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Original Article

Development of an Empirically Data-Based Supply Chain Management Framework for New Age Delivery Systems of Micro, Small, and Medium Scale Enterprises

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Abstract *- Indian MSMEs are struggling with a real problem: how to manage their supply chains effectively in today's digital economy. Today, e-commerce has completely taken over business activities, where delivering products to customers' doorsteps has become the norm. In the backdrop of the above, this investigation was carried out to delineate the critical factors that govern supply chain management in MSMEs. This data was collected from a total of 110 MSMEs of the Nagpur region, and the collected data was subjected to statistical analysis and principal factor analysis. The results of factor analysis revealed five clear patterns or factors, which explained about 60% of the variation in the data. Based on the results, five factors were identified: (1) The role of human resources in supply chain success, (2) Infrastructure and inventory management, (3) The impact of information technology, (4) Customer and supplier relationship management, and (5) Supplier selection strategies and performance benchmarking. The findings of this study provide helpful guidance for MSME owners of the Nagpur region, government policymakers, and logistics providers who want to improve their competitive position and achieve sustainable growth.*

Keywords *- Supply chain management, MSME, Manufacturing sector, Empirical framework, Operational performance, Digital economy, Vidarbha region.*

1. Introduction

Over the past few years, supply chain activities in India have been going through a noticeable shift. A significant reason for this change is the fast spread of e-commerce, digital service platforms, and new forms of last-mile delivery systems. These changes have helped customers get quicker and more convenient services, but for many Micro, Small, and Medium Enterprises (MSMEs), the situation has become more challenging as well as demanding. This is because, to date, most of the MSMEs follow the conventional supply chain routines for material sourcing, storage, and distribution. Though these approaches worked well earlier, in the present fast-paced market, they often become sluggish in operations, resulting in increased costs. Moreover, due to high expectations of the customers and the expectation of quicker response, the pressure on MSMEs to redesign their supply chain processes has become much stronger (Dey et al., 2021).

In the backdrop of the above situation, there is an urgent need for developing a supply chain framework that is based on data and reflects the real working conditions of MSMEs (Kamboj and Rana, 2023). Hence, instead of models that are specifically built for large companies, MSMEs require something pragmatic that relies on real-life data (Fauzi and Sheng, 2022). To achieve this, the present investigation was carried out to address that gap by examining information collected from people working in the MSMEs that was subsequently used to develop the SCM framework. Basically, the purpose of this exercise was not only academic; the intention is also to provide insights that policymakers, logistics partners, and MSME owners can use while making practical decisions.

The rapid spread of online marketplaces and new methods of reaching customers has changed the way products move across the country (Ba and Rahman, 2023). While this has opened new opportunities, it has also highlighted the fact that MSMEs—despite contributing nearly one-third of the national GDP and employing over 110 million people—often operate with outdated or rigid supply chain systems (Jayaram et al., 2014). These systems are not always suitable for a market that demands quicker,

cheaper, and more flexible delivery options (Bhatti et al., 2025).

Although India has adopted digital technologies relatively at a larger scale, the benefits of modern-day supply chain technologies have not reached the MSMEs. Still, many units struggle with a shortage of skilled staff, limited information systems, and weak infrastructure (Rao et al., 2023). As a result, common challenges, such as regular delays, high transportation costs, and coordination problems with suppliers and customers, continue to affect them.

Moreover, the existing SCM models are often not compatible with MSMEs' day-to-day operations, especially when they are forced to deal with new-age delivery platforms and shifting customer expectations. Hence, to remain competitive, MSMEs need more responsive and data-supported supply chain strategies (Saad et al., 2025). Considering this aspect, this investigation explores the main elements that shape supply chain performance in manufacturing MSMEs (Dey et al., 2024).

1.1. Research Gap

Most of the SCM frameworks have been developed with larger firms in mind, which means they do not fully capture the day-to-day constraints under which MSMEs operate. Smaller firms usually work with limited funds, fewer people, and basic systems, and these realities rarely appear in mainstream SCM models. Second, many studies discuss digital technologies, but very few link them specifically to new-age delivery systems such as app-based logistics, real-time tracking, or multi-channel order fulfilment.

1.2. Problem Statement

Given these gaps, MSMEs require an SCM framework that is not borrowed from large-firm models but reflects their own practical situations.

1.2.1. Novelty and Contribution

This study adds to the existing SCM literature in several ways:

The study uses factor analysis to identify the major SCM dimensions that influence operational outcomes in MSMEs and develops the first empirically tested SCM framework that is designed explicitly for MSMEs working with new-age delivery mechanisms in the Nagpur region of India.

Hence, the insights generated from this study will be helpful for policymakers, logistics service providers, and MSME managers of the Nagpur region who aim to strengthen competitiveness in a digital environment. Overall, this study tries to fill an important academic and practical gap by offering a supply chain framework that is both empirically validated and suited to the transition happening within Indian MSMEs.

2. Materials and Methods

This study followed a quantitative approach to build a Supply Chain Management framework that reflects the real working conditions of MSMEs involved in new-age delivery systems.

2.1. Sampling Strategy

The study focused on manufacturing-based Micro, Small, and Medium Enterprises located in the Nagpur region of central India. This region has a large number of MSMEs that depend heavily on supply chain activities such as sourcing, production, transport, and warehousing, so it served as a suitable setting for the research. A purposive sampling method was used so that only those firms directly handling supply chain operations were included.

Although factor-analytic studies usually prefer a larger sample size—roughly 5 to 10 responses per survey item—the realities of MSME research often make this difficult. The questionnaire had 41 items, which ideally requires more than 200 responses, but many earlier SCM studies in similar resource-limited settings have worked with 50–90 respondents. In this study, 110 usable responses were gathered, which is above the typical MSME benchmark and also meets the minimum requirement for factor analysis, which satisfied the minimum adequacy criteria (KMO > 0.7).

2.2. Instrument Design

A structured questionnaire was prepared after reviewing recognised SCM models and previous studies in the field. The items used a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The instrument was designed to capture five broad supply chain dimensions:

- Workforce and human resource capabilities
- Infrastructure and inventory readiness
- Information technology integration
- Customer and supplier relationships
- Supplier base optimisation

2.3. Data Collection Procedure

All the necessary data were collected mainly through personal visits to the selected MSMEs. The feedback was provided by respondents, including supervisors, managers, and supply chain staff who had direct experience with day-to-day operations. Filled questionnaires were checked manually to ensure consistency. The responses were subjected to statistical analysis using SPSS 24.0 software.

2.4. Reliability and Validity Analysis

The internal consistency of the questionnaire was confirmed by a Cronbach's alpha value of 0.937. At the same time, the adequacy of the sample was ensured by a 0.745 value of the Kaiser–Meyer–Olkin (KMO) measure. Bartlett's Test of Sphericity was also significant ($p<0.001$), confirming that there were enough correlations among variables to proceed with dimensional reduction.

2.5. Factor Analytic Approach

Factor Analysis was carried out to identify the major SCM-related dimensions that influence MSME operations. The Varimax rotation technique was used so that the extracted factors were easier to interpret. Based on the Scree plot and variance explained, five factors were extracted, which together accounted for a little over 60% of the total variation in the data. These five components formed the foundation of the proposed SCM framework for MSMEs.

2.6. Ethical Considerations

Participation in the study was voluntary, and all respondents were informed about the purpose of the research. No names, personal identifiers, or sensitive business information were collected.

3. Results and Discussion

This section presents the study's empirical findings.

3.1. Initial Data Screening

The 110 questionnaires that were received were checked one by one to ensure they were correctly filled out. I looked for issues like unanswered items, repeated marking, or any pattern that suggested the respondent rushed through the survey. Fortunately, none of the forms showed such problems, so all responses were kept for analysis. After this basic screening, the information was entered into SPSS, and separate editable files were maintained so that the process could be rechecked later if needed.

3.2. Preliminary Data Quality Assessment

To get an initial idea of how respondents perceived different SCM practices, simple descriptive statistics were calculated. The mean values showed that vertical integration had the lowest average score (3.90), while improved sales performance had the highest (4.16). Since most of the items recorded mean values above 3, it indicated that, overall, the respondents viewed supply chain activities in a positive light. The standard deviation values were also within a normal range, which suggested that the responses were pretty consistent across the sample.

3.3. Reliability Analysis

Internal consistency was tested using Cronbach's alpha. The results are presented in Table 1.

Table 1. Reliability analysis - scale (Alpha)

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
.937	.939	41

3.4. Validity Assessment

Sampling adequacy was confirmed using the Kaiser–Meyer–Olkin (KMO) test, while inter-item correlation suitability was verified with Bartlett's Test of Sphericity. Results are provided in Table 2.

Table 2. KMO and bartlett's test results

Measure	Value
KMO Measure of Sampling Adequacy	0.745
Bartlett's Test of Sphericity (Approx. Chi-Square)	Significant at $p < 0.001$

The KMO value (>0.7) and significant Bartlett's test confirm the suitability of the dataset for factor analysis.

3.5. Factor Extraction (Eigenvalues and Variance Explained)

Principal Component Analysis (PCA) was conducted using Varimax rotation. The first five factors had eigenvalues greater than 1 and collectively explained more than 60% of the cumulative variance. This aligns with recommended SCM dimensionality thresholds in empirical research.

Table 3. Total variance explained

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	10.27	31.12	31.12	10.27	31.12	31.12	4.65	14.08	14.08
2	2.91	8.82	39.94	2.91	8.82	39.94	3.97	12.04	26.12
3	2.43	7.36	47.29	2.43	7.36	47.29	3.93	11.91	38.03
4	2.37	7.18	54.47	2.37	7.18	54.47	3.75	11.37	49.40
5	1.83	5.54	60.01	1.83	5.54	60.01	3.50	10.62	60.01
6	1.75	5.29	65.30						
7	1.47	4.45	69.75						
8	1.16	3.53	73.28						
9	1.15	3.48	76.76						
10	1.05	3.17	79.92						

11	0.78	2.36	82.28						
12	0.72	2.17	84.45						
13	0.66	2.00	86.45						
14	0.64	1.94	88.40						
15	0.49	1.49	89.89						
16	0.46	1.39	91.28						
17	0.39	1.19	92.48						
18	0.35	1.06	93.54						
19	0.31	0.94	94.48						
20	0.29	0.88	95.35						
21	0.26	0.78	96.13						
22	0.23	0.70	96.83						
23	0.21	0.64	97.47						
24	0.17	0.52	97.99						
25	0.15	0.46	98.45						
26	0.14	0.41	98.86						
27	0.08	0.25	99.11						
28	0.07	0.20	99.32						
29	0.06	0.19	99.50						
30	0.05	0.17	99.67						
31	0.05	0.15	99.82						
32	0.04	0.12	99.94						
33	0.02	0.06	100.00						

3.6. Rotated Component Matrix

To enhance interpretability, Varimax rotation was applied. A simplified and readable version of the rotated loadings is provided in the Table.

Table 4. Rotated component matrix

	Component									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Subcontracting	.885									
Recognition of good work through incentives	.878									
Enterprise Resource Planning	.836									
Employee's ability to change	.590									
e-procurement to save time	.555									
Holding safety stock		.902								
Smooth integration of the new system with the existing system		.900								
State-of-the-art warehouse		.881								
Online monitoring of stock			.787							
Radio Frequency Identification			.762							
Better quantity and on-time information			.737							

Better quality of information			.549							
Customer Relationship Management				.839						
Decision support/expert system				.833						
Supplier Relationships Management				.598						
Vertical integration				.545						
Optimum number of suppliers					.810					
Outsourcing supplies					.796					
Supply chain benchmarking					.557					
Commitment of Employees					.425					
Manufacturing Resources Planning						.746				
Superior working conditions						.648				
Clear logistic plan (SOP)						.599				
Independent logistic department						.577				
Material Requirements Planning						.406				
Electronic Data Interchange							.836			
Skills, Computer literacy within the company							.799			
Just-in-time supply								.814		
Strategic planning								.810		
Advanced Planning System									.862	
Warehouse Management System									.763	
Third Party Logistics										.702
Bar coding										.696
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.										
a. Rotation converged in 13 iterations.										

3.7. Naming and Interpretation of Factors

The five extracted factors were interpreted based on the thematic similarity of highly loaded variables:

1. Human Resource Capability in SCM
2. SCM Infrastructure and Inventory Readiness
3. Role of Information Technology in SCM
4. Customer and Supplier Relationship Management
5. Supplier Base Optimisation and Benchmarking

These reflect a multi-dimensional structure of SCM performance within MSMEs.

3.8. Discussion of Findings

The overall results show that the role of human resources stands out as the strongest factor influencing supply chain performance in MSMEs. Most small firms still depend heavily on the skills and adaptability of their

workforce because they cannot automate processes at the same level as large companies. This observation is broadly in line with earlier studies that emphasised how employee competence supports quick decision-making and flexibility in smaller organisations.

The second major factor relates to infrastructure and inventory readiness. Many MSMEs struggle with storage limitations, manual record-keeping, and the absence of proper systems to track stock movement. When such gaps are present, daily operations slow down, and errors increase, making it harder for firms to meet delivery expectations.

Technology use forms the third important factor. Tools such as real-time tracking, basic data analytics, RFID tags, and online stock monitoring are slowly becoming unavoidable, especially for businesses working with new-age delivery platforms. The findings suggest that MSMEs that adopt these technologies tend to handle uncertainty better and respond faster to customer needs.

The fourth and fifth factors highlight the importance of relationship management and supplier optimisation. Strong coordination with customers and suppliers helps firms reduce delays and maintain reliable operations. Similarly, managing the number of suppliers, using benchmarking practices, and choosing the right partners help MSMEs keep sourcing costs under control.

Put together, these five factors give a clearer picture of how supply chains in MSMEs actually function in the present digital environment. They also point to areas where small firms can improve if they want to stay competitive in a market that is rapidly shifting towards technology-enabled logistics.

3.9. Factor Naming

Factor naming was carried out after reviewing the items that showed the highest loadings under each component. Usually, three or four items that strongly relate to a single theme are examined together to understand what each factor represents. A straightforward and meaningful name was chosen so that the reader can easily understand the underlying dimension. The naming process involved a mix of statistical interpretation and subjective judgment.

Based on this assessment, the perception of the manufacturing firms regarding SCM arrangements could be grouped under five key areas.

Table 5. Description of factors

Factors	Factor's Name	Loading Variables
Factor 1	Importance of human resources in SCM	• Subcontracting • Recognition of good work through incentives • Enterprise Resource Planning • Employee's ability to change • e-procurement to save time
Factor 2	SCM-related infrastructure and inventory	• Holding safety stock • Smooth integration of the new system with the existing system • State-of-the-art warehouse
Factor 3	Role of information technology in SCM	• Online monitoring of stock • Radio Frequency Identification • Better quantity and on-time information • Better quality of information
Factor 4	Customer and supplier relationship management	• Customer Relationship Management • Decision support/expert system • Supplier Relationships Management • Vertical integration
Factor 5	Supplier number and supplier benchmarking	• Optimum number of suppliers • Outsourcing supplies • Supply chain benchmarking • Commitment of Employees

- Factor 1 was named "Importance of Human Resources in SCM", which highlights the role of human resources and related activities in improving the operational effectiveness of an enterprise.
- Factor 2 was named "SCM Related Infrastructure and Inventory". It represents the infrastructure and inventory-related aspect of SCM for improving the operational effectiveness of an enterprise.

- Factor 3 was named "Role of Information Technology in SCM". It emphasizes the higher use of information technology-assisted tools for improving the operational effectiveness of an enterprise.
- Factor 4 was named "Customer and Supplier Relationship Management". It represents the importance of managing cordial/healthy relations with suppliers and customers for improving the operational effectiveness of an enterprise.
- Factor 5 was named "Supplier Number and Supplier Benchmarking". It represents the importance of an optimum number of suppliers and their benchmarking using various parameters for improving the operational effectiveness of an enterprise.

4. Conclusion

This study tried to understand how supply chain practices actually work inside India's manufacturing MSMEs, especially at a time when delivery systems and customer expectations are changing quickly. Based on the responses collected from 110 MSMEs, five major areas were identified as influencing SCM in MSMEs. These included the role of people and workforce skills, the condition of infrastructure and inventory systems, the extent to which technology is used in day-to-day operations, the quality of relationships with customers and suppliers, and how effectively suppliers are selected and managed.

The findings also show that MSMEs function in a very resource-limited environment, and therefore, their supply chains behave differently from those of large firms. This makes the present framework useful because it is based on actual data from MSMEs, rather than assumptions from big-industry models. The study offers a clearer picture of the areas where MSMEs need support—better training, modern storage facilities, simple digital tools, and stronger partnerships across the chain.

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Appendix 1. Total Variance Explained

Component	Initial Eigenvalue	% of variance	Cumulative %	Extraction SS Loadings (Eigenvalue)	% of variance	Cumulative %
1	12.163	29.667	29.667	12.163	29.667	29.667
2	5.244	12.787	42.454	5.244	12.787	42.454
3	3.667	8.993	51.447	3.667	8.993	51.447
4	2.917	7.116	58.563	2.917	7.116	58.563
5	2.199	5.365	63.928	2.199	5.365	63.928
6–41	*(All eigenvalues <1, omitted as per PCA rule)*	—	—	—	—	—

Appendix 2. Full Rotated Component Matrix (Varimax Rotation)

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Subcontracting	0.885	—	—	—	—
Incentive Recognition	0.878	—	—	—	—
ERP Usage	0.836	—	—	—	—
Employee Adaptability	0.590	—	—	—	—
e-Procurement	0.555	—	—	—	—
Holding Safety Stock	—	0.902	—	—	—
System Integration	—	0.900	—	—	—
State-of-the-Art Warehouse	—	0.881	—	—	—
Online Stock Monitoring	—	—	0.787	—	—
RFID Usage	—	—	0.762	—	—

Timely Information	—	—	0.737	—	—
Information Quality	—	—	0.549	—	—
Customer Relationship Management	—	—	—	0.839	—
Decision Support System	—	—	—	0.833	—
Supplier Relationship Mgmt	—	—	—	0.598	—
Vertical Integration	—	—	—	0.545	—
Optimum Supplier Number	—	—	—	—	0.810
Supply Outsourcing	—	—	—	—	0.796
Benchmarking Practice	—	—	—	—	0.557
Employee Commitment	—	—	—	—	0.425