Correlation analysis between overall mean

Null Hypothesis (H_0): There is no significant relationship between factors affecting cost reduction and time saving**.**

Alternative Hypothesis (H_1): There is significant relationship between factors affecting cost reduction and time saving**.**

Table 3: Correlation Analysis Between Overall Mean

Mean		mean1	mean2	mean3	mean4	mean5
Route Optimi-zation	Pearson Correlation	1	.355**	.280**	.278**	.326**
	Sig. (2-tailed)		.000	.002	.002	.000
	N	120	120	120	120	120
Vehicl-e Utilizat-ion	Pearson Correlation	.355**	1	.342**	.276**	.240**
	Sig. (2-tailed)	.000		.000	.002	.008
	N	120	120	120	120	120
Mode of Transp-ortation	Pearson Correlation	.280**	.342**	1	.304**	.175
	Sig. (2-tailed)	.002	.000		.001	.056
	N	120	120	120	120	120
Traffic Conges-tion Level	Pearson Correlation	.278**	.276**	.304**	1	.297**
	Sig. (2-tailed)	.002	.002	.001		.001
	N	120	120	120	120	120
Wareh-ouse Locatio-n	Pearson Correlation	.326**	.240**	.175	.297**	1
	Sig. (2-tailed)	.000	.008	.056	.001	
	N	120	120	120	120	120

The correlation analysis shows that the five variables have positive relationships with each other, though the strength of the relationships differs. The strongest relationship is between Route Optimization and Vehicle Utilization (r =. 355), indicating a significant positive association. Route Optimization also has significant positive relationships with Mode of Transportation, Traffic Congestion Level, and Warehouse Location. Vehicle Utilization is positively correlated with Mode of Transportation, Traffic Congestion Level, and Warehouse Location. However, the relationship between Mode of Transportation and Warehouse Location is weak and not statistically significant. Overall, the results indicate that improvements in one factor tend to be associated with improvements in the others.

Managerial Implications

- Adopt advanced routing and predictive tools with real-time traffic and weather updates to improve route planning and delivery efficiency.
- Improve vehicle and load utilization by implementing load monitoring systems, AI-driven load optimization, and tracking key metrics like average load factor.
- Strengthen logistics team capabilities through regular training on route optimization, digital tools, and capacity utilization practices.
- Use data-driven transport decisions by reviewing transport modes periodically based on cost, delivery time, shipment size, and urgency.
- Manage traffic congestion effectively by integrating GPS and predictive traffic analytics, expanding off-peak deliveries, and coordinating with local authorities.
- Enhance warehouse location planning by using logistics performance data and Geographic Information Systems (GIS) for strategic warehouse placement and network redesign.

Conclusion

Logistics practices are moderately effective but still require improvement to achieve full efficiency. Route planning and traffic management need stronger implementation through better monitoring and planning systems. Vehicle utilization and transport decisions should be supported with advanced technologies and data-driven approaches. Improving warehouse location strategies and coordination among logistics functions can enhance operational performance. Overall, adopting modern technologies, improving employee skills, and focusing on sustainable logistics will strengthen efficiency and competitiveness.

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