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Impact of Supply Chain Management Practices on Business Excellence: An AI-Enabled Future Roadmap for Mechanical Engineering Enterprises

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Abstract:

The purpose of this study is to examine the impact of Supply Chain Management (SCM) practices on Business Excellence in mechanical engineering enterprises and to propose an Artificial Intelligence (AI)-enabled future roadmap for sustaining excellence. The study is based on primary data collected from management and employees of mechanical engineering firms. Statistical tools such as descriptive statistics, correlation analysis, and Structural Equation Modeling (SEM) were used for data analysis. The results reveal a strong and significant relationship between SCM practices and Business Excellence. Further, the study integrates AI as a strategic enabler that can enhance decision-making, operational efficiency, supplier collaboration, and organizational performance. The paper concludes with managerial implications and future research directions emphasizing AI-driven excellence.

Keywords: Supply Chain Management, Business Excellence, Artificial Intelligence, Mechanical Engineering Enterprises,

Introduction:

In today's highly competitive and dynamic business environment, organizations are compelled to continuously improve their performance to achieve Business Excellence. Supply Chain Management (SCM) has emerged as a critical strategic tool for enhancing operational efficiency, customer satisfaction, and organizational competitiveness. Mechanical engineering enterprises, characterized by complex production systems and extensive supplier networks, heavily rely on effective SCM practices for sustainable growth.

With rapid advancements in digital technologies, particularly Artificial Intelligence (AI), traditional SCM practices are undergoing significant transformation. AI offers advanced capabilities such as predictive analytics, intelligent automation, and real-time decision support, which can further strengthen SCM practices and contribute to Business Excellence. Therefore, this study not only examines the impact of SCM practices on Business Excellence but also integrates AI as a future-oriented strategic enabler.

Review of Literature:

Supply Chain Management (SCM) has been widely recognized as a critical determinant of organizational performance and Business Excellence. Early studies emphasized SCM as the integration of key business processes from end users through original suppliers that provide products, services, and information adding value for customers and stakeholders (Mentzer et al., 2001). Effective SCM practices such as strategic supplier partnerships, customer relationship management, information sharing, and lean operations have been empirically linked with improved operational and financial performance.

Li et al. (2006) identified core SCM practices including strategic supplier partnership,

customer relationship, level of information sharing, quality of information sharing, and postponement, and demonstrated their positive impact on competitive advantage and organizational performance. Similarly, Flynn, Huo, and Zhao (2010) highlighted the importance of supply chain integration in achieving superior firm performance.

Business Excellence frameworks, such as the EFQM and Malcolm Baldrige models, emphasize leadership, strategy, people, processes, and results as key enablers of excellence. Studies by Oakland (2014) and Dahlgaard et al. (2013) established that process integration and continuous improvement are central to achieving sustainable excellence.

Recent research has increasingly focused on digital transformation and Industry 4.0 technologies in SCM. Artificial Intelligence (AI), machine learning, big data analytics, and Internet of Things (IoT) have been identified as transformative technologies capable of enhancing supply chain visibility, agility, and resilience (Wamba et al., 2017; Ivanov & Dolgui, 2020).

AI-enabled SCM allows organizations to shift from descriptive and diagnostic analytics to predictive and prescriptive decision-making. Studies by Choi, Wallace, and Wang (2018) and Min (2010) emphasized the role of AI in demand forecasting, inventory optimization, and risk management. However, despite growing conceptual discussions, empirical studies integrating SCM practices, Business Excellence, and AI—particularly in mechanical engineering and manufacturing enterprises—remain limited.

Therefore, the present study contributes to the literature by empirically examining the SCM–Business Excellence relationship and proposing an AI-enabled future roadmap to sustain excellence.

Objectives of the Study:

1. To analyze the SCM practices adopted by mechanical engineering enterprises
2. To examine the relationship between SCM practices and Business Excellence
3. To assess the impact of SCM practices on Business Excellence
4. To propose an AI-enabled future framework for enhancing Business Excellence

Research Methodology:

Sample Design and Research Methodology:

Research Design:

The present study adopts **a** descriptive and analytical research design**.** The research is descriptive in nature as it attempts to describe the existing Supply Chain Management (SCM) practices and their association with Business Excellence (BE) in medium and large-scale mechanical engineering enterprises. It is analytical because it empirically examines relationships among SCM constructs and Business Excellence using statistical tools.

Population of the Study:

The population of the study consists of employees working in medium and large-scale mechanical engineering enterprises located in Satara District, Maharashtra**.** These enterprises primarily belong to the mechanical, auto-ancillary, engineering, metallurgical, machinery, and allied manufacturing sectors.

The target population includes employees working in:

- Purchase and Materials Management
- Logistics and Supply Chain
- Production and Operations
- Quality Management
- Marketing
- Human Resource Management

Sampling Frame:

`The sampling frame was developed using records obtained from:

- District Industries Centre (DIC), Satara
- MIDC Offices
- Industrial Associations operating in Satara district

Based on these sources, 23 prominent Original Equipment Manufacturers (OEMs) operating in the mechanical engineering sector were identified for the study.

Data Collection Method:

Primary data were collected using a structured questionnaire designed specifically for employees. The questionnaire covered:

Demographic details:

- SCM practices (information management, supplier partnership, lean systems, benchmarking, etc.)
- Perceptions related to Business Excellence

The total sample size for the present study comprises **154 respondents,** consisting of **154 management-level respondents (n = 154)** and **400 employee-level respondents (n = 400)** drawn from selected medium and large-scale mechanical engineering enterprises in Satara district. The inclusion of both management and employee respondents was intentionally designed to capture **multi-level perspectives** on Supply Chain Management (SCM) practices and their influence on Business Excellence (BE)

Profile of Sample Enterprises:

Table 1: Company Profile of Sample Enterprises

Characteristics	Category	Management (n=154)	Employees (n=400)	Management (%)	Employees (%)
Tier in Supply Chain	First-tier suppliers	127	279	54.27	53.34
	Other-tier suppliers	107	244	45.72	46.65
Age of Firm	≤ 10 years	21	84	13.62	21.00
	> 10 years	133	316	86.38	79.00
ISO Certification	ISO Certified	154	327	100.00	81.75
	Planning for ISO	0	47	0.00	11.75
	Non-ISO	0	26	0.00	6.50

Table 2: Type of Ownership

Ownership Type	Management (%)	Employees (%)
Proprietorship	18.18	19.73
Partnership	0.00	2.86
Private Limited	50.00	48.56
Public Limited	31.82	28.83

Table 3: Nature of Enterprises

Nature	Management (%)	Employees (%)
Auto Ancillary	17.53	21.37
Engineering & Machine Tools	19.43	20.64
Metallurgical	13.27	11.72
Machinery	9.00	8.86
Mechanical	40.75	37.41

Table 4: Firm Size Based on Turnover

Turnover (INR Million)	Management (%)	Employees (%)
100–<250	13.64	16.31
250–<500	18.18	24.69
≥500	68.18	59.00

Correlation Analysis:

The correlation analysis reveals a strong and positive relationship among SCM dimensions such as corporate culture, customer relationship, facilities, information management, inventory management, lean systems, benchmarking, strategic planning, supplier partnership, and subcontracting. All correlations were found to be statistically significant ($p < 0.0001$), indicating the interdependence of SCM practices.

SCM Practices and Business Excellence:

Table 5: Correlation among SCM Constructs

(All correlations significant at $p < 0.0001$)

SCM Dimensions	Correlation with Business Excellence
Corporate Culture	0.734
Customer Relationship	0.785
Facilities	0.667
Information Management	0.704
Inventory Management	0.748
Lean System	0.724
SCM Benchmarking	0.733
Strategic Planning	0.689
Supplier Partnership	0.692
Subcontracting	0.658

The results indicate that all SCM dimensions have a significant positive relationship with Business Excellence. Customer relationship management and inventory management emerged as the strongest predictors of Business Excellence.

Structural Equation Modeling Results:

Table 6: Model Fit Indices (SEM)

Construct	CMIN/DF	GFI	CFI	SRMR
Corporate Culture	2.18	0.98	0.98	0.005
Customer Relationship	0.08	0.99	0.99	0.005
Facilities	0.86	0.99	1.00	0.007
Inventory Management	0.76	1.00	0.99	0.005
Supplier Partnership	2.14	0.99	0.97	0.000

Table 7: Structural Relationship

Path	Standardized Estimate	Result
SCM → Business Excellence	0.50	Significant ($p<0.001$)

The SEM results confirm that SCM practices have a significant direct effect on Business Excellence, validating the proposed research model.

Discussion of Findings:

The findings of the study are consistent with earlier research, confirming that effective SCM practices significantly enhance Business Excellence. Organizations that emphasize strategic planning, lean operations, supplier collaboration, and information integration achieve superior performance. The strong correlation among SCM dimensions highlights the need for an integrated supply chain approach rather than isolated practices.

Integration of Artificial Intelligence for Business Excellence:

Future Roadmap:

The empirical findings of the study establish SCM practices as key drivers of Business Excellence. However, in an era of Industry 4.0 and digital transformation, the integration of Artificial Intelligence (AI) can further amplify the effectiveness of SCM practices.

AI in Strategic Planning and Forecasting:

AI-driven predictive analytics can assist organizations in demand forecasting, capacity planning, and risk assessment, enabling proactive and data-driven strategic decisions.

AI-Enabled Inventory and Operations Management:

Machine learning algorithms can optimize inventory levels, reduce waste, and improve production scheduling, thereby supporting lean and operational excellence.

AI for Supplier Relationship and Risk Management:

AI tools can evaluate supplier performance, predict disruptions, and enhance collaboration, strengthening strategic supplier partnerships.

AI in Information Management and Benchmarking:

AI-enabled dashboards and intelligent systems can provide real-time visibility across the supply chain and support continuous benchmarking against best-in-class performance.

AI-Driven Business Excellence Framework:

In the proposed framework, SCM practices serve as foundational capabilities, AI acts as a strategic enabler, and Business Excellence emerges as a sustained outcome. This integration enhances agility, resilience, and competitiveness.

Managerial Implications:

Managers should focus on integrating AI technologies with existing SCM practices by investing in digital infrastructure, skill development, and analytics capabilities. Aligning AI initiatives with organizational strategy will enable enterprises to achieve sustainable Business Excellence.

Conclusion:

The study concludes that SCM practices play a vital role in achieving Business Excellence in mechanical engineering enterprises. The integration of Artificial Intelligence provides a powerful future pathway for enhancing SCM effectiveness and sustaining excellence. Organizations adopting AI-enabled SCM practices are likely to gain significant competitive advantages.

Future Research Directions:

Future studies may explore longitudinal analysis, cross-industry comparisons, and empirical testing of AI-enabled SCM frameworks using advanced analytics.

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