THE IMPACT OF TRANSPORTATION BOTTLENECKS ON LEAD-TIME AND OVERALL SUPPLY CHAIN PERFORMANCE IN RAIPUR

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ABSTRACT

Transportation bottlenecks plays a crucial role in the industries of developing countries, especially where insufficient infrastructures, traffic jams and improper logistics systems influence the efficiency of supply chain. Raipur, being an industrial hub with urbanization potentials witnesses increasing problems associated with late deliveries due to these bottlenecks, necessitating prolonged lead-time and frustrating customer satisfaction, while pressurizing transport performance. The study utilizes a mixed approach to examines the influence of transportation inefficiencies on lead-time and operational outcomes of late delivery in Raipur supply chain. The findings identify the main causes of these delays, measuring their impact, offer strategic approaches for preventing the bottlenecks on transportation. Moreover, the research provides suggestion and recommendations on how to mitigate production disruptions optimizes operational efficiency and maintain customer satisfaction level.

Keywords: Transportation, Bottleneck, Lead-time, Supply Chain Performance, Disruption, Late-delivery.

INTRODUCTION

Raipur serves as a critical transit location for movement of goods to and from different part of India. It also has access to several major national highways and railway lines. The rapid industrialization in Raipur especially in cement, steel, coal and agriculture sectors has significantly promoted its economic growth and development. Despites this economic potentials, there are several challenges in its infrastructure for logistics and transportation system. These challenges comprise congestion at key interchanges, underdeveloped roads network, and connectivity to major roads, creating problems associated with lead-time, operational efficiency and overall supply chain performance. This study explore how Raipur's transportation bottlenecks impacted supply chain, focusing on identifying the root cause and suggesting actionable solutions tailored to the region's logistics environment.

Background of the Study

Raipur, the capital of Chhattisgarh is a strategic destination for trade, commerce and logistics operations, connecting major industrial cities like Mumbai, Kolkata and Delhi. The city is also positioned at the intersections of national highways NH-6, NH-43, and NH-30. Its proximity to heavy industrial producing regions such as steel manufacturing hubs, makes it ideal place for transporting raw-materials, components and finished goods. Raipur's accessibility to railways plays a key role in facilitating transportation of goods to other parts of India.

Rodrigue et al. (2020) defined transportation bottlenecks as a point of delay or congestion that hinder the smoot flow of goods within a supply chain. The rapid urbanization and economic growth in Raipur have out-spaced the development of transportation infrastructure. As a result, businesses faces increased lead-time, higher logistics costs and reduced operational efficiency^[26]. The Indian Ministry of Road and Highways (2020) reported that inefficiencies in public transportation system may increase logistics costs by up to 14% GDP^[8]. In Raipur, these challenges are evident in industries reliant on time-sensitive deliveries, like agriculture, manufacturing and retail. For instances, agricultural supply chain of Raipur is significantly impacted by post-harvest losses and reduced profitability for farmers due to delays^[6] (Chaudhary et al., 2022).

Lead-time is one of the most essential component of supply chain performance metric which is directly affected by transportation bottlenecks. Traffic congestion, insufficient



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transport infrastructure and supply chain disruption are mostly caused by delays in delivery, creating a negative effect on production planning, inventory management and service level (Simchi-Levi et at., 2021). Moreover, Mentzer et al. (2018) argued that prolonging lead-times can necessitate higher safety stock level and increases uncertainties, reducing customer satisfaction and agile supply chain.

In Raipur, the potential solutions for preventing transportation bottlenecks require technology adoption, like predictive analytics and real time tracking systems. Study by Singh & Gupta (2023) highlighted that there is limited application of these technologies due to the high cost of implementation and inadequate technical expertise across Raipur's businesses. The findings of this research underscore the importance of collaboration among government agencies, private sector and local stakeholders to improve Raipur's transportation systems^[21].

Objectives of the Study

- 1. To investigate the key factors contributing to transportation bottlenecks in Raipur.
- 2. To analyze the relationship between transportation bottlenecks and lead time in Raipur.
- 3. To examine the effects of transportation inefficiencies on supply chain performance
- 4. To provide actionable strategic approaches for mitigating transportation bottlenecks and foster supply chain efficiency in Raipur.

Research Questions

- 1. What are the primary causes of transportation bottlenecks in Raipur?
- 2. To what extent that Raipur's transportation bottlenecks affect lead-time?
- 3. What are the potential implications of prolonged lead-times on supply chain performance?
- 4. What strategic approaches could be implemented to ensure a resilient supply chain in Raipur?

The Needs of the Study

This research study aimed at exploring an in-depth understanding issues and challenges affecting transportation bottlenecks on lead-time and overall supply chain performance through developing strategies and interventions that would promote efficient and cost-effective operations. By providing Raipur's specific insights into these challenges, the study contributes to the existing body of knowledge and discourse. Moreover, the study will offer practical recommendations for transport and logistics managers, policy makers



and supply chain experts on how to improve transportation system to avoid bottlenecks, alongside promoting economic competitiveness in Raipur.

Scope of the Study

The study is specifically limited to Raipur's transportation systems but can be useful to other cities in central India, focusing on analyzing bottlenecks with lead-times and their impact to local supply chain in Raipur. It also explores the contributing factors such as traffic congestion, infrastructure deficits and regulatory barriers, including identifying and adopting technological solutions in addressing these challenges.

The study emphasized the needs for broader supply chain management principles and prosperous logistics environment for Raipur's local businesses.

LITERATURE REVIEW

The existing literature of this study provides a detailed understanding of the causes, implications, and potential solutions to the challenges bedevilling transportation bottlenecks on lead-time and supply chain performance. The review will establish a foundation for analysing key studies, including the interplay between transportation inefficiency and supply chain dynamics.

Definition and Causes of Transportation bottlenecks

Rodrigue et al. (2020) define transportation bottlenecks as point of congestion or delay that disrupt the movement of goods within a supply chain^[27]. They are often caused by inefficient traffic management, inadequate infrastructure and regulatory constraints. Additionally, Lack of multimodal transport systems and poor condition of road networks are the most frequent causes of transportation bottlenecks in emerging cities^[7] (Chopra & Mendel, 2022). The growing industrialization and urbanization in Raipur have worsening these challenges, undermining transport and logistics operations, while significantly affecting supply chain performance^[3](Agarwal & Sharma, 2021).

Influence on Lead-time

Lead-time is an essential metric for measuring supply chain management performance, which directly affect transportation bottlenecks. Adewale et al. (2021) suggested that post-harvest losses and decreased profit in agricultural supply chain is significantly resulted by transportation delays^[2]. In Raipur, the movement of perishable goods has been observed with similar trends, resulting in significant damages and quality degradation^[22](Olukanni et al., 2021). This indicates the extent of relationship between



transportation bottlenecks and lead-time, particularly evident in time-sensitive industry. Therefore, prolonged lead-time necessitates higher safety of stock levels, increasing uncertainty and in supply chain agility.

Impact on Supply Chain Performance

Transportation bottlenecks have profound implications on supply chain performance, causing late deliveries and increased lead-time. Inefficient transportation systems are significantly reducing order fulfilment rates, diminishing customer satisfaction and increases overall logistics costs^[18] (World Bank, 2019). In Raipur, transportation costs, service level rates and customer satisfaction have a far-reaching implication on supply chain and its key performance metrics. Adeola & Oladimeji (2020) emphasized that delay in freight movement increase fuel consumption and labor costs, while also affecting the reliability of delivery^[1]. The competitiveness of businesses in the region is undermined by these inefficiencies, particularly small and medium enterprises(SMEs) that have insufficient resources to absorb additional costs^[21](Singh & Gupta, 2023)

Technological and Policy Intervention

In Raipur, GPS-enabled tracking system used provides an improvement in freight visibility and lessen lead-time. According to Agrawal and Sharma (2021), businesses that uses these technologies have reported significant improvements in delivery reliability and customer satisfaction. The barrier for adopting technology solutions is often associated with initial cost of implementation. Additionally, the policy interventions play a pivotal role in addressing transportation bottlenecks through infrastructure upgrade and expansion^[28]. The expansion of rail networks, investments in road rehabilitations and establishment of multimodal transport systems are crucial for improving logistics efficiency^[27] (Rodrigue et al., 2020). To administer delay and optimize freight movement, there is need for regulatory reforms to simplified interstate trade, reducing transit times and logistics costs.

Theoretical Framework

The structural approach to analyzing the impact of transportation bottlenecks requires a theoretical strategy such as Supply Chain Operations references (SCOR). This model underscores the importance of optimizing key processes, including planning, sourcing, making, delivery and return management to improve overall efficiency^[7] (Chopra & Meindl, 2022) Similarly, Raipur's transport and logistics providers can use this model to



investigate and identify the bottlenecks on lead-time and overall supply chain performance through developing interventions necessary to address them.

Knowledge Gap and Future Research Directions

This study identifies numerous gaps on this topic despite the extensive literature reviewed on transportation bottlenecks. Research on this specific field of study is limited based on the findings on this research, particularly on SMEs and their commitment to adopting technology-driven solutions to prevent bottlenecks in transportation. Additionally, future research on this field should focus on developing specific region approach for improving transportation and logistics efficiency, emphasizing capacity building and stakeholder collaboration. More research to evaluate the long term impact of policy interventions and investment in infrastructure on Raipur's supply chain is highly needed, including comparative studies between Raipur and other emerging cities to provide valuable insights into practices and studies learned.

RESEARCH METHODOLOGY

This study employs a mixed approach, integrating quantitative and qualitative data to provide a in-depth understanding and ensures a robust analysis through leveraging the relevance of numerical data and valuable insights from interview participants. These approaches aim at investigating the impact of transportation bottlenecks on lead-time and overall supply chain performance in Raipur.

Research Design

The research design of this study involves collection and analysis of quantitative data, followed by qualitative data to intricate on the quantitative outcomes. This quantitative design aimed at identifying patterns and similarities between transportation bottlenecks and supply chain performance, while exploring the underlying reasons and contextual factors behind the patterns by qualitative analysis.

Sampling Population

Quantitative Aspect

The sample size comprise 55 respondents is purposively selected, ranging from students, retailers, shop-owners, supply chain experts and distributors to ensure a limited representation from stakeholders. This sampling technique uses questionnaire to enable those with requisite and direct experience of transportation and supply chain management to respond.



Qualitative Aspect

The interview conducted in this study consists of 12 participants using snowball sampling. They include representative of SMEs, logistics experts and government officials in Raipur. This sampling technique is used to identify contextual insights from key stakeholders of transportation and supply chain dynamics.

Data Analysis

Quantitative Data Analysis

A descriptive statistic such as mean, median and standard deviation were used to analyze the data collected and summarized the frequency of the impact of transportation bottlenecks. Additionally, correlation and regression analysis were used to evaluate the relationship between transportation bottlenecks and lead-time.

Qualitative Data Analysis

The contextual data received from interview is also analyze using thematic method to identify and interprets patterns among the data. The theme generates initial code to organize the data, while ensuring a systematic and transparent analysis process.

Ethical Consideration

The key ethical considerations adhered to the principles of this study includes protecting their rights of anonymity, confidentiality and well-being of the participants. Their participation was entirely voluntary and can withdraw their input at any process of this research without penalty. Similarly, the overall data collected were secured, stored but accessible to only researcher and his supervisor.

Limitation of the Study

The methods used in this research identifies several limitations such as:

- 1. The generalizability of the findings is limited to other regions due to small sample size used.
- 2. Participants were selected based on their relevance to the study which simultaneously contributed to Selection bias as a result of using purposive sampling.
- 3. The questionnaires and interviews conducted may often lead to response bias due to overstating or understating the severity of transportation bottlenecks.



This methodology highlighted statistical trends and contextual factors with nuance understanding of the challenges and broad improvement to transportation and supply chain efficiency in Raipur.

ANALYSIS OF FINDINGS

The findings of this study provides a comprehensive detail of data analysis, incorporating quantitative data from 57 respondents and qualitative data from 11 interview participants. The research approaches employed would ensures an in-depth understanding of the key challenges and potential solutions.

Quantitative Analysis

Demographic Analysis of the Respondents

The demographic profile used in this study placed limitations to only participants that are relevant to the research topic. They include shop owners, distributors, retailers and students based on their experiences. Moreover, the questionnaire respondents comprise 75% males and 25% females respectively.



a. Age group of the participants

Graph 1 : Age Group of the Respondents

Graph 1 The findings shows that the significant number of the responses has been collected from within the age bracket of 15-25 years, constituting 40% and followed by 25% among those from 26-35 age distribution. The average participants were 20% across



36-45 years, while the lowest participants came from elderly participants with 15% responses.



b. Current Educational Status of the Respondents

Graph 2 : Education of the Respondents

Graph 2 The pie-chart above illustrates that 35% 0f the respondents possessed postgraduate education which represents average responses from intellectuals, with highest responses of 40% from under graduate students. Subsequently, the lowest responses were collected from those that are neither post or undergraduates with 25% responses.

Analysis of Impact

a. Diversity and Frequency of transportation bottlenecks

Aspects	Frequency
Insufficient and outdated roads networks	25%
Traffic congestion	30%
Vehicle problems	25%
Delays in check-points	20%

Table 1 : Transportation Bottlenecks

Table 1 The frequency rated in relation to insufficient roads networks were mutually exclusive with Vehicles problems at 25% respectively. The significant issues with highest percentages of response was traffic congestion with 30%, while also delays in authorities' checks indicated 20% which represent the lowest.

b. Influence on lead-time





Graph 3 : Effects of Bottlenecks on Lead-time

Graph 3 The transportation bottlenecks found is significantly increasing lead-time days. The above scatter plot indicated 45% of the respondents claimed 4 days' increase as a result of bottlenecks, alongside 29% that experiences at least 3 and half days. The average respondents that represents 15% opted for additional 2days and 11% claimed at least a day and half.

c. Impact on supply chain performance



Graph 4 : Impact on SC

Graph 4 above pie-charts illustrate that 30% of the respondents are in the opinion that transportation bottlenecks increases costs, while the modal responses attributed 52% of



these bottlenecks affect customer satisfaction as well as 18% of respondents that claimed the impacts are on inventory management issues such as understocking or overstocking.

Qualitative Analysis

This section integrates thematic analysis with comparative insights to explore the vulnerability of transportation bottlenecks and its impacts on lead-time and supply chain performance.

Thematic Analysis

- **a. Traffic Congestion**: participants repeatedly recounted traffic congestions and public concentration on only Raipur, without considering the potential of Naya Raipur (New Raipur). For instance, a retailer of agricultural commodities argued that the volume of freight inside the city surpass the capacity of the current road networks. This create handling concerns on traffic personnel in a densely populated area. Similar findings were reported by Agarwal and Sharma (2021) who emphasized the need for better urban planning and infrastructural development in India^[3].
- **b. Delays in Toll-gates**: Some of the logistics experts and truck drivers that regularly uses Raipur's Highways highlighted frequent time spent on paperwork and inspections when transporting goods from Raipur to Pune and other parts of India, adds unnecessary delays to the lead-time in transportation process. This observation aligns with Kumar & Anbanandam (2020) who identified regulatory bottlenecks as a major challenge in Indian logistics^[29].
- **c. Impact on Local Supply Chain**: Interviewees narrated how transportation bottlenecks often disrupted supply chain operations. A Restaurant Distributor blamed most of the late deliveries experienced often lead to customer frustrations, particularly when timely delivery is indispensable. A study by Chopra & Meindl (2022), also identified the needs for a reliable and uninterrupted supply chains^[7].

Other interview observations are:

- a. Impact on Agricultural products: Frequent post-harvest losses in Raipur were resulted from delays in deliveries of perishable goods especially during peak seasons. Corroborating findings by Adeola and Oladimeji (2020)^[1].
- **b. Impact on Small Scale Manufacturers**: The frequent disruption of production schedules was usually caused by untimely and inconsistency of raw materials deliveries.



Incorporating Quantitative and Qualitative Analysis

The use of combined research approach in this study is to explore an in-depth insights of the research problem through triangulating numerical data and contextual views by the following points:

- **a.** The quantitative data that clearly delays experienced by 2 days increase was backed-up by qualitative insights of traffic congestion and toll-gate checking.
- **b.** The correlation between bottlenecks and increased costs was supported by a truck driver who highlighted additional costs often simultaneously incurred such as fuel wastage and vehicles servicing.

By integrating these findings, the study aimed at providing a comprehensive view of the impact of transportation bottlenecks on overall supply chain performance.

DISCUSSION OF FINDINGS

Transportation bottlenecks may often arise from various factors such as bad condition of roads networks and connectivity, transportation and logistical barriers as well as external operational disruptions. The efficiency and effectiveness of supply chain operation is crucial for businesses aiming to maintain resilience and competitiveness. An in-depth understanding of the impact of transportation bottlenecks can reduce the significant challenges posed to supply chain performance.

Causes of Transportation Bottlenecks

The findings of this study suggests Raipur's transportation bottlenecks have stems primarily from lack of adequate and well-maintain roads, rail connectivity and unpredictable external factors^[5]. The results of the findings aligned with Kumar et al. (2022)^[10]. The following broader observations are suggested:

- **a. Insufficient Infrastructure**: Insufficient transportation and logistics infrastructure have limit the free and uninterrupted flow of goods and services throughout the region, impacting manufacturing by reducing distribution capabilities.
- b. Traffic congestion: In India, several issues like inefficient fleet and urban management system, port and other terminal congestions, including inadequate warehousing facilities, leading to considerable delays. For instance, during covid-19 pandemic the challenges has resulted in significant disruptions in global supply chains.



c. Institutional and Regulatory Barriers: The time taken to process proper transport documents and frequent inspections to be conducted can slow down the supply chain operations. This institutional and regulatory complexities have been identified, profoundly contributing to additional operational costs.

Impact of bottlenecks on lead-time

Lead-time refers to the taken from placing an order to its fulfilment and delivery. This duration between initial and completion often directly or indirectly affects supply chain operations.

- **a.** Late Delivery: Late delivery can be attributed to transportation bottlenecks caused by delays, prompting prolonged led-times. For example, traffic congestion inside Raipur city have notably decreases the availability of essential commodities to some densely populated areas and indicating disruptions in the supply chain.
- **b.** Unpredictable Inventory Management: Transportation bottlenecks can increase uncertainty by making it challenging for businesses to forecast, plan and optimized inventory that would affect customer satisfaction.

Impact of Bottlenecks on Supply Chain Performance

Supply chain operation is severely affected by various aspects of transportation bottlenecks. Some of which are as follows:

- **a. Incurring higher additional costs**: Transportation bottlenecks often lead to increased operational costs as a result of extended lead-time and storage needs, adding labor hours and shipping requirements. Transportation and logistics in India constitutes 13-14% GDP due to higher costs of their operation, compared to 8-9% in developed economies.
- **b.** Eroding Customer Trust and Loyalty: The satisfaction level of customer may often be low due to inability and constant failure to deliver goods on time. This will significantly affect the company's reputation and future dealings.
- **c. Overstocking and understocking**: Transportation bottlenecks can lead to considerable inventory management issues that could be detrimental to business operations. Overstocking and understocking can also disrupt and straining stock levels, impacting relationships among supply chain partners.



Case Study: India's Transportation and Logistics Sector

This research underscores a pertinent example of how transportation bottlenecks impact supply chain performance in India's logistics sector:

- a. Cost of Logistics to India's GDP: Transportation and logistics costs India 15% of its gross domestic products (GDP), higher than 8-10% in other developed countries. The attributed factors of such disparity were inefficient fleet composition, lack of nationwide multi-modal logistics system and outdated material handling infrastructures.
- **b. Government Intervention**: The government of India Introduce a multi-modal logistics parks (MMLPs), to connects and consolidates the rail, roads, air and waterways. This government initiative aimed at upgrading the existing transport and logistics infrastructure, alongside reducing operational cost of transportation and delayed deliveries.

Broader Implications

As per World Bank estimates in its (2023) reports^[17], "Inefficiency in logistics costs emerging markets billions of dollars annually". While emphasizing the need for comprehensive reforms, this study extends the findings beyond Raipur to offer in-depth insights on how transportation bottlenecks become a broader systematic issue affecting lead-time and overall supply chain performance in developing countries. Additionally, addressing transportation bottlenecks requires the following recommended strategic approaches:

- a. Investing in Robust transportation system: Infrastructure development such as connecting roads, ports and railways to reduce overloads on single mode, clear traffic congestion and foster prompt delivery. The Multi-modal logistics parks (MMLPs) initiative in India is a good step towards this trend.
- **b. Implementing Advanced Technology**: Technology in transportation should be incorporated and updated to mitigate the vulnerability of bottlenecks on supply chain. The use of block-chain technology, IOTs, and GPS tracking systems have shown significant improvement in ensuring sustainable supply chain management by offering greater transparency and traceability.
- **c.** Leveraging Big Data Analytics: Recent research studies indicated a significant positive impact of big data analytics on supply chain performance, providing proactive measures to transportation bottlenecks and enabling better decision making. Bose et al. (2023) demonstrated that companies adopting this technology



reports 25% reduction in their lead-time and 15% improvement in overall supply chain efficiency^[20].

d. Policy Reforms and Collaboration: The government of India establishes logistics division within the ministry of commerce and industry to integrate and coordinate sustainable development of the sector. This intervention aimed at simplifying regulatory frameworks and enhancing stakeholders' collaboration to alleviate institutional bottleneck hindering transportation and overall supply chain.

The above discussion of findings offer valuable insights of how transportation bottlenecks becomes a critical impediment to lead-times and supply chain efficiency, impacting operational costs, customer satisfaction and inventory management.

CONCLUSION

The findings of this research integrates quantitative data with qualitative insights to shield multifaceted lights on the causes, implications, consequences and potential solutions of how transportation bottlenecks affect diverse dimensions of supply chain operations. A significant correlation has been identified between transportation bottlenecks and prolonged lead-times, including delays attributed by traffic congestions, inefficient fleets management and limited transportation networks connectivity. These unbearable challenges frequently disrupt and hinder the smooth in-and-out flow of goods and services from one place to another. Moreover, the scenario leads to unpredictable delivery schedules by complicating businesses to hold excess inventories or risk stock outs, alongside increasing operational costs which subsequently have impact on profitability and performance. The cornerstone of modern business success is customer satisfaction which is heavily interconnected with timely delivery. Delivery delays is significantly eroding customer loyalty and trust, reputational damages and above all lost sales revenue among others. The findings intersected other global research that underscores the need for universal nature of transportation challenges and their far-reaching implications.

Finally, Transportation bottlenecks are systematic issues that require integrated efforts to address not merely logistics issues alone. The findings suggested operational resilience and sustainable interventions for addressing transportation bottlenecks on lead-time and overall supply chain performance, while ultimately creating customer value and enhancing economic development.



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