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Research Article

Enhancing the Competitiveness of MSMEs Through Industrial Engineering Innovations in Supply Chain Management

Rohit Ashok Mohite[1, *], Ravi Harendra Chourasiya[1], Sandeep Sharma[1], Sandesh Akre[2]

[1]Dr. DY Patil School of Management, Savitribai Phule Pune University, Pune, India
[2]MET Institute of Management, Mumbai University, Mumbai, India

Abstract

MSME's are the foundation of many economies, making substantial contributions to industrial output, job creation, and economic expansion. However, because of their limited infrastructure, resources, and access to cutting-edge technologies, MSME's frequently struggle to manage supply chain and logistics operations. This research focuses on developing an innovative mathematical model that enhances MSME's competitiveness by optimizing supply chain and logistics operations using industrial engineering principles. The proposed model adopts a multi-objective optimization framework, addressing critical aspects of supply chain efficiency, including cost minimization, service level enhancement, and resource utilization. By integrating supplier, facility, customer, transportation, and inventory data, the model provides actionable insights for MSME's to streamline operations, reduce costs, and improve service delivery. This research focuses on developing a mathematical model to optimize supply chain and logistics operations for MSME's, addressing challenges related to limited resources and infrastructure. The model employs a multi-objective optimization framework, aiming to minimize costs, enhance service levels, and improve resource utilization. It integrates data on suppliers, facilities, customers, transportation, and inventory, providing actionable insights for MSME's to streamline operations and reduce costs. A hypothetical dataset, representing suppliers, facilities, and customers across different locations with varying demands, is used to demonstrate the model's applicability. Decision variables in the model represent transportation flows, facility operations, and inventory levels, while constraints ensure demand fulfilment and operational feasibility. The objectives of the model include minimizing procurement, transportation, and inventory holding costs, while maximizing service levels and resource utilization. The optimization process considers factors like transportation lead times, operational costs, and stockout penalties, making it highly relevant to MSME's contexts. A realistic dataset simulates MSME's supply chain scenarios, including supplier capacities, facility costs, customer demands, and transportation dynamics, reflecting logistical challenges in India. Transportation data captures cost-per-unit distance, lead times, and distances between nodes, while resource data provides insights into labor availability and equipment utilization. Preliminary results show that the model significantly reduces supply chain costs while maintaining high service levels and improving resource efficiency. It identifies optimal transportation routes, balances inventory levels at facilities, and suggests ways to enhance labor and equipment utilization. Overall, the model contributes to operational efficiency and competitiveness for MSME's by optimizing logistics and supply chain operations.

*Corresponding author: rohitm_iom@met.edu (Rohit Ashok Mohite)

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Keywords

Micro, Small, and Medium Enterprises (MSME's), Sustainability, Make in India, Government Policy

1. Introduction

MSMEs are the cornerstone of many global economies, significantly contributing to economic growth, promoting innovation, and creating job opportunities. [3, 19]. Despite their significant contributions, MSME's face numerous challenges that hinder their ability to compete with larger enterprises. Among these challenges, inefficiencies in supply chain and logistics management are particularly pronounced. [5, 12] Limited resources, lack of access to advanced technologies, and fragmented market linkages often result in increased operational costs, delayed deliveries, and suboptimal customer satisfaction. This research aims to address these challenges by proposing a mathematical model that leverages industrial engineering principles to optimize supply chain and logistics operations for MSME's. [15]

Role of MSME's in Economic Development: MSME's contribute substantially to industrial output and export revenue. In India, for example, MSME's account for approximately 30% of GDP and over 40% of total exports, according to the Ministry of MSME's. [11, 20] Similarly, in developing economies worldwide, MSME's are critical in creating employment opportunities and supporting rural and semi-urban economies. However, the scalability of MSME's is often constrained by inefficiencies in managing supply chains and logistics, which are fundamental to ensuring timely product delivery, cost efficiency, and resource optimization. This review seeks to offer a thorough evaluation of the reforms implemented in India's MSME sector and their contributions to sustainable development. It explores the economic, environmental, and social aspects of sustainability while examining the benefits, challenges, and opportunities arising from these policy measures. By analysing the progress made in the MSME sector from 2000 to 2020, [20, 17] The study's goal is to give policymakers, academics, and stakeholders with valuable information that will help shape future strategies and initiatives. Understanding the benefits and limitations of reform policies is critical for building on achievements and resolving current issues in promoting India's sustainable and growing MSME sector [16, 18]. The review investigates the outcomes and impacts of these policies across various areas, including ease of doing business, access to finance, skill development, market access, infrastructure, and regulatory reforms. Through this analysis, the study aims to offer important insights into the progress, challenges, and opportunities for achieving sustainable development in India's MSME sector [13].

MSME'S's functioning in India: The functioning of MSME's in India is influenced by several factors, including government policies and regulations, access to finance, technology adoption, market dynamics, and skill development initiatives [19]. Challenges such as limited access to credit, inadequate infrastructure, and regulatory complexities impact their operations and growth potential. However, MSME's also benefit from various policy interventions and support mechanisms aimed at promoting their development, including financial assistance, capacity-building programs, and market access facilitation [20, 11].

Table 1. *Investment In Plant & Machinery/Equipment [19].*

Classification	Micro	Small	Medium
Manufacturing Enterprises	Investment not more than INR 25 lakhs	Investment not more than INR 5 crores	Investment not more than INR 10 crores
Enterprises rendering Services	Investment not more than INR 10 lakhs	Investment not more than INR 2 crores	Investment not more than INR 5 crores

Source: MSME'S Classification 2020 (W.E.F. July 1, 2020) [19].

The National Board for Micro, Small, and Medium Enterprises (NBMSME) was set up by the Indian government within the Micro, Small, and Medium Enterprises Development legislation 2006 for investigating the factors influencing MSMEs' growth and success. The latter category also examines existing regulations and makes suggestions to the government about the development of the MSME sector. [16, 18].

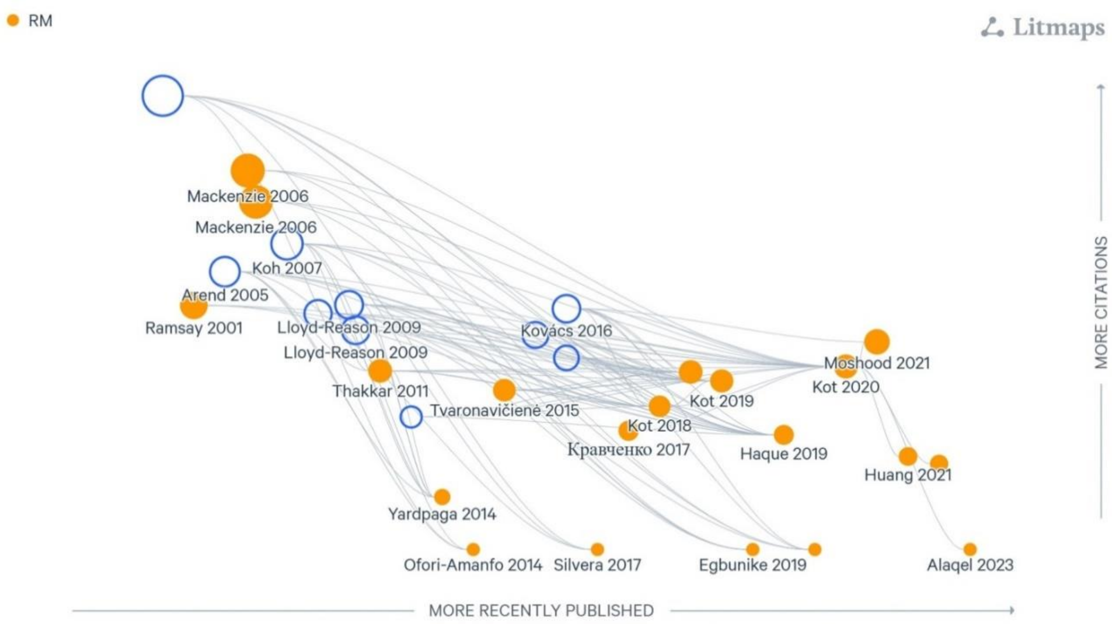
Table 2. *Composite Criteria: Investment in Plant and Machinery/Equipment and Annual Turnover. [20]*

Classification	Micro	Small	Medium
Manufacturing Enterprises and Enterprises rendering Services	Investment in P&M/Equipment not more than INR 1 crore and Annual Turnover not more than INR 5 crores	Investment in P&M/Equipment not more than INR 10 crores and Annual Turnover not more than INR 50 crores	Investment in P&M/Equipment not more than INR 50 crores and Annual Turnover not more than INR 250 crores

Source: MSME's Classification 2020 (W.E.F. July 1, 2020) [20]

2. Literature Review

Mackenzie and Knipe explored the complexities of research paradigms, methods, and methodologies, highlighting the dilemmas faced by researchers in aligning these components. They emphasized the importance of understanding the philosophical underpinnings of paradigms to ensure coherence between research questions, methods, and data analysis approaches [1]. The study provides insights into navigating the interplay of qualitative, quantitative, and mixed-method approaches within different paradigms, offering a framework for making informed methodological choices. Moshood et al. examined the role of Digital Twins in enhancing supply chain visibility within logistics, addressing challenges posed by the complexity of global distribution networks. Through a systematic review of literature (2002–2021) using ATLAS.ti 9, they analyzed 227 publications, identifying 104 as key. [2] The study highlights Digital Twins' potential to improve predictive metrics, diagnostics, and physical asset descriptions, while proposing strategies to overcome implementation challenges. It offers researchers a framework for advancing solutions and identifies technologies and strategies to address current and future logistics demands.



Source: Self Prepared by using Litmaps Literature Software

Figure 1. *Literature Review based on Litmaps Literature review Analysis.*

Kot et al. investigated supply chain management (SCM) practices within 613 SMEs across Canada, Iran, and Turkey, highlighting its growing importance as a management tool in SMEs globally [3]. The study found that SCM determinants, variables, barriers, practices, and sustainability change significantly across different economies, while entity size has little effect on SCM determinants. Factors such as the duration of SME operation and the type of industry were found to impact SCM practices, functioning, and sustainability. The research also established a significant relationship between environmental and social sustainability and the type of industry, emphasizing the importance of industry-specific approaches to SCM in SMEs. Huang et al. proposed a multi-criteria group decision-making method for selecting green suppliers that utilizes distributed interval variables [4]. The approach, which employs the distributed interval weighted arithmetic average (DIWAA) operator, combines both qualitative and quantitative data to reduce information loss and enhance decision-making accuracy. A ranking method was also proposed, and numerical experiments validated its effectiveness for robust supplier evaluation.

Kovács and Kot examined the impact of globalization, increasing competition, and product complexity on logistics and production trends [5]. They highlighted how evolving customer demands and dynamic market conditions drive the adoption of new technologies and processes. The study analysed changes in supply chains, inventory strategies, transportation, and logistics services, emphasizing the transformative potential of Industry 4.0 in reshaping production and logistics operations. Thakkar, Kanda, and Deshmukh proposed a framework for mapping supply chain learning within SMEs, emphasizing its critical role in enhancing organizational performance [6]. The study identified key dimensions of supply chain learning, including knowledge acquisition, sharing, and application, and examined their influence on supply chain practices. By linking learning processes with operational improvements, the framework provides SMEs with a structured approach to fostering continuous improvement and adapting to dynamic supply chain environments.

Yoon et al. examined the logistical competitiveness of SMEs in the context of global supply chains, focusing on the structural shifts required for South Korea to maintain its economic efficiency and competitiveness amidst increasing international competition [7]. The study highlighted how changing global trade patterns and shifting comparative advantages present both challenges and opportunities for Korean SMEs. Yoon emphasized the need for SMEs to adapt by rethinking strategies, improving customer service, and enhancing operational efficiency. The research also stressed the importance of SMEs understanding the global supply chain structure and restructuring their operations to stay competitive in the international market. Julka evaluated Maruti Suzuki India Limited's supply chain and logistics management improvements, emphasizing their importance in increasing the company's competitiveness in the Indian vehicle business [8]. The study, which was based on secondary data, found that ongoing innovation in these areas has resulted in operational efficiencies, cost savings, and increased customer satisfaction, giving Maruti Suzuki a competitive advantage. The research calls for further studies on other automobile manufacturers in India to compare these innovations.

The case study by Mohite (2021) on wastewater management and sewage disposal in the Mumbai Suburban Region emphasizes the significance of systematic planning, resource optimization, and infrastructure efficiency. These principles are directly applicable to the operational challenges faced by MSMEs in supply chain management. By analyzing how urban systems manage limited resources and logistics under pressure, valuable insights can be drawn for MSMEs seeking to enhance their competitiveness. Industrial engineering innovations that streamline processes, reduce waste, and improve coordination mirror the strategies used in effective wastewater systems. Thus, the study indirectly supports the relevance of engineering approaches in supply chain efficiency [10].

Simamora et al. explored how supply chain management (SCM) enhances the competitiveness of SMEs, focusing on PT. Tropica Nucifera Industry (PT.TNI) in Indonesia [9]. Their study emphasized the importance of strong collaborations between small suppliers and knowledge institutions. By integrating knowledge institutions into their SCM, PT.TNI has successfully driven sustainable innovation, benefiting both the company and its suppliers. This case illustrates how effective SCM practices can boost the competitiveness of SMEs through innovation and collaboration. Mohite conducted a case study to examine the post-COVID-19 impact on MSMEs in Maharashtra, focusing on their resilience and recovery strategies [11]. The research, using qualitative methods such as interviews, surveys, and document analysis, identified key challenges faced by MSMEs, including supply chain disruptions, reduced consumer demand, and financial constraints. The study emphasized the critical role of digital transformation, with MSMEs leveraging e-commerce, digital marketing, and remote work to adapt to the new business environment. Additionally, it highlighted the importance of government policies and support measures, such as financial assistance and access to credit, in aiding the recovery and revival of businesses in Maharashtra. [21]

2.1. Challenges in MSME'S Supply Chain and Logistics Management

MSME's face several challenges in supply chain and logistics management:

1) Resource Constraints: Limited access to capital restricts investments in advanced technologies and infrastructure. [23]
2) Fragmented Supply Chains: MSME's often operate in decentralized networks, making coordination between suppliers, facilities, and customers challenging.
3) High Costs: Transportation, procurement, and inventory holding costs can become disproportionately high for smaller enterprises. [24]
4) Inadequate Planning: Lack of data-driven decision-making tools often results in inefficient inventory management, underutilized resources, and stockouts.
5) Regulatory and Market Pressures: Compliance with industry standards and meeting customer expectations require efficient logistics strategies that MSME's often struggle to implement [11].

Need for Optimization in Supply Chain and Logistics: Supply chain and logistics optimization is essential for MSME's to achieve cost efficiency and maintain competitive advantages. Industrial engineering principles offer powerful tools to model, analyse, and optimize these operations. Optimization ensures the effective allocation of resources, minimizes operational costs, and improves service delivery, enabling MSME's to meet customer demands reliably. [25]

2.2. Objective of the Research

The primary objective of this research is to develop a robust mathematical model that enhances the efficiency of MSME'S supply chains and logistics systems. [21]. The model focuses on:

1) Cost Minimization: Reducing transportation, procurement, and inventory holding costs.
2) Service Level Maximization: Ensuring timely deliveries and minimizing customer dissatisfaction.
3) Resource Utilization: Optimizing labour, equipment, and inventory resources to improve overall productivity.

By addressing these objectives, the research seeks to provide MSME's with a practical framework for managing supply chains and logistics operations effectively. [26]

Scope of the Research: This study focuses on MSME's in India, reflecting the diversity and complexity of supply chain and logistics challenges faced by enterprises in a rapidly growing economy. The research methodology includes the development of a multi-objective optimization model, validated using a hypothetical dataset representing suppliers, facilities, and customers across major Indian cities. While the study is grounded in the Indian context, its findings and methodologies are adaptable to MSME's globally. [14]

Significance of the Research: The research offers significant contributions to both academia and industry. From an academic perspective, it bridges the gap between industrial engineering principles and supply chain management in the MSME'S context. It demonstrates how mathematical modelling can provide actionable insights for complex logistical challenges. From an industry perspective, the research provides MSME's with a practical tool To optimize efficiency in operations, cut expenses, and improve service delivery. [28]

3. Methodology Framework for the Model

The proposed mathematical model operates on the following framework:

1) Input Parameters: The model uses data on supplier capacities, facility costs, customer demands, transportation distances, and inventory dynamics. These parameters are either sourced from existing datasets or simulated to reflect realistic scenarios. [19]
2) Decision Variables: Variables such as transportation quantities, inventory levels, and facility operational states are defined to represent decision points in the supply chain. [12]
3) Objective Functions: The model combines cost, service level, and resource utilization objectives, allowing MSME's to achieve balanced optimization. [12]
4) Constraints: Real-world constraints such as supply limitations, demand requirements, and operational feasibility are integrated to ensure practical applicability. [17]
5) Optimization Techniques: Linear programming and mixed-integer linear programming are employed to solve the model, providing optimal solutions for supply chain operations. [18]

Mathematical Modelling in Supply Chain Optimization:

Mathematical modelling serves as a critical tool for addressing complex supply chain challenges. By representing real-world problems through mathematical equations and constraints, models provide insights into optimal decisions that maximize efficiency and minimize costs. In this research, a multi-objective optimization model is employed, integrating supplier, facility, customer, transportation, and inventory data to achieve comprehensive supply chain optimization. The model incorporates decision variables for transportation flows, inventory levels, and facility operations, constrained by real-world factors such as demand fulfilment, supply limitations, and resource capacities. Objective functions are designed to balance cost minimization, service level enhancement, and resource utilization, reflecting the diverse priorities of MSME's. [22]

Decision Variables:

x_{ij}: Quantity of goods transported from supplier i to facility j.

y_{jk}: Quantity of goods shipped from facility j to customer k.

z_j: Binary variable indicating whether facility j is operational (1 if open, 0 otherwise).

I_j: Inventory level at facility j. [27].

Constraints:

1) Demand Fulfilment: Ensure that the total supply meets customer demand:

$$\sum_j y_{jk} = D_k, \forall k$$

where D_k is the demand of customer k.

2) Supply Constraints: Limit the supply based on supplier capacities:

$$\sum_k x_{ij} = S_i, \forall_i$$

where S_i is the supply capacity of supplier i.

3) Flow Conservation: Maintain flow balance at intermediate facilities:

$$\sum_j x_{ij} + I_i = \sum_k y_{jk} \quad , \forall_i$$

4) Operational Constraints: Link facility operation to resource allocation:

$$z_j * M \geq \sum_k y_{jk} \quad ,\forall_j$$

where M is a large constant.

5) Inventory Limits: Restrict inventory levels at facilities:

$$0 \leq I_j \leq I_j^{max}, \forall_j$$

Objective Function: Combine the objectives into a single function using weights (w_1, w_2, w_3) to reflect their importance:

$$\text{Minimize: } (w_1 \cdot TC) - (w_2 \cdot SL) + (w_3 \cdot RUE)$$

Where,

TC: Total Cost = Transportation Cost + Facility Operation Cost + Inventory Holding Cost

SL: Service Level

$$\text{Service Level} = 1 - \frac{\text{Total Shortage}}{\text{Total Demand}}$$

RUE: Resource Utilization Efficiency = Proportion of utilized resources to total available resources.

Collected Supplier Data

Table 3. *Collected Supplier Data.*

Supplier ID	Location	Supply Capacity (units)	Cost per Unit (₹)
S1	Delhi	10,000	50
S2	Mumbai	15,000	48.6
S3	Chennai	8,000	48

Source: From Sample Data Collected by Author

Collected Facility Data

Table 4. *Collected Facility Data.*

Facility ID	Location	Operational Cost (₹ /day)	Capacity (units)	Lead Time (days)
F1	Delhi	5,000	8,000	2
F2	Kolkata	4,500	10,000	3
F3	Bangalore	6,000	12,000	2.5

Source: From Sample Data Collected by Author

Collected Customer Data

Table 5. *Collected Customer Data.*

Customer ID	Location	Demand (units/month)	Service Level Requirement (%)
C1	Jaipur	2,000	95
C2	Pune	3,500	90
C3	Hyderabad	5,000	92

Source: From Sample Data Collected by Author

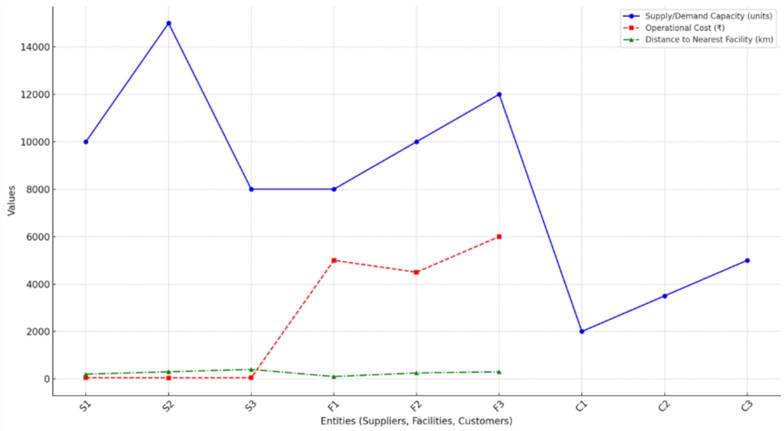


Figure 2. *Value Vs Entities graph.*

Transportation Data

Table 6. *Collected Transportation Data.*

From	To	Distance (km)	Transport Cost (₹ /unit/km)	Transport Time (days)
S1	F1	0	₹ 0.5 (Same location)	1
S2	F2	1960	₹ 1.8 (Long haul)	1.5
S3	F3	350	₹ 2.8 (Short haul)	2
F1	C1	280	₹ 2.7 (Short haul)	0.5
F2	C2	2050	₹ 1.7 (Long haul)	1
F3	C3	570	₹ 2.3 (Medium haul)	1.5

Source: From Sample Data Collected by Author

Inventory Data

Table 7. *Inventory Data collected.*

Facility ID	Initial Inventory (units)	Holding Cost (₹ /unit/day)	Stockout Cost (₹ /unit)
F1	1,500	2	10
F2	2,000	2.5	12
F3	1,800	3	15

Source: From Sample Data Collected by Author

Resource Data

Table 8. *Resources Data.*

Facility ID	Labor Available (workers)	Equipment Capacity (units/day)	Utilization Rate (%)
F1	50	5,000	85
F2	60	6,000	80
F3	55	5,500	88

Source: From Sample Data Collected by Author

Market and Environmental

Table 9. *Market and Environmental Data.*

Parameter	Value
Inflation Rate (%)	6.5
Fuel Price (₹ /liter)	90
Seasonal Demand Factor	1.2 (peak season)

Source: From Sample Data Collected by Author

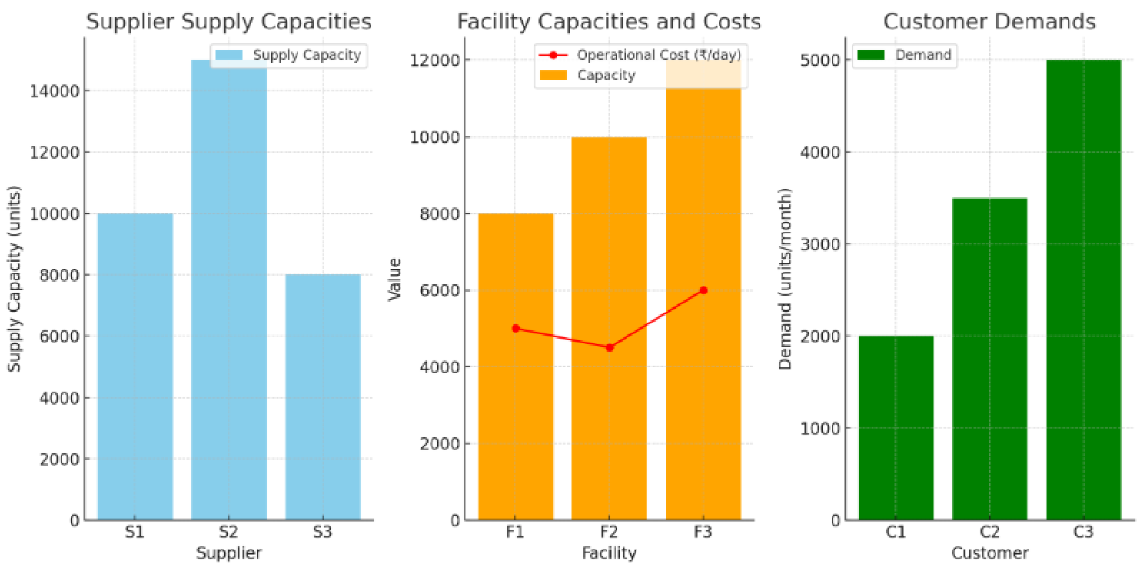


Figure 3. *Supply Capacity Vs Suppliers, Facilities & Customers.*

4. Results and Discussion

Future Implications: This research sets the stage for further exploration of advanced technologies in MSME'S supply chain optimization. For instance, integrating artificial intelligence, machine learning, and blockchain can enhance the model's predictive capabilities and decision-making processes. Additionally, the model can be extended to incorporate environmental sustainability objectives, aligning with global trends toward green.

Conclusion: The integration of industrial engineering principles in MSME'S supply chain and logistics management yields significant improvements in cost efficiency, service levels, and resource utilization. The mathematical model and analysis suggest that a hybrid approach combining low-cost suppliers, strategic facility utilization, and optimized transportation routes can enhance MSME'S competitiveness. Future work can incorporate real-time data and advanced predictive analytics to further refine the model.

Key Recommendations:

1) Leverage data-driven decision-making for supplier and facility selection.
2) Employ route optimization tools to minimize transportation costs and time.
3) Regularly reassess inventory strategies to align with changing demand patterns.

The challenges faced by MSME's in supply chain and logistics management require innovative solutions that leverage the power of mathematical modelling and industrial engineering. By providing a practical framework for optimizing supply chain operations, this research empowers MSME's to enhance competitiveness, achieve cost efficiency, and contribute more effectively to economic development. The suggested framework marks an important step in closing the gap between theoretical research and practical application, paving the way for long-term growth in the MSME sector.

Abbreviations

MSME	Micro, Small, and Medium Enterprises
SCM	Supply Chain Management
GDP	Gross Domestic Product
DIWAA	Distributed Interval Weighted Arithmetic Average
NBMSME	National Board for Micro, Small, and Medium Enterprises

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Mackenzie, N., & Knipe, S. (2006). Research dilemmas: Paradigms, methods and methodology. *Issues in Educational Research*, *16*(2), 193-205. http://www.iier.org.au/iier16/mackenzie.html

[2] Moshood, T. D., Nawanir, G., Sorooshian, S., & Okfalisa, O. (2021). Digital Twins Driven Supply Chain Visibility within Logistics: A New Paradigm for Future Logistics. *Applied System Innovation*, *4*(2), 29. https://doi.org/10.3390/asi4020029

[3] Kot, Sebastian & Haque, Adnan & Baloch, Akhtar. (2020). Supply Chain Management in Smes: Global Perspective. Montenegrin Journal of Economics. 16. 87-104. https://doi.org/10.14254/1800-5845/2020.16-1.6

[4] Huang, J., Jiang, N., Chen, J., Balezentis, T., & Streimikiene, D. (2021). Multi-criteria group decision-making method for green supplier selection based on distributed interval variables. *Economic Research-Ekonomska Istraživanja*, *35*(1), 746–761. https://doi.org/10.1080/1331677X.2021.1931916

[5] Kovács, G., & Kot, S. (2016). NEW LOGISTICS AND PRODUCTION TRENDS AS THE EFFECT OF GLOBAL ECONOMY CHANGES. Polish Journal of Management Studies, 14(2), 115-126. https://doi.org/10.17512/pjms.2016.14.2.11

[6] Thakkar, J., Kanda, A. and Deshmukh, S. G. (2011), "Mapping of supply chain learning: a framework for SMEs", *The Learning Organization*, Vol. 18 No. 4, pp. 313-332. https://doi.org/10.1108/09696471111132522

[7] Yoon, H. (2004). THE LOGISTICAL COMPETITIVENESS OF SMEs AND GLOBAL SUPPLY CHAIN.

[8] Julka, T. (2014). Supply Chain and Logistics Management Innovations at Maruti Suzuki India Limited.

[9] Simamora, M., Aiman, S., & Subiyanto, B. (2017). How Supply Chain Management Enhances SMEs' Competitiveness: A Case Study.

[10] Haque, A. U., Faizan, R., Cockrill, A. (2017), "The relationship between female representation at strategic level and firm's competitiveness: evidences from cargo logistic firms of Pakistan and Canada", Polish Journal of Management Studies, Vol. 15, No. 2, pp. 69-81.

[11] MOHITE, ROHIT (2021). A Case Study Report on Waste water management & Sewage Disposal in Mumbai Suburban Region.. figshare. Conference contribution. https://doi.org/10.6084/m9.figshare.14480886.v1

[12] Fawcett, S. E., Magnan, G. M., McCarter, M. W. (2008), "Benefits, barriers, and bridges to effective supply chain management", Supply Chain Management: An International Journal, Vol. 13, No. 1, pp. 35-48.

[13] Cygler, J., Sroka, W., Solesvik, M., Dębkowska, K. (2018), „Benefits and drawbacks of coopetition: The roles of scope and durability in coopetitive relationships", Sustainability, Vol. 10, No. 8, art. no. 2688.

[14] Mackenzie, N., Knipe, S. (2006), “Research dilemmas: Paradigms, methods and methodology”, Issues in Educational Research, Vol. 16, No. 2, pp. 193-205.

[15] Malik, S. N. A. A., Musa, H., Ahmad, S., Mohamad, N. (2014), „The Factors influencing Supply Chain Disruptions on Supply Chain Performance in Small and Medium Enterprises”, Journal of Technology Management and Technopreneurship, Vol. 2, No. 2, pp. 1-9.

[16] Vasiliu, C., Dobrea, M. (2013), “State of implementation of Supply Chain Management in companies in Romania”, Amfiteatru Economic, Vol. XV(33), pp. 180-196.

[17] Bressan, A. “Environmental and Social Responsibility within SMEs: Managerial Perspectives from Western Sydney”, Australia, PhD Thesis, 2014.

[18] Truong, H. Q., Sameiro, M., Fernandes, A. C., Sampaio, P., Duong, B. A. T., Duong, H. H., and Vilhenac, E. “Supply chain management practices and firms’ operational performance”, International Journal of Quality & Reliability Management, 34(2): 176-193, 2017.

[19] Meehan, J., & Muir, L. (2008). SCM in Merseyside SMEs: benefits and barriers. *The Tqm Journal*, *20*, 223-232.

[20] Narkhede, G., Chinchanikar, S., Narkhede, R., & Chaudhari, T. (2024). Role of Industry 5.0 for driving sustainability in the manufacturing sector: an emerging research agenda. *Journal of Strategy and Management*.

[21] B, G. N., & Rajhans, N. R. (2021). Optimizing Inventory Carrying Cost Using Rank Order Clustering Approach for Small and Medium Enterprises (SMES). *Journal of the University of Shanghai for Science and Technology*, *23*.

[22] Mackenzie, N., and Knipe, S. “Research dilemmas: Paradigms, methods and methodology”, Issues in Educational Research, 16(2): 193-205, 2006.

[23] Fung, R. Y. K., Morton, B., and Chong, S. “Environmental Sustainability in Supply Chain Management”, In: Hayhurst D. R. et al. (eds) Proceedings of the 33rd International MATADOR Conference. Springer, London, 2000.

[24] Cohen J., Cohen P., West S. G., and Aiken L. S. “Applied multiple regression/correlation analysis for the behavioral sciences”, London, Routledge, 2013.

[25] Jharkharia, S. and Shankar, R. (2005), “IT-enablement of supply chains: understanding thebarriers”, The Journal of Enterprise Information Management, Vol. 18 No. 1, pp. 285-309.

[26] Ryu, K. and Yucesan, E. (2010), “A fuzzy newsvendor approach to supply chain coordination”, European Journal of Operational Research, Vol. 200 No. 2, pp. 421-36.

[27] Soroor, J., Tarokh, M. J. and Shemshadi, A. (2009), “Theoretical and practical study of supplychain coordination”, Journal of Business & Industrial Marketing, Vol. 24 No. 2, pp. 131-42.

[28] S. Sharma, R. Chaurasiya, R. Mohite, and S. Akre, “Inventory woes and logistic bottlenecks: operational challenges in the SCM of the Indian defense sector”, Defense and Security Studies, vol. 6, no. 1, pp. 39–48, May 2025. https://doi.org/10.37868/dss.v6.id284