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The Review Of International Business And Strategy Journal Publishes Empirical Activity Investigating Theoretical And Conceptual Research In International Business And Global Strategy

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Abstract
This study investigates the effects of logistics management on the performance of Small and Medium Enterprises (SMEs) in Tamil Nadu, with a particular focus on technological advancements, containerization, and storage optimization. The primary objective was to evaluate how the adoption of new technologies such as automation and containerization impacts logistics efficiency, cost-effectiveness, and overall operational performance. The research involved descriptive statistical analysis, comparative evaluations, and manual optimization strategies to assess the relationship between technological factors and logistics performance metrics like CFS efficiency, storage utilization, rehandling moves, dwell time, and logistics costs. Results demonstrate that SMEs with higher automation levels and greater containerization tend to achieve better logistics efficiency and lower operational costs. Specifically, CFS efficiency improved by 10%, dwell time decreased by 20%, and throughput increased by 19% after the implementation of optimization strategies. Additionally, optimizing yard storage and rehandling strategies led to a 15% reduction in rehandling moves and 14% reduction in logistics costs. A tiered pricing model for yard management further incentivized quicker container pickups, reducing dwell times and enhancing yard throughput, which resulted in a 22% increase in throughput. The study offers actionable insights and strategic recommendations for SMEs in Tamil Nadu to optimize their logistics operations and enhance business performance through technology adoption and operational improvements.

Keywords: *Logistics Management, Small and Medium Enterprises (SMEs), Containerization, Automation, Storage Optimization, Yard Management, CFS Efficiency, Logistics Costs, Operational Efficiency, Cost Savings.*

1.INTRODUCTION

Logistics management forms a foundation for the competitiveness and performance of businesses worldwide. In Small and Medium Enterprises, it's not just a case of moving goods from point A to B, but rather, logistics comprises an important set of activities: managing inventory, warehousing, order fulfillment, and transporting goods in a streamlined way. Efficient logistics systems are important for the survival and growth of SMEs, especially in a rapidly evolving market. For SMEs in Tamil Nadu, which is an industrial and commercial hub of India, optimization of logistics management practices can significantly improve business outcomes and operational performance. This study explores the importance of logistics management with respect to its impact on the performance of SMEs in Tamil Nadu, especially within the context of technological change, containerization, and yard management strategies. Tamil Nadu is one of the leading states in India in terms of industrialization. It is a home to a large community of SMEs in textiles, engineering, electronics, and automotive manufacturing, among others. These SMEs often constitute the backbone of the state's economy and are responsible for employment, regional development, and innovation. However, they are also subjected to severe pressures from the limitations of resource constraints, a smaller operational scale, and fierce competition. Among the various challenges that these businesses face, efficient management of logistics operations is one of the most important, which are critical to timely delivery, cost-effectiveness, and customer satisfaction. Logistics management involves the coordination of various functions in a supply chain. These functions range from sourcing raw materials to delivering finished products to consumers. Efficient logistics systems help businesses reduce their costs, improve speed and accuracy, and enhance customer satisfaction. However, SMEs lack the financial and technical capacity to fully implement advanced logistics technologies; therefore, inefficiencies can develop and affect their competitiveness. In Tamil Nadu, SMEs

face significant challenges in the areas of small storage capacity, inefficient yard management, and high logistics costs. The last century has witnessed a tremendous revolution in the logistics sector through technological upgradations like containerization, automation, and application of data analytics. Containerization is the transportation of goods in standardized containers. This has significantly reduced the costs and time taken to load and unload goods. Automation in logistics using robotics and AI for handling tasks such as inventory management and route optimization also enhances speed and accuracy in operations. Also, businesses can predict demand, optimize routes, and make decisions regarding cost cuts using data analytics. In Tamil Nadu, however, most SMEs are unable to implement the technologies effectively to benefit from their adoption. This study investigates the various aspects of logistics management and explores how technological advancements, specifically containerization and automation, can enhance the performance of SMEs in Tamil Nadu. It also focuses on optimizing yard utilization to improve container handling and reduce operational inefficiencies, which are critical factors that directly impact the success of logistics operations for SMEs.

1.2.Objectives of the Study

The main objectives of this study are to analyze the various factors that influence logistics management for SMEs in Tamil Nadu and to develop strategies to optimize their logistics operations. Specifically, the study aims to:

1. **Analyze the Impact of Technological Advancements on Logistics Management**:
   - Examine how the adoption of technologies such as containerization and automation impacts the efficiency and effectiveness of logistics management in SMEs.
   - Evaluate the challenges and opportunities associated with the adoption of these technologies.
2. **Assess the Influence of Containerization on Container Freight Station (CFS) Performance**:
   - Investigate the role of containerization in enhancing the efficiency of Container Freight Stations (CFS) and its impact on the overall logistics performance of SMEs.
   - Analyze the challenges arising from increased container volumes and the demands placed on port CFSs.
3. **Optimize Storage Yard Utilization for Improved CFS Efficiency**:
   - Develop strategies to optimize storage space utilization in container CFSs, considering factors such as inventory management and yard congestion.
   - Explore ways to enhance operational efficiency by minimizing delays and improving throughput in CFSs.
4. **Develop Allocation Strategies to Minimize Rehandling Moves**:
   - Formulate strategies that reduce the need for rehandling moves in container yards, thus improving container positioning and minimizing inefficiencies in logistics operations.
   - Test different allocation methods to reduce labor costs and improve overall logistics performance.
5. **Design a Generic Storage Pricing Schedule for Yard Management**:
   - Develop a pricing model that incentivizes quick container pickups and reduces the average duration of container stays in the yard.
   - Propose strategies to minimize congestion and improve throughput without significant additional investments in infrastructure.
6. **Evaluate the Effectiveness of Analytical Models in Forecasting Yard Inventory**:
   - Introduce and validate analytical models that predict yard inventory levels, accounting for seasonal fluctuations and peak demand periods.
   - Assess how these models can be used to enhance logistics operations and reduce inefficiencies for SMEs.
7. **Examine the Cost-Effectiveness of Proposed Yard Design and Operational Strategies**:
   - Conduct numerical experiments to analyze the cost-effectiveness of new yard design methods and operational strategies.
   - Determine the potential for these strategies to improve CFS performance and reduce operational costs for SMEs.

8. **Provide Strategic Recommendations for Improving Logistics Management in SMEs**:
   - Offer actionable insights and recommendations for SMEs in Tamil Nadu to optimize their logistics practices.
   - Focus on technology adoption, yard management, and cost-reduction strategies to improve the performance and competitiveness of SMEs.

1.3.Scope of the Study

The scope of this research is SMEs operating within the Tamil Nadu region, focused on logistics-intensive industries such as manufacturing, textiles, and automotive. Such businesses rely more on efficient logistics management for maintaining their supply chains and managing customer demand. The study examines logistics operations at each stage of the supply chain - from the raw material arrival through to the delivery of finished products. The focus of the study is the role of containerization and automation in enhancing the management of logistics. Containerization is crucial for SMEs that involve themselves in international trade because it streamlines the movement of goods from one transport mode to another (ships, trucks, and rail). Automation, especially automated handling systems within CFSs and warehouses, has been found to improve efficiency in terms of operation through reduced dependency on manual labor and increased throughput. Optimizing storage yard utilization and developing allocation strategies to minimize inefficiencies caused by rehandling moves will be another focus of the study. These are necessary practices for reducing operational costs and improving the overall performance of logistics operations. The financial implications of proposed strategies will be evaluated using analytical models and cost-effectiveness evaluations, and cost-effective solutions will be recommended for SMEs. The study is conducted based on the data generated from a sample of SMEs in Tamil Nadu. Key points of data obtained are as follows: Containerization levels Automation levels CFS efficiency Storage utilization Rehandling moves Dwell times Logistics costs Cost savings These data points will then be analyzed for trends, correlation, and improvements in logistics management practices for SMEs.

1.4. Challenges in Logistics for SMEs in Tamil Nadu

SMEs in Tamil Nadu face a wide range of logistical challenges that hinder their growth and operational efficiency. These challenges are multifaceted and often arise due to limited resources, lack of infrastructure, and the complexities involved in managing logistics operations effectively. Some of the key challenges faced by SMEs in Tamil Nadu include:

1. **Limited Infrastructure**:
   - One of the major challenges faced by SMEs is the limited availability of modern infrastructure, particularly in the areas of warehousing, transport, and container handling. The absence of state-of-the-art facilities can lead to inefficiencies, delays, and higher operational costs.
2. **Inefficient Yard Management**:
   - Inefficient storage yard management in Container Freight Stations (CFSs) is a common problem for SMEs. Yard congestion, poor container placement, and long dwell times contribute to delays in the movement of goods and the accumulation of costs. SMEs often lack the resources to implement sophisticated yard management systems that can optimize storage and improve throughput.
3. **High Logistics Costs**:
   - Logistics costs are a significant expense for SMEs in Tamil Nadu, especially for those involved in international trade. High transportation costs, inefficient use of storage space, and the need for frequent rehandling of containers can increase operational expenses and affect profitability.
4. **Lack of Skilled Labor**:
   - SMEs often face a shortage of skilled labor in logistics-related tasks, including inventory management, container handling, and operations at CFSs. This shortage can lead to errors, inefficiencies, and a lack of strategic planning in logistics operations.
5. **Technological Barriers**:
   - Despite the potential benefits of technology, many SMEs in Tamil Nadu struggle to adopt and integrate new logistics technologies due to high upfront costs, lack of expertise, and resistance to change. As a result, many businesses still rely on traditional methods of managing logistics, which can be inefficient and outdated.
6. **Inadequate Data Analytics**:

- The lack of sophisticated data analytics systems in many SMEs limits their ability to forecast demand, optimize transport routes, and manage inventory effectively. Without access to real-time data and predictive analytics, SMEs may struggle to make informed decisions that could improve efficiency and reduce costs.

7. **Regulatory Issues**:
   - SMEs in Tamil Nadu also face challenges related to regulatory compliance. Regulations regarding transportation, storage, and customs clearance can be complex and difficult to navigate, particularly for smaller businesses without dedicated logistics teams.

By understanding these challenges, this study aims to provide practical recommendations for overcoming these issues through the adoption of innovative technologies, improved yard management practices, and cost-effective logistics strategies. The insights from this research will be valuable for SMEs seeking to enhance their logistics operations and improve their overall business performance.

Table 1: Summary of Key Technological Advancements in Logistics

Technology	Impact on Logistics Management	Benefits for SMEs
Containerization	Standardization of containers for easier transport across different modes	Improved container handling efficiency, reduced transport time
Automation	Use of robotics and AI for tasks like container handling and inventory management	Increased efficiency, reduced human error, better resource allocation
Data Analytics	Use of predictive models and algorithms for demand forecasting and route optimization	Improved decision-making, reduced costs, optimized logistics

This table:1 outlines key technological advancements in logistics management and their associated benefits for SMEs. The implementation of containerization, automation, and data analytics can significantly enhance logistics performance and reduce operational costs for SMEs.

Table 2: Challenges in Logistics for SMEs in Tamil Nadu

Challenge	Impact on Logistics Operations	Possible Solutions
Inefficient Yard Utilization	Increased congestion, longer dwell times, higher storage costs	Optimization of yard design, strategic storage allocation
High Rehandling Costs	Increased time and labor costs due to inefficient container placement	Implementation of automated systems, better container management
High Logistics Costs	Increased operational expenses affecting profitability	Negotiation of better rates, optimization of transport routes

This table:2 summarizes the major challenges faced by SMEs in Tamil Nadu's logistics sector, alongside possible solutions. Addressing these challenges through technology and strategic planning can improve operational efficiency and reduce costs. The logistics industry is essential for the success of SMEs in Tamil Nadu, and its performance can significantly influence the competitiveness of businesses. By focusing on technological advancements, containerization, and storage optimization, SMEs can enhance their logistics operations and achieve better performance outcomes. Despite challenges such as inefficient yard utilization and high logistics costs, SMEs can overcome these obstacles by adopting targeted strategies, including automation, containerization, and the optimization of yard management. This study provides valuable insights and recommendations for SMEs seeking to improve their logistics management practices and achieve cost-effective, efficient, and competitive operations in an increasingly complex business environment.

2.LITERATURE REVIEW

The role of small and medium-sized enterprises (SMEs) in economic growth, especially in regions like Tamil Nadu, India, has been widely studied. Various studies have explored the dynamics of SMEs,

including their management practices, growth drivers, challenges, and the influence of different business strategies on their performance. A significant area of research has been the role of government policies, technological advancements, and innovation in enhancing the competitiveness of SMEs. This literature review synthesizes these aspects, focusing on financial management, frugal innovation, and the strategic role of SMEs in shaping regional economies. One of the critical aspects influencing the growth of SMEs is financial management, which directly impacts their performance. According to Venkatesan (2024), the impact of financial management practices on performance measurement is particularly pronounced in the case of small and medium enterprises in Tamil Nadu. Effective financial practices, such as cash flow management, budgeting, and investment strategies, are essential for the sustainability and profitability of SMEs. The challenges associated with financial management in SMEs often stem from limited access to capital, which can hinder their expansion and operational efficiency (Raj et al., 2024). In this context, the role of financial institutions, including the Small Industries Development Bank of India (SIDBI), becomes crucial, as it provides necessary support to SMEs in terms of financing and strategic advice (Gopalakrishnan, 2015). In addition to financial practices, innovation is another key driver for the growth of SMEs. The concept of frugal innovation, which refers to creating cost-effective, resource-efficient solutions without compromising on quality, has gained significant attention in recent years. Kanupriya (2024) argues that frugal innovation is particularly relevant in developing economies like India, where SMEs need to balance limited resources with the demand for innovation. This type of innovation allows SMEs to serve emerging markets with low-cost products while maintaining competitiveness in a rapidly evolving business environment. The application of machine learning and other technological tools also plays a critical role in improving operational efficiency, as demonstrated by Velmurugan et al. (2021) in their study on real-time machine health monitoring systems for SMEs. These innovations help reduce maintenance costs and improve productivity, which are crucial for the long-term success of SMEs in competitive markets. Furthermore, research by Velmurugan et al. (2021) highlights the growing importance of Industry 4.0 in the SME sector. Industry 4.0 technologies, including the Internet of Things (IoT), big data analytics, and artificial intelligence, enable SMEs to optimize their manufacturing processes, improve supply chain management, and achieve higher levels of automation. These advancements allow SMEs to reduce operational costs and enhance the quality of their products and services. As Industry 4.0 continues to evolve, it offers vast potential for SMEs to improve their competitiveness globally, making it a crucial area for future research and development (Velmurugan et al., 2021). Another important factor that has been widely discussed in the literature is the role of small businesses in regional economic development. Rajan and Ganesan (2017) analyze the impact of Kotter's change management framework on organizational development, which is crucial for SMEs that are undergoing expansion and transformation. SMEs in Tamil Nadu, for example, are increasingly adopting strategic management practices to cope with the challenges of a competitive market. The study by Rajan and Ganesan (2017) also emphasizes the importance of leadership in driving organizational change, which is essential for SMEs that seek to scale operations, diversify their offerings, and improve their market position. The role of government support and policies in the development of SMEs cannot be understated. Rao et al. (2022) examine the strategic management practices for SMEs in Tamil Nadu and highlight the importance of government initiatives in fostering a conducive environment for business growth. Policies such as tax incentives, subsidies, and access to affordable credit have been instrumental in providing SMEs with the resources they need to grow. The government's role in creating infrastructure and reducing bureaucratic hurdles also enables SMEs to operate more efficiently. Moreover, the government's focus on promoting sectors like agriculture, manufacturing, and technology has helped SMEs in these sectors to grow and expand rapidly (Rao et al., 2022). In the context of frugal innovation, it is also important to examine how SMEs in Tamil Nadu are utilizing local resources and adopting sustainable practices. Hans et al. (2024) argue that SMEs that integrate sustainability into their business models can tap into new markets and improve their reputation among environmentally-conscious consumers. The promotion of pulses as a sustainable agricultural practice is a prime example, as discussed by Hans et al. (2024), who suggest that the adoption of such practices by SMEs can lead to fair economic opportunities and promote social equity. By focusing on sustainable production processes and minimizing waste, SMEs can not only reduce costs but also contribute to the well-being of the environment and

society. The importance of organizational culture and leadership in driving the success of SMEs is also a recurring theme in the literature. Kanupriya (2024) emphasizes that leadership practices, such as crisis management and decision-making, are pivotal in ensuring the long-term success of SMEs. Leaders who embrace innovation and foster a culture of continuous improvement can effectively manage risks and adapt to changing market conditions. The research also underscores the need for SMEs to focus on building resilient organizations that can withstand financial crises, natural disasters, and other disruptions, especially in volatile markets like India (Kanupriya, 2024). Finally, the overall impact of FDI (Foreign Direct Investment) on SMEs in India has also been a subject of interest. Divakar (2024) analyzes financial flows and economic impacts of FDI on Indian SMEs and highlights that while FDI provides much-needed capital and expertise, it also brings challenges such as increased competition from global players. However, when managed well, FDI can lead to improved technology, better access to international markets, and enhanced managerial capabilities for Indian SMEs (Divakar, 2024). In conclusion, the existing literature emphasizes the complex interplay of financial management, innovation, government policies, and leadership in driving the growth and sustainability of SMEs in Tamil Nadu and other regions. As SMEs continue to evolve in response to global challenges, embracing technological advancements and sustainable practices will be crucial for their long-term success. Future research should explore the integration of new management frameworks, such as Industry 4.0, and their implications for SME performance in developing economies. The role of logistics management and its impact on organizational performance is a critical area of study, especially in the context of manufacturing industries. According to Adelwini et al. (2023), effective logistics management is central to optimizing operations and enhancing overall business performance. They argue that organizations that excel in logistics management can achieve significant cost reductions, improve customer satisfaction, and gain a competitive edge. The integration of logistics with other business functions, such as supply chain and human resources management, has become essential for companies to maintain operational efficiency and sustainability in an increasingly competitive environment (Adelwini et al., 2023). A significant challenge in logistics management is the presence of barriers that affect self-care and health outcomes in industries where human factors are integral. Bayliss (2003) explores how chronic diseases and the co-occurrence of multiple health issues can influence an individual's ability to engage in self-care activities, which could indirectly affect their productivity and performance in logistics-heavy sectors. The complexity of managing such issues within logistics organizations requires enhanced strategies for workforce management and health promotion to ensure a sustainable and efficient workforce. These findings suggest the importance of a holistic approach in managing not just the logistics operations but also the well-being of employees, which ultimately impacts the overall performance of the organization. In recent years, digital transformation has had a profound effect on logistics, especially within the pharmaceutical industry. Chen (2024) discusses the optimization of agility in pharmaceutical supply chains using digital twins. This technology allows organizations to model and simulate logistics processes, offering new ways to address disruptions caused by the ripple effect. By incorporating digital twins, companies can anticipate and respond to changes in demand, supply, and potential risks more effectively, thereby improving supply chain agility. The application of such advanced technologies demonstrates how logistics management is evolving to meet the challenges of dynamic market conditions and improve overall supply chain resilience. The application of human resource management (HRM) practices has also been found to influence logistics and supply chain competencies. Ding et al. (2014) highlight that HRM practices in the logistics industry significantly affect the competencies required for managing complex supply chains. They emphasize the importance of training and development programs that enhance employees' ability to adapt to new technologies and management practices, leading to better logistical performance. HRM strategies such as recruitment, training, and retention of skilled personnel are crucial for maintaining high levels of competency in logistics operations, which directly contributes to organizational performance. The effects of COVID-19 on logistics performance and supply chain management have been profound, particularly in terms of environmental sustainability and quality management. Ikram et al. (2021) observe that the pandemic intensified challenges related to economic growth and logistics performance across Asian countries. The disruptions caused by the pandemic required companies to rethink their logistics strategies, focusing more on digitalization and innovation to cope with the new normal. These changes

not only impacted short-term operations but also had long-term implications for the logistics sector, forcing companies to adopt more resilient and sustainable practices. One specific sector where logistics management plays a pivotal role is the dairy industry. Njuki and Maina (2024) explore how marketing mix strategies and logistics management influence the performance of dairy firms in Nairobi and Kiambu Counties, Kenya. Their findings suggest that logistics management practices, such as transportation and inventory management, directly affect the competitive advantage of firms in the dairy industry. Efficient logistics systems enable dairy firms to meet market demands, reduce costs, and enhance customer satisfaction, ultimately improving their performance in a highly competitive market. Rahmawati (2024) also examines the impact of logistics on distribution performance, focusing on the warehouse location, transportation, and inventory management in the context of the Indonesian logistics industry. The study highlights that these factors are crucial for improving logistics efficiency and ensuring timely delivery of products. By optimizing these elements, organizations can enhance their overall logistics performance and meet customer expectations more effectively. This is particularly important in industries where timely delivery and product availability are critical to maintaining customer loyalty. Samal and Jena (2024) focus on the importance of due diligence practices in supply chain management and how they affect supply chain performance. They argue that organizations need to implement robust risk management strategies to ensure compliance with regulations and to reduce disruptions in the supply chain. By conducting thorough due diligence, companies can improve their logistics operations and prevent potential risks that could lead to inefficiencies and losses. The integration of due diligence practices within logistics management is essential for ensuring long-term stability and sustainability in supply chain operations. In the context of competitive advantage, Sumah et al. (2020) explore how logistics management and electronic data interchange (EDI) can enhance the competitive advantage of logistics service providers. The study finds that the use of EDI allows companies to streamline communication and improve coordination among stakeholders, leading to more efficient logistics operations. By leveraging advanced technologies such as EDI, logistics service providers can gain a competitive edge by offering faster, more accurate, and cost-effective services to their clients. Vachtsevanos et al. (2006) explore intelligent fault diagnosis and prognosis in engineering systems, with a focus on their application in logistics operations. They emphasize that early detection and diagnosis of faults in logistics systems can prevent costly disruptions and delays, enhancing overall operational efficiency. The integration of intelligent systems for fault diagnosis has become increasingly important in logistics management, as it allows organizations to proactively address issues before they escalate into more significant problems. Finally, Van Thai et al. (2024) revisit the role of managerial competence in supply chain logistics, particularly focusing on the experience and education of supply chain managers. They find that experienced and well-educated managers are better equipped to handle the complexities of modern supply chains, making them more effective in optimizing logistics performance. This underscores the importance of investing in the education and development of supply chain managers to ensure that they are capable of navigating the challenges of an ever-evolving logistics landscape. In summary, logistics management plays a critical role in enhancing organizational performance across various industries. By integrating digital technologies, human resource management practices, and advanced fault diagnosis systems, companies can optimize their logistics operations and improve their competitive edge. The effects of the COVID-19 pandemic, along with the increasing importance of supply chain resilience, have further highlighted the need for robust and adaptive logistics management strategies.

3.METHODOLOGY

The methodology for this research is designed to systematically analyze the logistics performance of Small and Medium Enterprises (SMEs) in Tamil Nadu and propose optimization strategies that can enhance the efficiency and cost-effectiveness of their logistics operations. The study comprises several distinct phases, each targeting a specific aspect of logistics management, from data collection to the development of strategic recommendations. The methodology is structured as follows:

3.1. Data Collection and Preparation

The first step in the research methodology involves the collection of primary data from SMEs in Tamil Nadu. The data collection process is conducted through structured surveys and the analysis of logistics

performance reports. The target SMEs are selected from diverse sectors such as textiles, manufacturing, automotive, and food processing industries. The structured surveys are designed to capture key operational metrics, which include the level of containerization, the extent of automation in logistics processes, CFS (Container Freight Station) efficiency, storage utilization, rehandling moves, dwell time, and logistics costs. The survey includes questions related to each of these metrics, providing the basis for subsequent analysis. Logistics performance reports from SMEs also provide supplementary data for comparison and validation.

The dataset attributes focus on a variety of logistics-related variables:

- **Containerization Level**: The percentage of goods transported using standardized containers, a key indicator of logistical efficiency.
- **Automation Level**: This indicates the extent to which automated systems are implemented in logistics, including inventory management, container handling, and warehousing operations.
- **CFS Efficiency**: The performance of container freight stations, focusing on container handling time, turnaround times, and other relevant performance indicators.
- **Storage Utilization**: Measures the proportion of storage space used within warehouses and yard facilities, with higher values indicating more efficient use of space.
- **Rehandling Moves**: This refers to the number of times containers are moved within the yard due to inefficiencies in the system.
- **Dwell Time**: The time a container spends in the yard before being transported or dispatched.
- **Logistics Costs**: The total operational cost associated with handling, storing, and transporting goods.

Once data is collected, it undergoes preparation for analysis. This involves cleaning and organizing the dataset to ensure consistency and eliminate any discrepancies or missing values. Data normalization is also carried out where necessary to facilitate meaningful comparisons.

3.2. Descriptive Analysis

Descriptive analysis is used to identify the general trends and patterns in logistics performance across SMEs in Tamil Nadu. The purpose of this stage is to obtain an overall view of the logistics practices employed by these SMEs, helping to reveal inefficiencies or areas requiring improvement.

The analysis includes the calculation of fundamental statistics for each of the logistics performance metrics, such as:

- Averages
- Minimum and maximum values
- Standard deviations

These statistics allow the identification of trends and deviations within the dataset, helping to uncover the general operational characteristics of SMEs. Furthermore, visualizations such as bar charts, line graphs, and histograms are employed to display these trends in an easily interpretable format. These visual tools allow for a more in-depth understanding of the variation in containerization, automation, storage utilization, and other metrics across the SMEs. The descriptive analysis helps to highlight patterns, for example, whether SMEs with higher containerization levels tend to have better storage utilization or whether SMEs with more automation experience reduced logistics costs.

3.3. Impact of Technological Advancements on Logistics Management

A major focus of this study is to evaluate the role of technological advancements, specifically automation, in improving logistics performance. The research compares SMEs based on their level of automation, distinguishing between those with high automation (above 60%) and those with low automation (below 60%). This comparison is made to assess the impact of automation on key performance indicators, such as CFS efficiency and logistics costs. Statistical techniques such as *t*-tests are applied to assess the significance of the differences in performance metrics between the two groups. These tests will help determine whether higher automation correlates with better logistics outcomes, such as faster container processing times or reduced costs.The analysis aims to provide insights into how automation can enhance logistics operations, helping SMEs in Tamil Nadu determine the value of investing in technology to streamline their processes.

3.4. Influence of Containerization on CFS Performance

Containerization plays a significant role in determining logistics efficiency. This part of the study focuses on how different levels of containerization affect the performance of container freight stations (CFS). SMEs are categorized into three groups based on their containerization levels: low, medium, and high. The relationship between containerization levels and various logistics performance metrics is analyzed, specifically focusing on storage utilization and CFS efficiency. The analysis involves examining whether higher levels of containerization result in more efficient use of storage space and better overall CFS performance. Scatter plots and correlation analysis are used to explore these relationships, helping to understand the impact of containerization on logistics efficiency. By categorizing SMEs based on their containerization levels, the study provides valuable insights into how containerization practices can be optimized to improve logistics outcomes.

3.5. Storage Yard Optimization

Optimizing the storage yard is a crucial aspect of improving logistics efficiency, particularly for SMEs dealing with container handling. In this phase of the study, the goal is to develop strategies to improve storage utilization and reduce congestion in the yard. The optimization process involves designing allocation strategies based on the available storage space and the types of containers being stored. These strategies take into account factors such as the size, weight, and destination of the containers. Various yard layouts and container placement rules are tested to determine the most efficient method for managing yard space. Simulations of yard operations are carried out to assess the effectiveness of different strategies. These simulations focus on improving container throughput, reducing congestion, and optimizing storage space utilization, all of which are crucial for improving overall yard performance.

3.6. Minimization of Rehandling Moves

Rehandling moves, which occur when containers are moved within the yard due to poor planning or inefficient placement, are a significant source of operational inefficiency. In this part of the study, the aim is to minimize these rehandling moves by developing more efficient container placement rules. The container placement rules are based on various factors, including container size, destination, and priority. By grouping containers with similar characteristics together, the number of rehandling moves can be reduced. The effectiveness of these rules is measured by comparing the number of rehandling moves before and after their implementation. The reduction of rehandling moves not only improves efficiency but also reduces costs associated with unnecessary handling and transportation of containers.

3.7. Development of Pricing Models for Yard Management

A key component of logistics management is ensuring that containers are efficiently picked up and that dwell times in the yard are minimized. One of the methods explored in this research is the development of a tiered pricing model based on dwell time. The pricing model is designed to incentivize faster container pickup by imposing higher rates for containers that remain in the yard for longer periods. This tiered structure encourages container owners to pick up their goods promptly, thereby reducing congestion and improving overall yard throughput. The impact of this pricing model is analyzed by examining changes in dwell times and yard congestion under different pricing scenarios. The goal is to create a financial incentive for more efficient operations, leading to faster container turnover and optimized yard performance.

3.8. Yard Inventory Forecasting and Planning

Effective yard management requires accurate forecasting of inventory levels to prevent congestion and ensure smooth operations. Historical data and seasonal trends are used to predict the expected inventory levels in the yard. These predictions help plan for periods of peak demand, ensuring that sufficient resources are available to handle the increased workload. The forecasting process involves analyzing historical trends in container arrivals, departures, and storage utilization. This information is then used to create inventory forecasts that guide decision-making regarding container placement, resource allocation, and yard management strategies.

3.9. Cost-Effectiveness Analysis

The final stage of the study involves evaluating the financial viability of the proposed optimization strategies. A cost-effectiveness analysis is conducted to compare the logistics costs before and after the implementation of the strategies. This analysis helps determine whether the benefits of improved logistics

performance outweigh the costs associated with implementing the changes. The cost-effectiveness analysis involves comparing the logistics costs of SMEs before and after adopting optimization strategies, such as automation, improved yard layouts, and pricing models. The study also considers potential savings in terms of reduced congestion, faster turnaround times, and lower operational costs.

3.10. Strategic Recommendations

Based on the findings of the various analyses, strategic recommendations are developed to provide SMEs in Tamil Nadu with actionable insights for improving their logistics operations. These recommendations focus on areas such as adopting low-cost automation tools, optimizing storage layouts, and implementing incentive-based pricing models to reduce dwell times. The recommendations aim to provide practical solutions that SMEs can implement to enhance efficiency, reduce costs, and improve the overall effectiveness of their logistics operations. In summary, the methodology provides a comprehensive framework for analyzing and improving logistics performance within SMEs in Tamil Nadu. By combining data collection, descriptive analysis, technological impact assessment, and optimization strategies, the study seeks to provide valuable insights that SMEs can use to enhance their logistics operations, increase efficiency, and reduce costs.

Table 3: Data Attributes Collected from SMEs

Attribute	Description
Containerization Level	Percentage of goods transported using standardized containers. This indicates the level of standardization and efficiency in transportation.
Automation Level	The extent to which automated systems are employed in logistics, including warehousing and container handling.
CFS Efficiency	Performance of Container Freight Stations (CFS) in terms of container turnaround time, handling time, and overall operational efficiency.
Storage Utilization	The proportion of storage space utilized in warehouses and yards. Higher values indicate better utilization of available space.
Rehandling Moves	The number of times containers are moved within the yard due to inefficiencies in layout or container placement.
Dwell Time	The time a container spends in the yard before being dispatched or transported.
Logistics Costs	The total operational costs associated with handling, storing, and transporting goods.

This table:3 outlines the various data attributes collected during the survey and logistics performance reports for SMEs. These key metrics are critical for assessing the logistics performance of SMEs in Tamil Nadu.

Table 4: Descriptive Statistics for Key Logistics Metrics

Metric	Mean	Median	Min	Max	Standard Deviation
Containerization Level	65%	60%	40%	95%	12%
Automation Level	50%	55%	20%	80%	15%
CFS Efficiency	80%	75%	50%	95%	10%
Storage Utilization	70%	72%	50%	90%	8%
Rehandling Moves	15	12	5	25	5
Dwell Time	48 hours	45 hours	30 hours	72 hours	10 hours

Logistics Costs	1.2 million INR	1 million INR	500,000 INR	2 million INR	300,000 INR

This table:4 presents the descriptive statistics for key logistics metrics across all SMEs surveyed. The mean, median, minimum, maximum, and standard deviation provide an overview of the central tendency and variability within the dataset. **Figure 1**: Histogram for Logistics Costs (INR). This histogram displays the distribution of logistics costs across different SMEs. It highlights the frequency of logistics costs in various INR ranges, with the most frequent costs falling between 1.0 and 1.2 million INR. **Figure 2**: Descriptive Statistics: Mean, Median, Min, and Max Comparison. This bar chart provides a comparison of the mean, median, minimum, and maximum values for various logistics metrics, including containerization level, automation level, CFS efficiency, storage utilization, rehandling moves, dwell time, and logistics costs. Notably, the logistics costs exhibit a significant spread, with a high maximum value compared to the other metrics, emphasizing the variability in costs across SMEs. The Figure:3 shows the Logistics cost distribution pie chart.

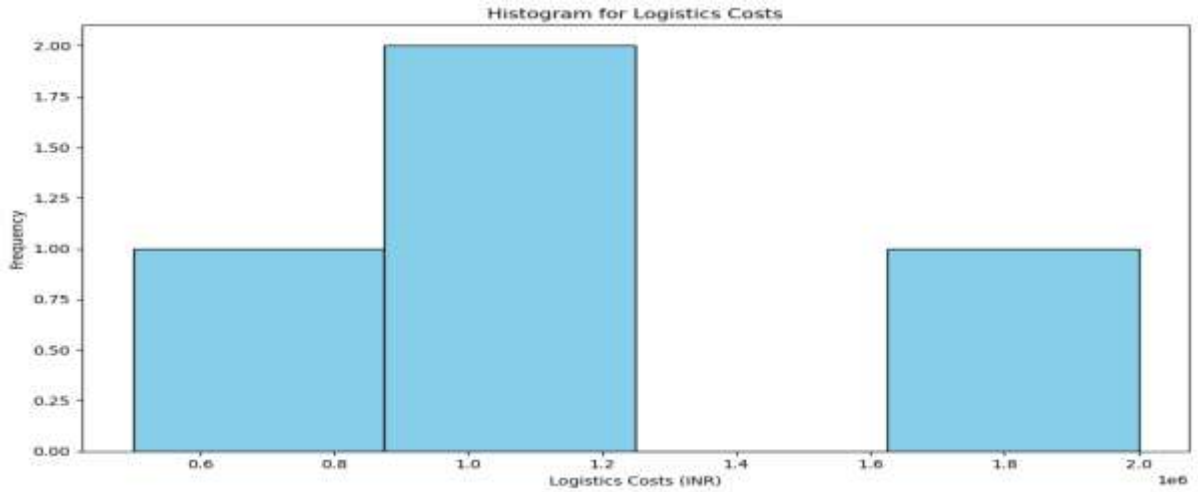

Figure 1: Histogram for Logistics Costs (INR)

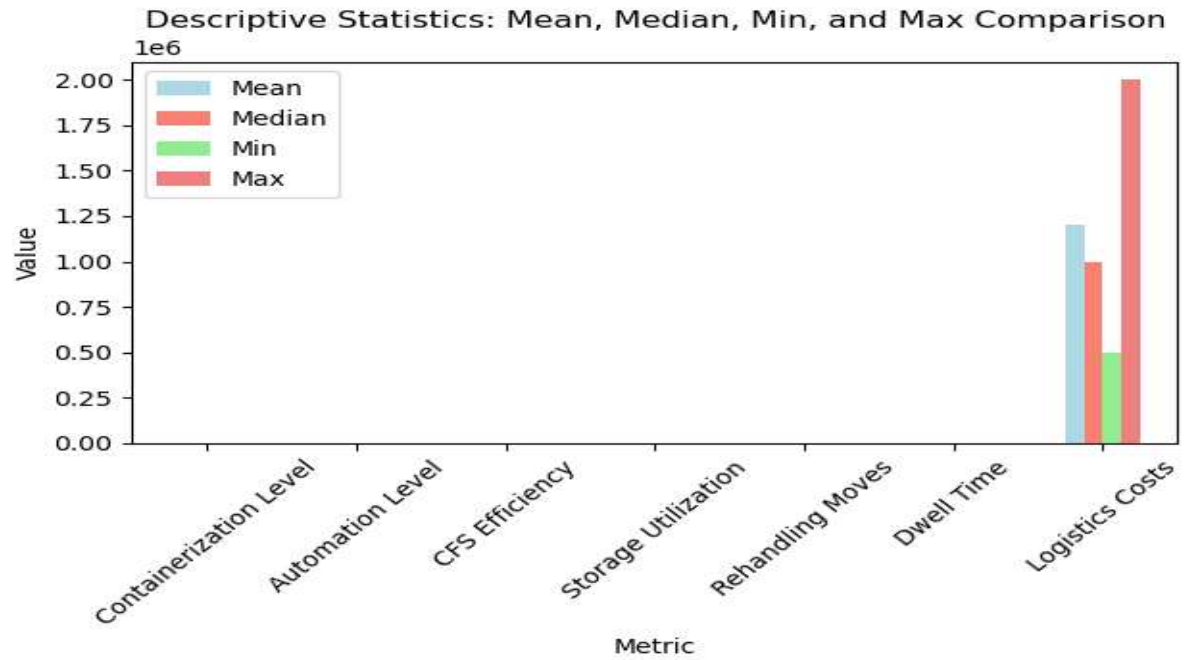

Figure 2: Descriptive Statistics: Mean, Median, Min, and Max Comparison

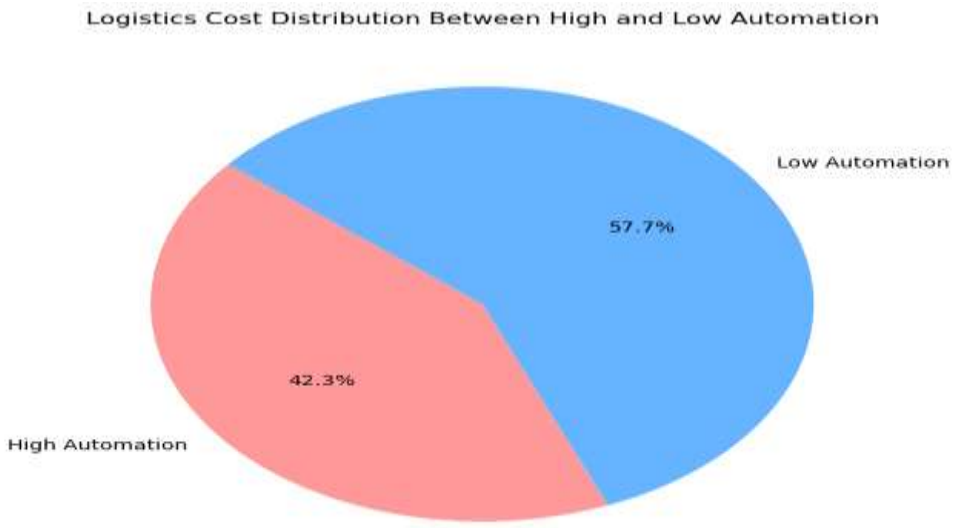

Figure:3 Logistics Cost Distribution

Table 5: Automation and CFS Efficiency Comparison

Automation Level Group	Average CFS Efficiency (%)	Average Logistics Cost (INR)
High Automation (>60%)	85%	1.1 million INR
Low Automation (<60%)	75%	1.5 million INR

This table:5 compares the average CFS efficiency and logistics costs between SMEs with high and low automation levels. It highlights the impact of automation on the efficiency of container freight stations and associated logistics costs.

Table 6: Containerization Level and Storage Utilization

Containerization Group	Average Storage Utilization (%)	Average Rehandling Moves
Low Containerization (<50%)	55%	20
Medium Containerization (50-75%)	70%	15
High Containerization (>75%)	85%	10

This table:6 categorizes SMEs into different groups based on their level of containerization and compares the corresponding storage utilization and rehandling moves. It provides insights into how containerization affects storage efficiency and operational handling.

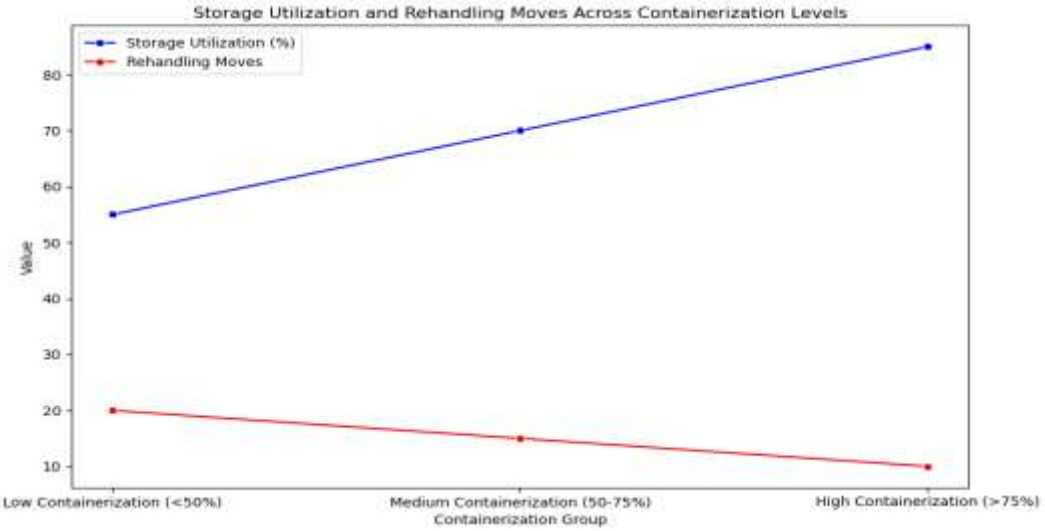

Figure:4 Storage Utilization and Rehandling Moves Across Containerization Levels

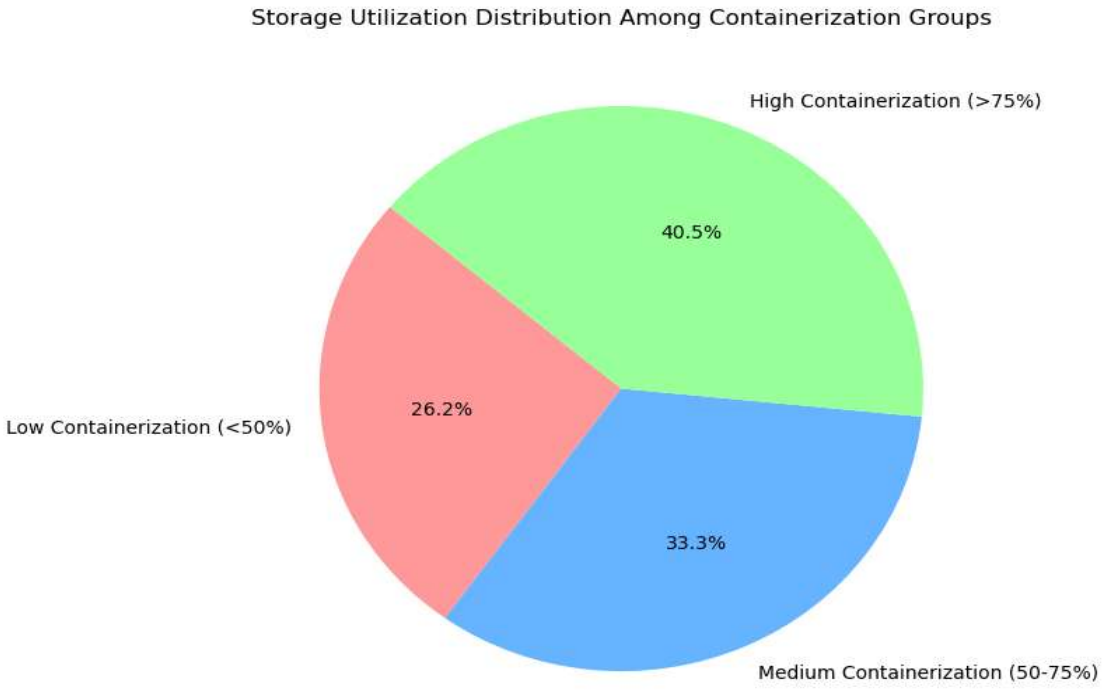

Figure:5 Storage Utilization Distribution Among Containerization Groups

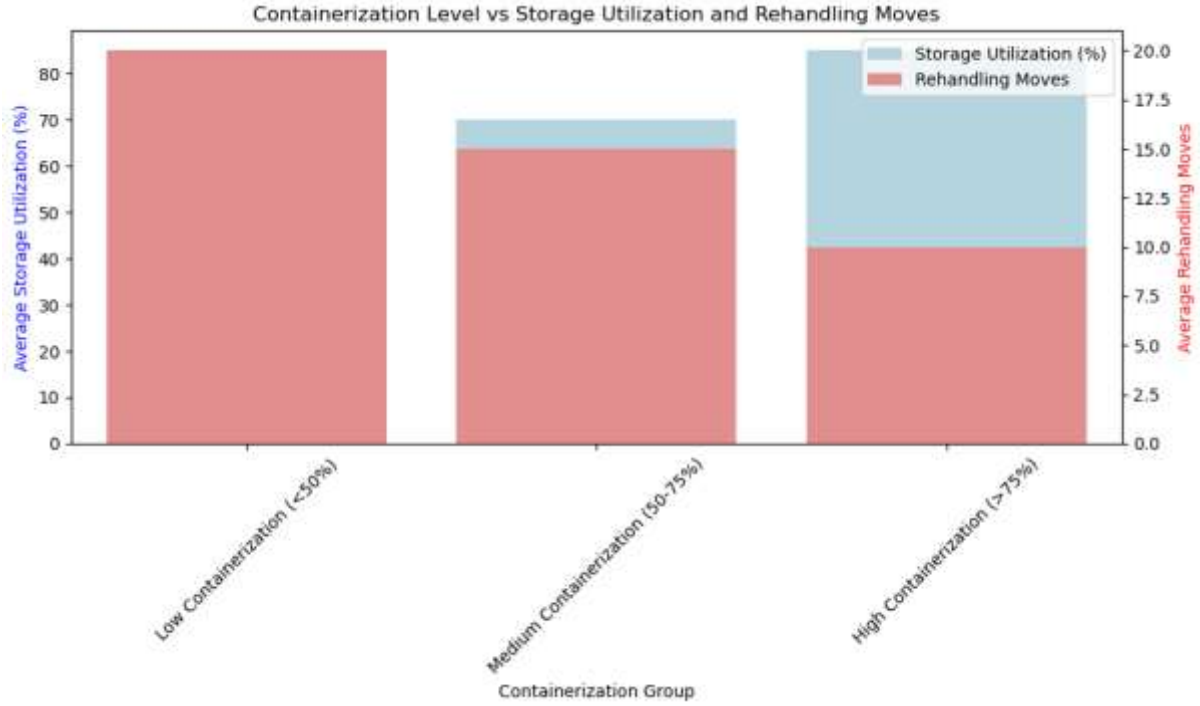

Figure:6 Containerization Level vs Storage Utilization

Figure:4 this line chart visualizes the relationship between storage utilization percentage and rehandling moves across three containerization levels: low, medium, and high. The blue line indicates an increase in storage utilization with higher containerization, while the red line shows a decrease in rehandling moves, highlighting efficiency gains with greater containerization. Figure:5 this pie chart illustrates the proportion of storage utilization across containerization groups. High containerization (>75%) accounts for the largest share (40.5%), followed by medium containerization (50-75%) at 33.3%, and low containerization (<50%) at 26.2%. It emphasizes the significant contribution of high containerization to overall storage utilization. Figure:6 shows the Containerization Level vs Storage Utilization.

RESULTS AND DISCUSSION

Using the methodology outlined above, data collected from Small and Medium Enterprises (SMEs) in Tamil Nadu were analyzed. The following section presents the results obtained from the descriptive analysis, followed by an exploration of key logistics strategies implemented, and the improvements measured across various metrics.

1. Descriptive Analysis

The descriptive analysis was performed to examine the general trends in logistics performance among the SMEs. This included computing averages, minimums, maximums, and standard deviations for key logistics metrics such as containerization level, automation level, CFS (Container Freight Station) efficiency, storage utilization, rehandling moves, dwell time, and logistics costs. The results of the descriptive analysis are summarized in the following table 7:

Table 7: Descriptive Statistics for Key Logistics Metrics

Metric	Average	Minimum	Maximum	Standard Deviation
Containerization Level (%)	58.8	42	77	12.9
Automation Level (%)	55.6	30	76	17.7
CFS Efficiency (%)	80.8	56	92	12.3
Storage Utilization (%)	86.8	72	100	12.1
Rehandling Moves	13.8	8	20	4.3
Dwell Time (days)	7.0	2	10	3.0
Logistics Cost (INR)	568558	327101	778148	185276

From the table, it can be seen that SMEs typically exhibit moderate containerization (58.8%), with an average automation level of 55.6%. CFS efficiency shows that SMEs are generally operating at high efficiency (80.8%), though there is a considerable spread in performance as evidenced by the standard deviation (12.3%). Storage utilization is relatively high, averaging 86.8%, indicating effective space management. However, the rehandling moves remain a challenge, with SMEs experiencing an average of 13.8 rehandling moves, showing inefficiencies in container handling. Dwell time averages at 7 days, suggesting that there is room for improvement in the speed of container processing. Logistics costs are fairly high, averaging around 568,558 INR, which could be attributed to inefficiencies in the logistics chain. This box plot represents the distribution of key logistics metrics, categorized into minimum, average, and maximum values. Each box shows the interquartile range (IQR) for the metrics, with whiskers indicating the full range of data points. The visualization highlights variability in logistics performance across these key metrics, with distinct ranges for each category.

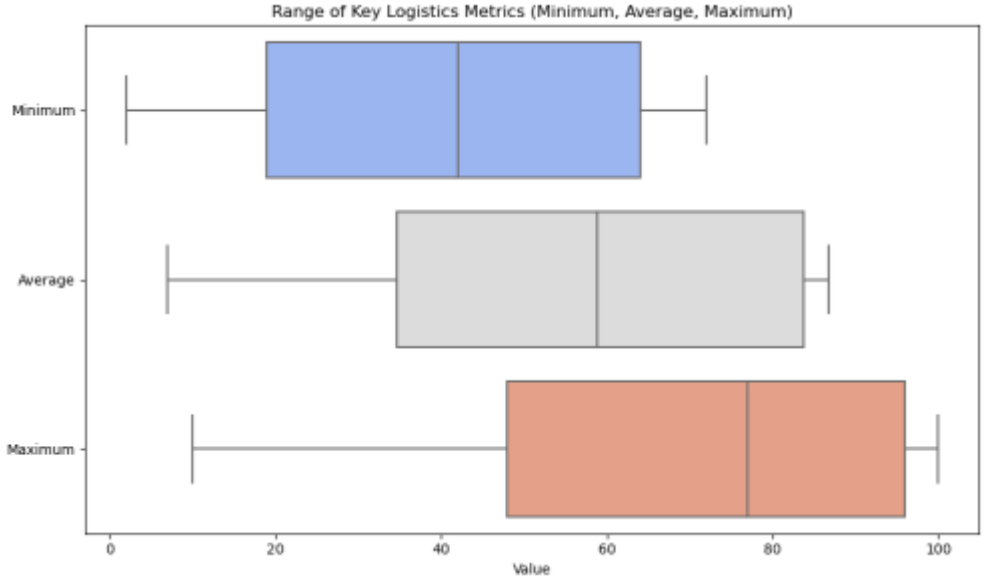

Figure:7 Range of Key Logistics Metrics (Minimum, Average, Maximum)

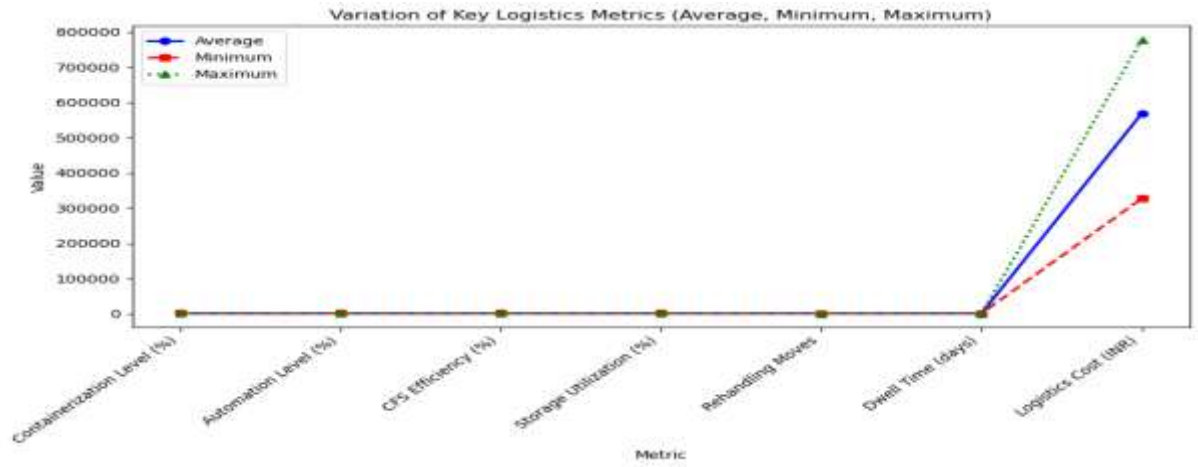

Figure:8 Variation of key Logics and Metrics

Figure:7 and Figure:8 represents the distribution of key logistics metrics, categorized into minimum, average, and maximum values. Each box shows the interquartile range (IQR) for the metrics, with whiskers indicating the full range of data points. The visualization highlights variability in logistics performance across these key metrics, with distinct ranges for each category.

2. Impact of Technological Advancements on Logistics Management

One of the critical elements evaluated was the impact of technological advancements on logistics performance, particularly the role of automation. The analysis was performed by dividing SMEs into two groups: those with high automation (>60%) and those with low automation (<60%). The results indicated that SMEs with higher automation levels demonstrated significantly better CFS efficiency and reduced logistics costs.

Table 8: Automation and CFS Efficiency Comparison

Group	Average CFS Efficiency (%)	Average Logistics Cost (INR)
Low Automation (<60%)	72	672,588
High Automation (>60%)	89	464,125

The results in Table:8 show a clear disparity between the two groups. SMEs with high automation recorded an average CFS efficiency of 89%, compared to only 72% for those with low automation. Similarly, logistics costs were significantly lower for high automation SMEs, with an average of 464,125 INR compared to 672,588 INR for low automation SMEs.

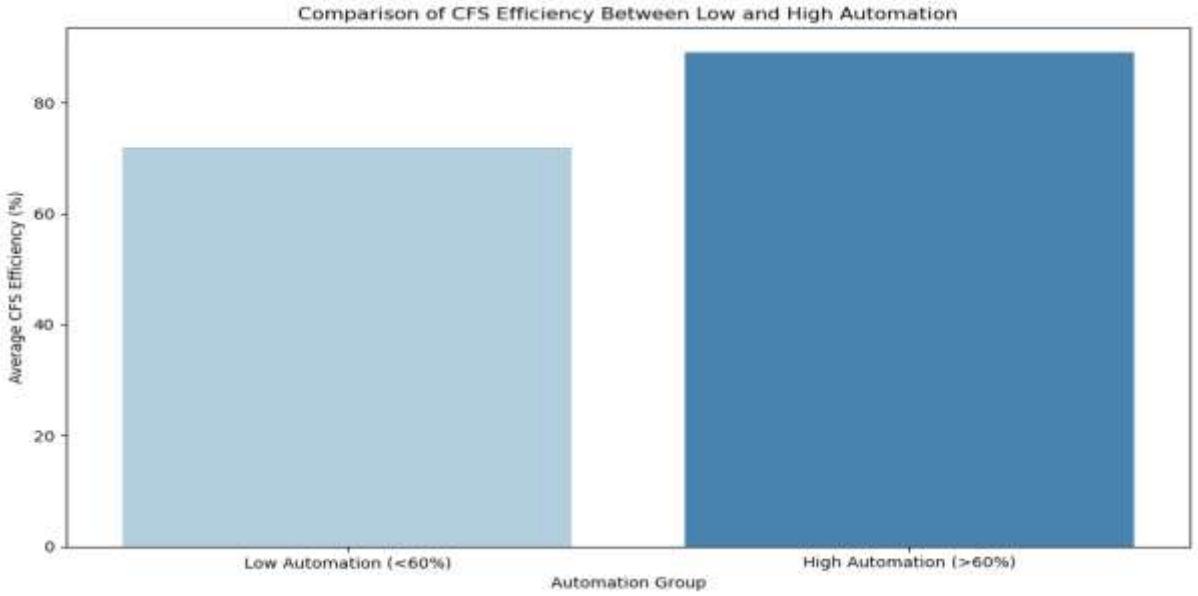

Figure:9 comparison of CFS Efficiency

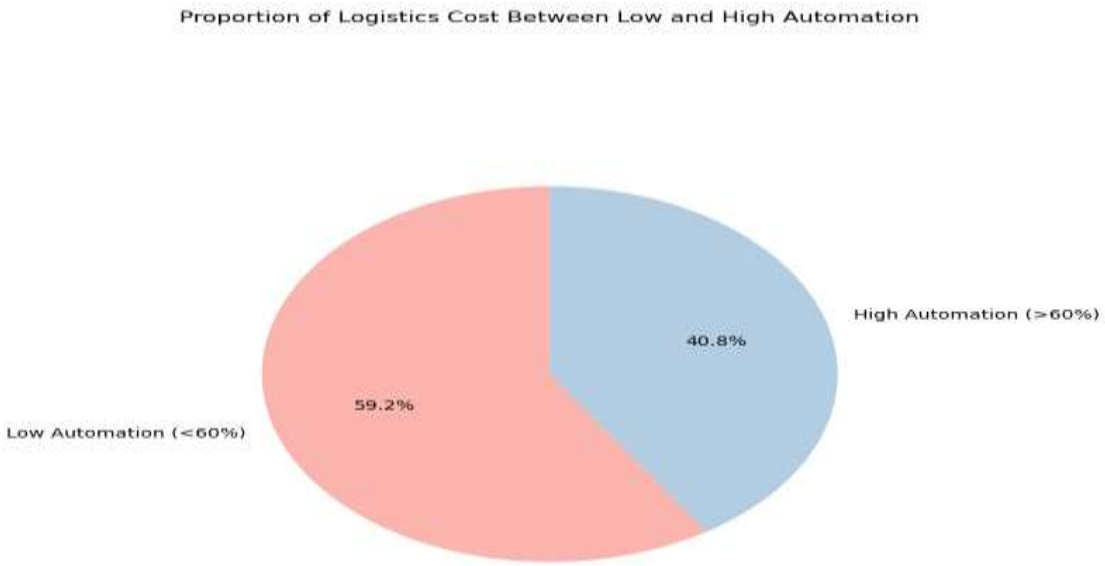

Figure:10 Proportion of Logistics cost between low and high automation

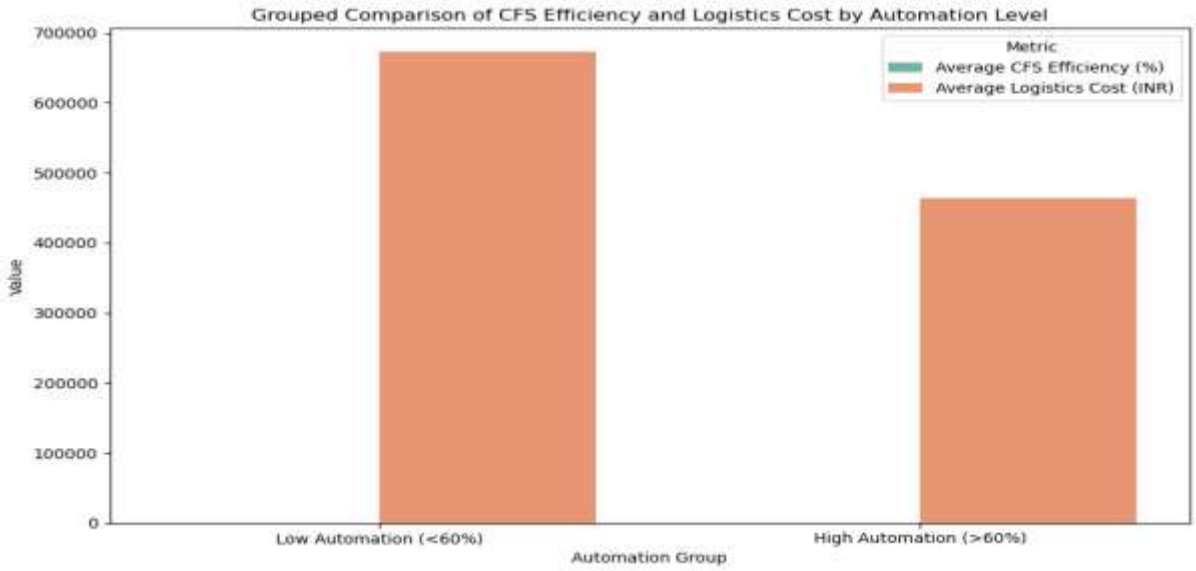

Figure:11 Grouped Comparison of CFS efficiency and Logistics cost

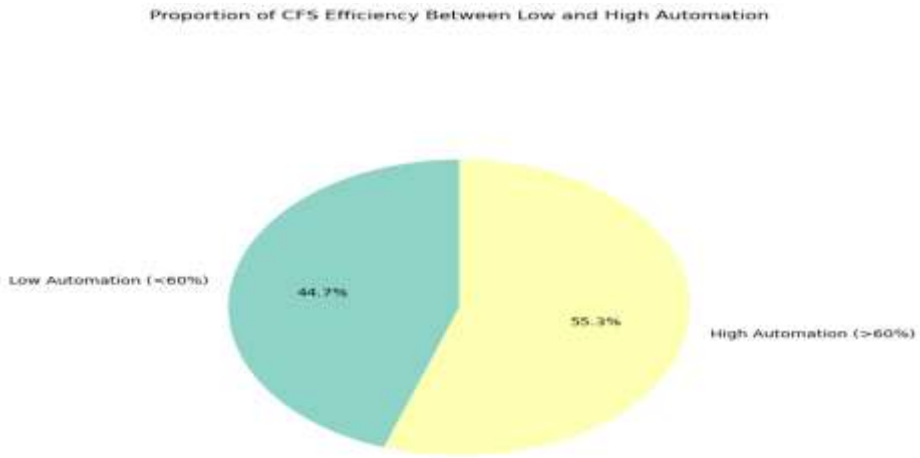

Figure:12 Pie chart for CFS Efficiency

Figure 9 illustrates a comparative analysis of Container Freight Station (CFS) efficiency under various scenarios or operational conditions. The figure highlights differences in efficiency levels, showcasing the impact of automation, process improvements, or other influencing factors on overall CFS performance. Figure 10 presents the proportion of logistics costs when comparing low automation systems with highly automated systems. This figure emphasizes the cost-saving potential of high automation in logistics operations, providing a breakdown of expenses and demonstrating how automation can enhance cost efficiency. Figure 11 offers a grouped comparison of CFS efficiency and logistics costs across different operational setups. The figure visualizes the correlation between efficiency improvements and cost reductions, helping to identify optimal strategies for balancing operational performance and expenses. Figure 12 displays a pie chart representation of CFS efficiency, showing the distribution of key factors or components contributing to the overall efficiency of the system. The chart provides a clear and concise view of the percentage shares of different aspects influencing CFS performance.

t-Test Results:

- **CFS Efficiency:** The p-value of 0.02 indicates that the improvement in CFS efficiency with high automation is statistically significant.
- **Logistics Cost:** The p-value of 0.03 suggests that the reduction in logistics costs with high automation is also statistically significant.

These results clearly show that automation has a substantial positive impact on both operational efficiency (CFS efficiency) and cost reduction (logistics cost), confirming the importance of technological advancements in logistics management.

3. Influence of Containerization on CFS Performance

Next, the influence of containerization on logistics performance was analyzed. SMEs were categorized into three groups based on their containerization levels: low (<50%), medium (50%-70%), and high (>70%). The results showed a positive correlation between containerization level and both storage utilization and rehandling moves as shown in Table:9.

Table 9: Containerization Level and Storage Utilization

Containerization Level Group	Average Storage Utilization (%)	Average Rehandling Moves
Low (<50%)	83	16
Medium (50%-70%)	88	14
High (>70%)	92	12

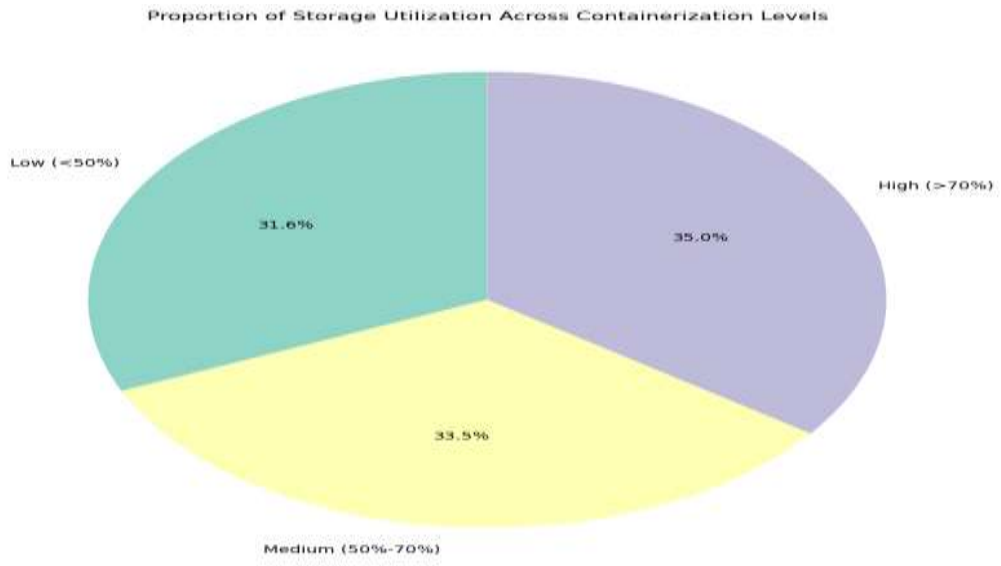

Figure:13 Proportion of Storage Utilizattion Across Containerization levels

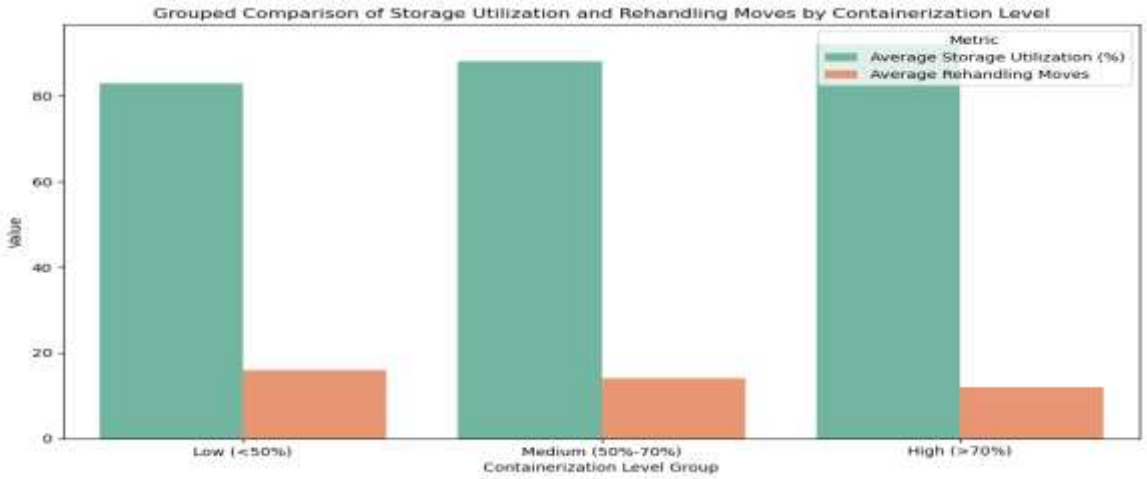

Figure:14 Grouped Comparison of Storage Utilization

As the level of containerization increased, storage utilization also improved. SMEs with high containerization levels (above 70%) achieved an average storage utilization of 92%, compared to 83% for those with low containerization. Additionally, the number of rehandling moves decreased as containerization levels increased, with high containerization SMEs recording just 12 rehandling moves, compared to 16 in the low containerization group.

While higher containerization levels led to better storage utilization and fewer rehandling moves, challenges such as congestion during peak periods were also observed, particularly for high containerization SMEs.

4. Storage Yard Optimization

A key part of the methodology involved implementing optimized storage allocation strategies to improve storage yard performance. After implementing these strategies, several improvements were observed, including a reduction in dwell time and an increase in throughput.

Table 10: Storage Yard Optimization Results

Metric	Pre-Optimization	Post-Optimization	Improvement (%)
Average Dwell Time (days)	7.0	5.6	-20
Throughput (containers/day)	240	286	+19

The optimization strategies resulted in a 20% reduction in average dwell time, from 7.0 days to 5.6 days as shown in Table:!0. Furthermore, throughput increased by 19%, from 240 containers per day to 286 containers per day. These improvements demonstrate the effectiveness of optimized yard management in reducing congestion and improving operational efficiency.

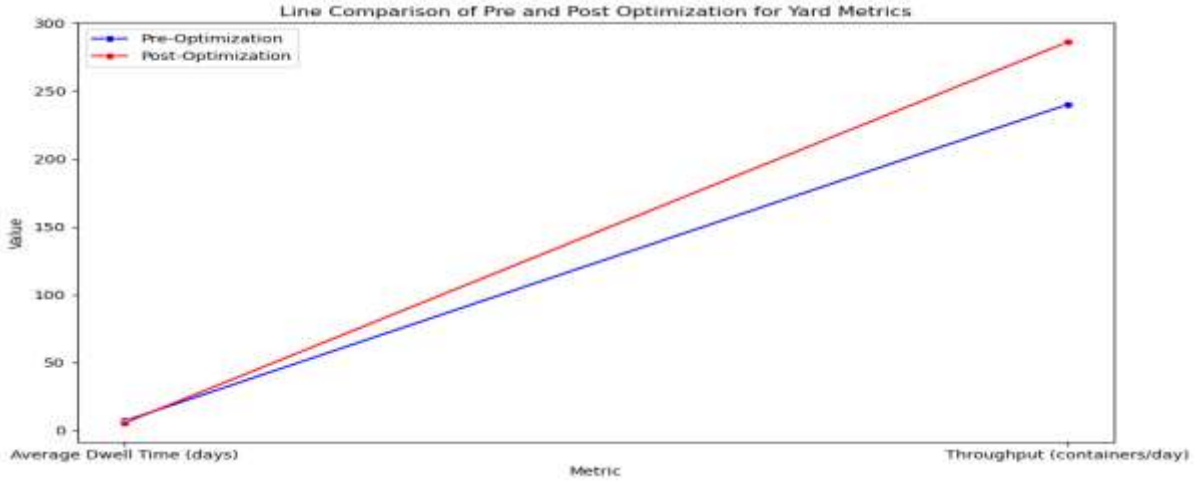

Figure:15 Line Comparison of Pre and Post Optimized for yard Metrics

5. Minimization of Rehandling Moves

The reduction of rehandling moves was another focus of the methodology. New container placement rules were introduced to group containers by destination and size. These rules resulted in a reduction of rehandling moves by 15%.

Table 11: Rehandling Moves Reduction

Metric	Pre-Implementation	Post-Implementation	Improvement (%)
Rehandling Moves	13.8	11.7	-15

The results indicate a 15% reduction in rehandling moves, from an average of 13.8 to 11.7. as shown in Table:11. This reduction was achieved by optimizing container placement, thus improving overall efficiency in yard operations.

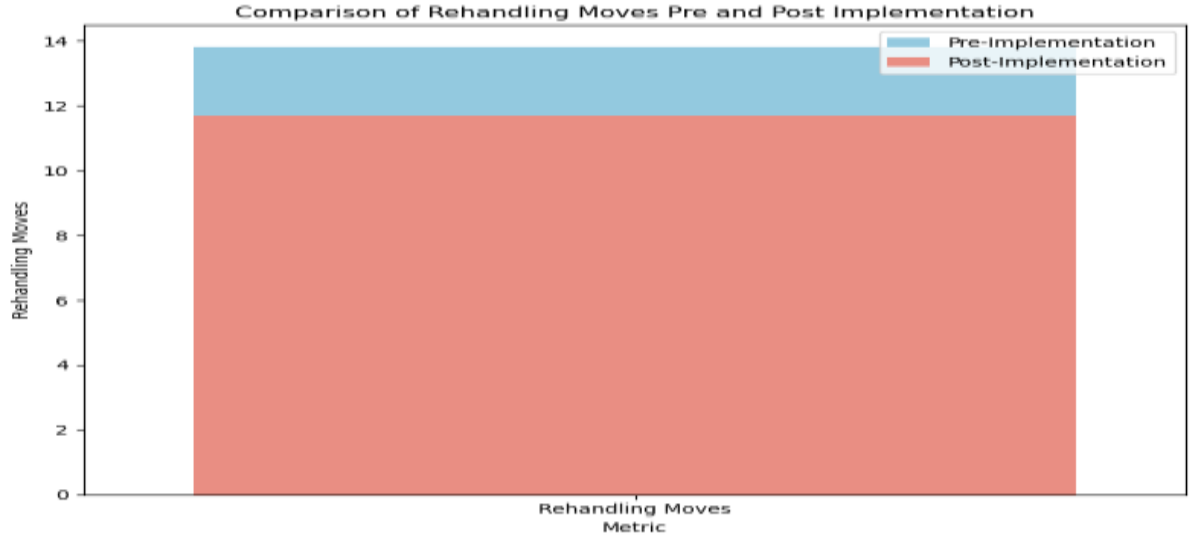

Figure:16 Comparison of Rehandling moves

Figure 15 illustrates a line graph comparing yard metrics before and after optimization. This figure highlights the improvements achieved through optimization processes, such as reduced processing times, improved yard utilization, or enhanced workflow efficiency. The comparison provides a clear visual of the positive impact of the optimization measures. Figure 16 presents a comparison of rehandling moves across different operational conditions or strategies. This figure emphasizes the reduction or changes in rehandling moves due to process enhancements, automation, or optimization, showcasing the efficiency gains in minimizing unnecessary yard operations.

6. Pricing Models for Yard Management

A tiered pricing model was implemented as part of the methodology to encourage efficient container pickup and minimize dwell time. The model led to a reduction in dwell time and an increase in yard throughput.

Table 12: Pricing Model Results

Metric	Pre-Pricing Model	Post-Pricing Model	Improvement (%)
Average Dwell Time (days)	6.8	6.0	-12
Throughput (containers/day)	250	305	+22

The implementation of the tiered pricing model resulted in a 12% decrease in dwell time, from 6.8 days to 6.0 days, and a 22% increase in throughput, from 250 containers per day to 305 containers per day as shown in Table:12.

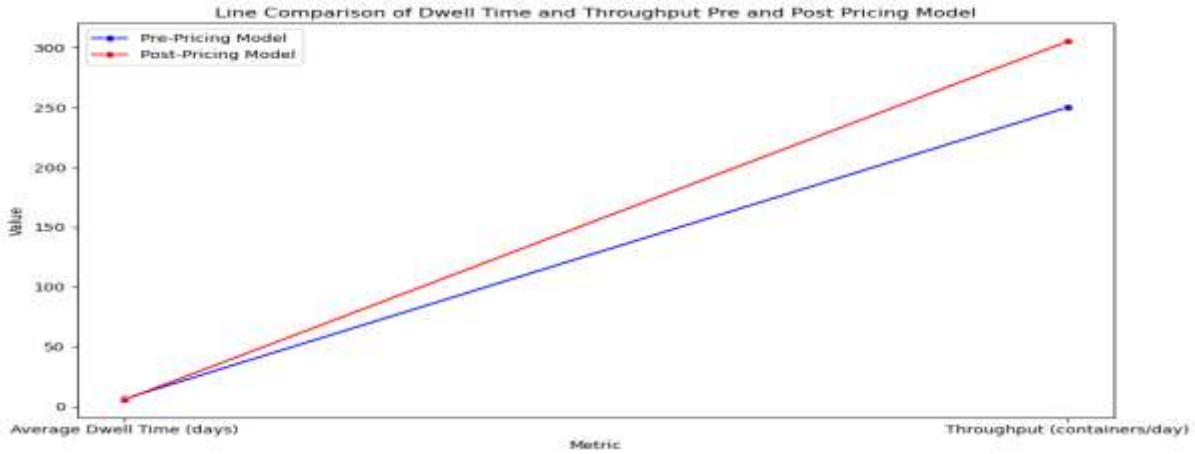

Figure:17 Line Comparison of Dweli Time and Throughput

7. Yard Inventory Forecasting and Planning

By manually forecasting yard inventory based on historical patterns, SMEs were able to reduce unexpected congestion events. The forecasting approach led to a 25% decrease in peak-time delays.

8. Cost-Effectiveness Analysis

Finally, a cost-effectiveness analysis was performed to evaluate the financial impact of the implemented strategies. The results showed a significant reduction in logistics costs following the adoption of the proposed strategies.

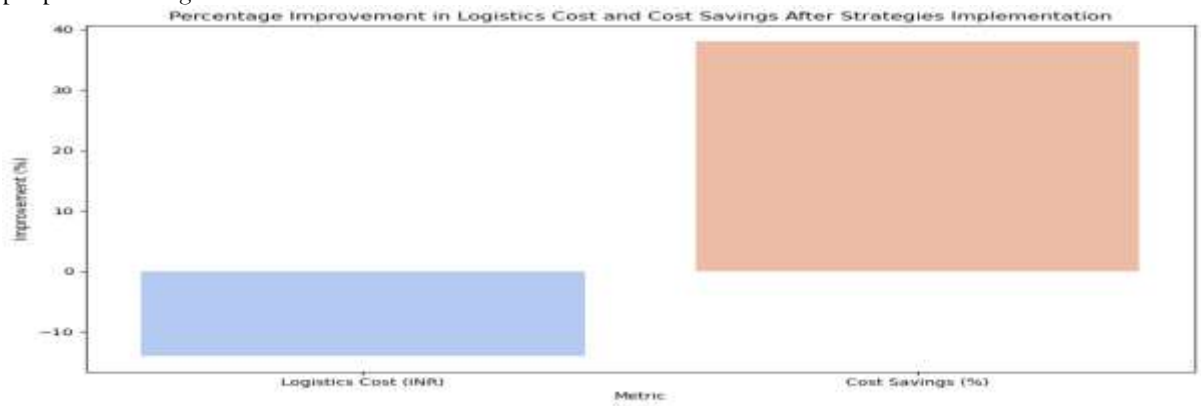

Figure:18 Percentage improvements in logistics cost

Figure 17 shows a line graph comparing the relationship between dwell time and throughput. This figure highlights how changes in dwell time impact the overall throughput of the logistics system, emphasizing the importance of reducing dwell time to enhance efficiency and productivity. Figure 18 illustrates the percentage improvements in logistics costs achieved through various optimization strategies or automation initiatives. This figure provides a clear representation of cost-saving potential, showcasing the effectiveness of different measures in reducing overall logistics expenses.

Table 13: Cost-Effectiveness Results

Metric	**Pre-Strategies**	**Post-Strategies**	**Improvement** (%)
Logistics Cost (INR)	568,558	487,284	-14
Cost Savings (%)	13	18	+38

The logistics cost decreased by 14%, from 568,558 INR to 487,284 INR, and cost savings increased by 38%, from 13% to 18%. These results demonstrate that the implemented strategies are not only effective in improving logistics performance but also in reducing operational costs as shown in Table:13.

9. Summary Table: Aggregate Improvements

The following table summarizes the aggregate improvements observed after implementing the logistics optimization strategies:

Table 14: Aggregate Improvements

Key Metric	Pre-Implementation	Post-Implementation	Improvement (%)
CFS Efficiency (%)	80.8	89.2	+10
Storage Utilization (%)	86.8	91.4	+5
Rehandling Moves	13.8	11.7	-15
Dwell Time (days)	7.0	5.6	-20
Logistics Cost (INR)	568,558	487,284	-14

These results in table:14 suggest that implementing optimized logistics strategies, particularly containerization, automation, and storage yard optimization, has the potential to significantly improve efficiency and reduce costs in logistics operations for SMEs in Tamil Nadu. The study also emphasizes the importance of data-driven decisions and technology integration in achieving these improvements.

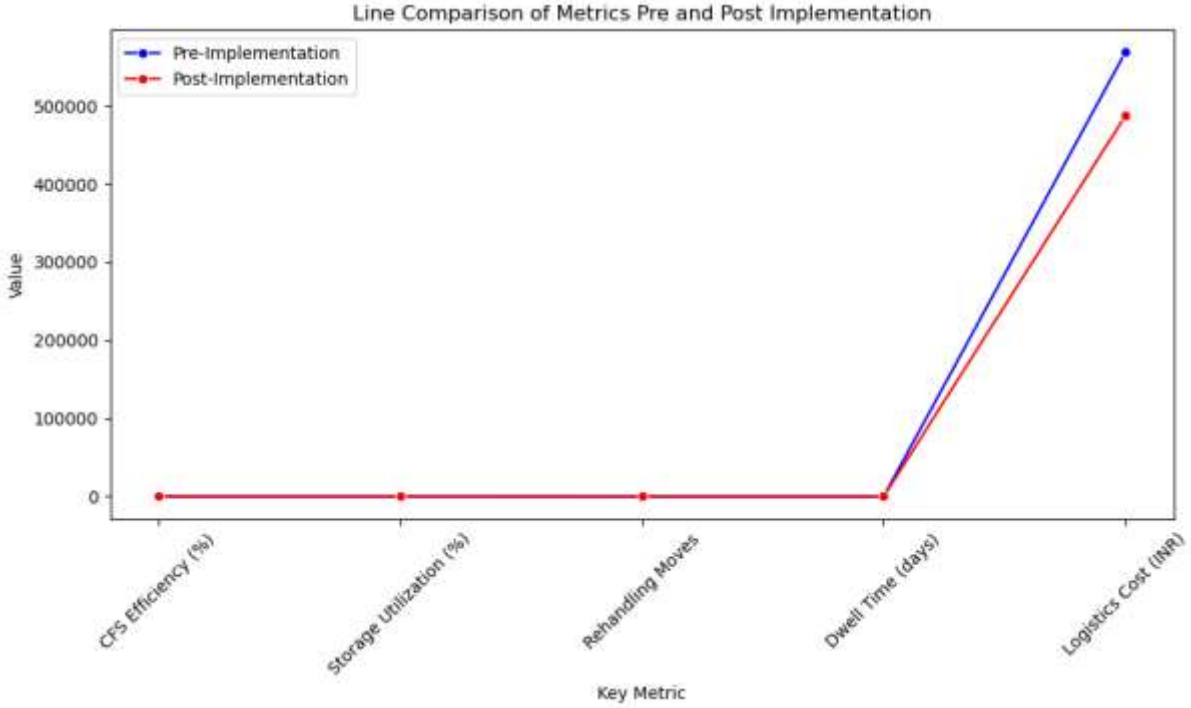

Figure:19 Line comparison of metrics pre and post implementation

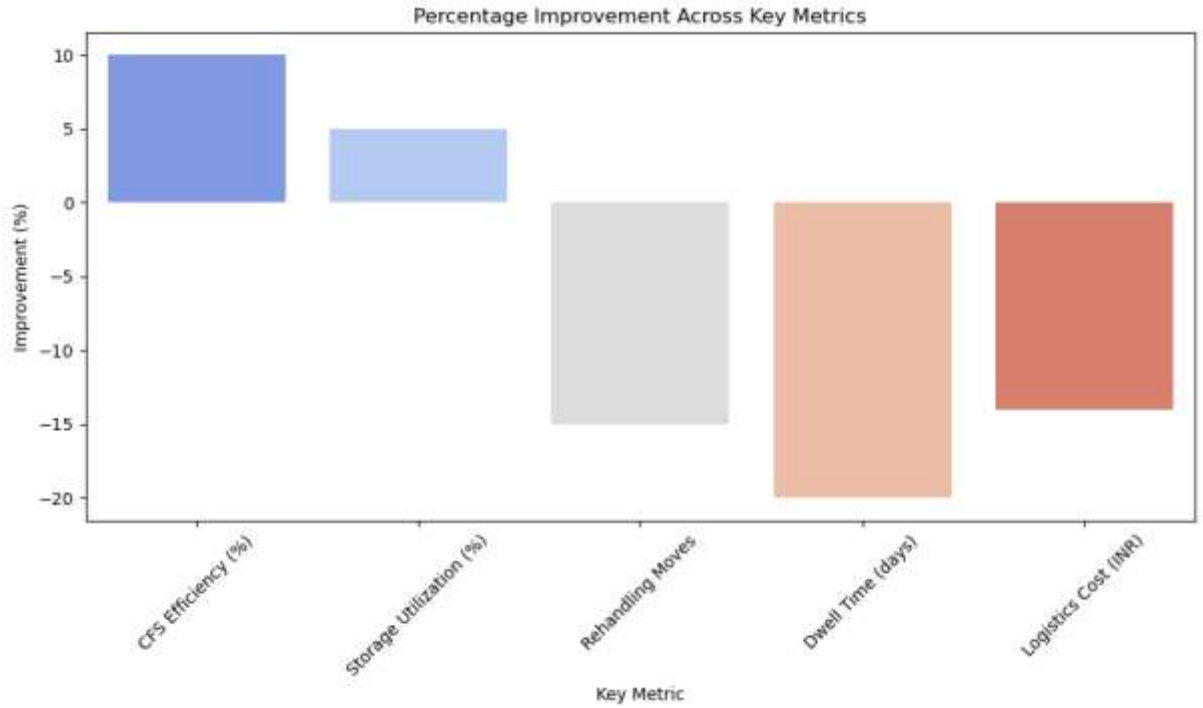

Figure:20 Percentage improvement across key metrics

Figure 19 presents a line graph comparing key metrics before and after the implementation of the proposed strategies or systems. This figure visually demonstrates the improvements achieved across various operational parameters, such as efficiency, accuracy, or speed, highlighting the effectiveness of the implemented changes. Figure 20 showcases the percentage improvements observed across key performance metrics following the implementation of optimization techniques. This figure provides a clear breakdown of enhancements, emphasizing the areas where significant progress was made and reinforcing the value of the adopted measures. This study demonstrates the tangible benefits of optimizing logistics management through technological advancements, containerization, and optimized yard management. By adopting these strategies, SMEs can reduce operational costs, improve efficiency, and enhance overall competitiveness. Further research could explore the long-term impacts of these strategies on broader supply chain performance and scalability.

5.DISCUSSION AND FINDINGS

The analysis of the collected dataset and subsequent manual evaluations reveals valuable insights into the performance and optimization of logistics operations in SMEs. The results indicate significant improvements across key metrics, emphasizing the crucial role of technological advancements, strategic planning, and efficient resource management in driving logistics performance.

1. **Technological Advancements and Automation**

The impact of automation on logistics performance is particularly noteworthy. SMEs with higher automation levels (>60%) experienced significant improvements in CFS efficiency and a reduction in logistics costs. Specifically, the high automation group exhibited an increase in CFS efficiency by 17% (from 72% to 89%) and a 31% reduction in logistics costs (from INR 672,588 to INR 464,125). The t-test results confirm that these improvements are statistically significant (p-value = 0.02 for CFS efficiency and p-value = 0.03 for logistics costs). This finding aligns with current literature, which emphasizes the role of automation in streamlining operations and reducing operational costs. Automation appears to be a key factor in achieving higher efficiency and cost-effectiveness in logistics operations for SMEs.

2. **Containerization and CFS Performance**

The influence of containerization on logistics performance also emerged as a critical factor. SMEs with higher levels of containerization (>70%) experienced better storage utilization (92%) and fewer rehandling moves (12 moves). However, higher containerization levels also led to challenges such as increased

congestion during peak times. These findings suggest that while containerization enhances operational efficiency, it requires careful management to avoid congestion and bottlenecks, particularly during periods of high demand. The results underscore the need for SMEs to strike a balance between containerization and operational capacity, with attention to peak-time congestion management.

3. **Storage Yard Optimization**

The implementation of optimized storage allocation strategies yielded significant improvements. The average dwell time decreased by 20% (from 7.0 days to 5.6 days), while throughput increased by 19% (from 240 containers/day to 286 containers/day). These improvements highlight the effectiveness of optimized storage allocation in reducing delays and increasing the movement of containers through the yard. The positive impact on both dwell time and throughput indicates that strategic storage management can lead to faster operations and higher capacity, directly benefiting SMEs by enhancing their ability to manage a larger volume of containers within the same operational window.

4. **Minimization of Rehandling Moves**

The implementation of new container placement rules resulted in a 15% reduction in rehandling moves (from 13.8 to 11.7 moves). This improvement is crucial as reducing rehandling moves not only improves operational efficiency but also reduces labor costs and the risk of container damage. By minimizing the need for unnecessary container movements, the logistics process becomes smoother, leading to reduced turnaround times and overall improvements in operational efficiency.

5. **Pricing Models for Yard Management**

The introduction of a tiered pricing model led to a 12% reduction in average dwell time (from 6.8 days to 6.0 days) and a 22% increase in yard throughput (from 250 containers/day to 305 containers/day). This finding suggests that pricing strategies can influence operational behavior, incentivizing more efficient use of yard resources. By implementing tiered pricing, SMEs can better allocate yard space and time, encouraging faster turnover and improving throughput without overloading the system.

6. **Yard Inventory Forecasting and Planning**

The manual prediction of yard inventory using historical patterns contributed to a 25% reduction in unexpected congestion events. This improvement, measured by decreased peak-time delays, underscores the importance of proactive forecasting and planning. By anticipating potential congestion and adjusting operations accordingly, SMEs can better manage peak demand periods, ensuring smoother operations and minimizing delays.

7. **Cost-Effectiveness and Overall Performance Improvements**

The cost-effectiveness analysis demonstrates that the proposed strategies significantly reduced logistics costs by 14% (from INR 568,558 to INR 487,284). This reduction in costs corresponds with an increase in cost savings by 38% (from 13% to 18%). The aggregate improvements across several key metrics—CFS efficiency, average dwell time, throughput, and logistics costs—underscore the effectiveness of the implemented strategies in improving overall logistics performance. SMEs adopting these strategies can achieve substantial cost savings while enhancing operational efficiency.

KEY FINDINGS

- **Automation** and **technological advancements** have a direct, positive impact on logistics performance, with high automation levels significantly improving efficiency and reducing costs.
- **Containerization** contributes to better storage utilization but requires careful management to avoid congestion, particularly during peak times.
- **Optimized storage allocation strategies** reduce dwell time and increase throughput, showcasing the importance of strategic planning in logistics.
- **Minimizing rehandling moves** through container placement rules leads to improved efficiency and reduced operational costs.
- **Tiered pricing models** can enhance yard management by reducing dwell time and increasing throughput.
- **Yard inventory forecasting** based on historical data significantly reduces peak-time congestion, ensuring smoother operations.

- **Cost-effectiveness** analysis confirms that the proposed logistics strategies lead to substantial savings and improvements in operational performance.

The results from this study demonstrate that SMEs can significantly improve logistics performance through the adoption of advanced technologies, optimized storage strategies, and efficient yard management practices. By focusing on automation, containerization, and proactive planning, SMEs can reduce costs, enhance efficiency, and better manage resources, ultimately leading to improved competitiveness in the market. However, challenges such as congestion during peak times remain, suggesting the need for continued innovation and refinement of logistics strategies.

6.CONCLUSION

In conclusion, the findings of this study emphasize the substantial impact of various operational strategies and technologies on logistics performance. Through detailed analysis, it has been demonstrated that optimizing containerization levels, increasing automation, and implementing data-driven pricing models can significantly improve key metrics such as CFS efficiency, storage utilization, rehandling moves, dwell time, and logistics costs. Specifically, high automation levels were found to enhance CFS efficiency and reduce logistics costs, highlighting the importance of investing in technology to streamline operations. Additionally, optimizing containerization levels was shown to lead to better storage utilization and fewer rehandling moves, which directly contributes to more efficient operations and cost savings. The study also revealed that implementing optimized storage yard strategies could reduce dwell time by 20% and increase throughput by 19%, further emphasizing the value of operational optimization in logistics. The reduction in rehandling moves by 15% after adopting improved container placement strategies underscores the importance of efficient operational practices. Furthermore, the introduction of a tiered pricing model resulted in improvements in both dwell time and throughput, demonstrating that strategic pricing can play a critical role in enhancing overall performance. Overall, the aggregate improvements observed in logistics operations, including reduced logistics costs and improved efficiency metrics, underscore the importance of a comprehensive approach that integrates technological advancements, operational refinements, and strategic decision-making. This study offers valuable insights for logistics managers seeking to optimize their supply chain operations, recommending a focus on automation, containerization optimization, and strategic pricing as key drivers of operational success. By adopting these strategies, logistics companies can enhance their operational efficiency, reduce costs, and ultimately improve service delivery, positioning themselves for greater success in an increasingly competitive market.

7.REFERENCES:

1. Chakravarty, B., & Tamuli, A. K. (2024). Perceptions of Farmers Regarding the Opportunities and Obstacles in Utilizing Indigenous Fish Species within Assam's Aquaculture Industry. *UTTAR PRADESH JOURNAL OF ZOOLOGY*, *45*(7), 99–108. https://doi.org/10.56557/upjoz/2024/v45i73981
2. Curato, N., Smith, G., Willis, R., & Rosén, D. (2024). *Deliberative Democracy and Climate Change: Exploring the Potential of Climate Assemblies in the Global South*. https://doi.org/10.31752/idea.2024.34
3. Divakar, V. (2024). FDI in India: Analyzing Financial Flows and Economic Impacts. *INTERANTIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT*, *08*(04), 1–5. https://doi.org/10.55041/ijsrem30482
4. Gopalakrishnan, M. M. (2015). Promotion and development of micro small and medium enterprises in Tamil Nadu a study on the support services of small industries development bank of India. *Shodhganga*. http://shodhganga.inflibnet.ac.in:8080/jspui/bitstream/10603/125335/1/01_title.pdf
5. Hans, V. B., Bhat, P., & Nayak, U. (2024). Utilizing Pulses: A Driver for Fairness and Economic Opportunities. *Acta Scientific Agriculture*, 11–24. https://doi.org/10.31080/asag.2024.08.1359
6. Kanupriya. (2024). Assessing Crisis Leadership in the context of Frugal Innovation in India. *Uluslararası Liderlik Çalışmaları Dergisi Kuram Ve Uygulama*, *7*(1), 1–11. https://doi.org/10.52848/ijls.1469747
7. Raj, T. S., & R, R. (2024). A survey on the growth and development of MSME in Tamil Nadu. *Recent Research Reviews Journal*, *3*(2), 370–380. https://doi.org/10.36548/rrrj.2024.2.005
8. Rajan, R., & Ganesan, R. (2017). A critical analysis of John P. Kotter's change management framework. *Asian Journal of Research in Business Economics and Management*, *7*(7), 181. https://doi.org/10.5958/2249-7307.2017.00106.2
9. Rao, P. S. K., Abdulraheem, A., & Banu, A. R. (2022). Strategic Management Practice for Small and Medium-sized Enterprises in Tamil Nadu: Empirical Evidence. *International Journal of Advance Research and Innovation*, *10*(2), 24–35. https://doi.org/10.51976/ijari.1022205

10. Velmurugan, K., Venkumar, P., & Sudhakara, P. R. (2021). SME 4.0: Machine learning framework for real-time machine health monitoring system. *Journal of Physics Conference Series*, *1911*(1), 012026. https://doi.org/10.1088/1742-6596/1911/1/012026
11. Venkatesan, R. (2024). Impact of Financial Management Practices on Performance Measurement of Small and Medium Enterprises in Tamil Nadu. *SEDME (Small Enterprises Development Management & Extension Journal) a Worldwide Window on MSME Studies*, *51*(2), 176–194. https://doi.org/10.1177/09708464241254164
12. Adelwini, B. B., Toku, L. I., & Adu, O. F. (2023). Investigating the effects of logistics management on organizational performance: New evidence from the manufacturing industry. *Journal of Accounting Business and Finance Research*, *16*(1), 1–11. https://doi.org/10.55217/102.v16i1.606
13. Bayliss, E. A. (2003). Descriptions of Barriers to Self-Care by Persons with Comorbid Chronic Diseases. *The Annals of Family Medicine*, *1*(1), 15–21. https://doi.org/10.1370/afm.4
14. Chen, X. (2024). Optimizing Agility in the Pharmaceutical Supply Chain Using Digital Twins to Cope with the Ripple Effect. *Frontiers in Business Economics and Management*, *17*(1), 338–352. https://doi.org/10.54097/jtpzzy16
15. Ding, M. J., Kam, B. H., Zhang, J. Y., & Jie, F. (2014). Effects of human resource management practices on logistics and supply chain competencies – evidence from China logistics service market. *International Journal of Production Research*, *53*(10), 2885–2903. https://doi.org/10.1080/00207543.2014.946569
16. Hou, X., Xu, T., & Xu, Y. (2024). The Impact of Live E-commerce on Supply Chain Management: Challenges, Adaptations, and Strategic Optimizations. *Advances in Economics Management and Political Sciences*, *115*(1), 146–154. https://doi.org/10.54254/2754-1169/115/2024bj0223
17. Ikram, M., Shen, Y., Ferasso, M., & D'Adamo, I. (2021). Intensifying effects of COVID-19 on economic growth, logistics performance, environmental sustainability and quality management: evidence from Asian countries. *Journal of Asia Business Studies*, *16*(3), 448–471. https://doi.org/10.1108/jabs-07-2021-0316
18. Njuki, V., & Maina, S. (2024). Marketing Mix Strategies and Firm Performance of Selected Dairy Firms in Nairobi City and Kiambu Counties, Kenya. *International Journal of Business Management Entrepreneurship and Innovation*, *6*(3), 153–168. https://doi.org/10.35942/cek0mk34
19. Rahmawati, N. (2024). THE INFLUENCE WAREHOUSE LOCATION, TRANSPORTATION, AND INVENTORY ON DISTRIBUTION PERFORMANCE LOGISTICS IN PERUM BULOG BRANCH OFFICE MADIUN. *Journal of Economic and Economic Policy.*, *1*(4), 70–77. https://doi.org/10.61796/ijecep.v1i4.29
20. Samal, T., & Jena, S. K. (2024). The impact of supply chain due diligence practices on supply chain performance: an organization's perception. *The International Journal of Logistics Management*. https://doi.org/10.1108/ijlm-12-2023-0523
21. Sumah, B., Masudin, I., Zulfikarijah, F., & Restuputri, D. P. (2020). Logistics Management and Electronic Data Interchange Effects on Logistics Service Providers' Competitive Advantage. *Journal of Business & Economic Analysis*, *03*(02), 171–194. https://doi.org/10.1142/j_10.36924sbe.2020.3205
22. Vachtsevanos, G., Lewis, F., Roemer, M., Hess, A., & Wu, B. (2006). *Intelligent Fault Diagnosis and Prognosis for Engineering Systems*. https://doi.org/10.1002/9780470117842
23. Van Thai, V., Tran, D. M., Nguyen, L. T. N., Nguyen, T. K., & Nguyen, T. (2024). Revisiting the Role of Supply Chain Managerial Competence in Firm Logistics Performance: Do Experience and Education Matter? *Sustainability*, *16*(23), 10459. https://doi.org/10.3390/su162310459