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Exploring Industry 4.0 Adoption in Indian Manufacturing: A Bibliometric Review

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Abstract: *This study conducts a bibliometric review of Industry 4.0 (I4.0) research in the Indian manufacturing sector from 2019 to August 2025 to synthesize fragmented evidence and identify thematic trends. Using Scopus data and analysis through Biblioshiny (R), sixty empirical papers were examined. The results show a 36.6% annual growth rate and strong international collaboration, reflecting the field's rapid development. Six key thematic clusters emerged: strategic modeling, sustainability, quality and performance, enabling technologies, empirical validation, and methodological approaches. The findings indicate that I4.0 adoption in India is primarily driven by leadership commitment, policy support, and technological readiness, while constrained by skill shortages, financial limitations, and infrastructural gaps. The study enhances understanding of how digital transformation contributes to sustainable industrial growth and provides practical insights for managers and policymakers to advance India's Industry 4.0 agenda.*

Introduction

The Fourth Industrial Revolution (Industry 4.0 or I4.0), characterized by the convergence of digital, physical, and biological systems, is reshaping global production and value chains (Kumar et al., 2020). Built on technologies such as the Industrial Internet of Things (IIoT), Artificial Intelligence (AI), Big Data Analytics (BDA), and Cyber-Physical Systems (CPS), I4.0 promises unprecedented levels of efficiency and mass customization (Jain & Ajmera, 2022; Prajapati et al., 2024). For emerging economies like India, I4.0 adoption is both a technological leap and a strategic imperative. It aligns with national programs such as *Make in India* and *Digital India*, enabling competitiveness, productivity, and high-skill employment (Sharma et al., 2024). Yet, India's heterogeneous SME ecosystem, infrastructural limitations, and human-capital challenges complicate large-scale transformation (Borana et al., 2024).

Problem Statement: While theoretical discussions on I4.0 are abundant, empirical validation within India's contextual realities is limited. Existing studies remain fragmented across journals and disciplines. This review consolidates those insights to provide an evidence-based synthesis of validated drivers, barriers, and outcomes.

Research Objectives

- Identify empirically validated drivers and enablers influencing I4.0 adoption.
- Examine barriers and challenges hindering implementation.
- Assess performance and sustainability outcomes linked to adoption.

Literature Review and Thematic Discussion

The empirical scholarship on Industry 4.0 (I4.0) in the Indian manufacturing sector has evolved from conceptual awareness to applied, data-driven inquiry. Early works emphasized defining the concept, while recent studies employ analytical frameworks such as Structural Equation Modeling (SEM), DEMATEL/ISM, and Best-Worst Method (BWM) to quantify adoption determinants and outcomes (Kumar et al., 2020; Joshi et al., 2024; Sharma et al., 2024). Overall, the literature reflects three converging discussions organizational enablers, implementation challenges, and performance transformation each situated within India's socio-technical realities.

- **Evolving Understanding of Drivers and Enablers**

Empirical evidence consistently emphasizes that successful I4.0 adoption is strategy-driven rather than technology-driven. Leadership commitment, resource allocation, and managerial vision appear as recurring enablers across sectors (Jain & Ajmera, 2022; Krishnan et al., 2021). Over time, the debate has shifted from *whether* top management support matters to *how* it interacts with organizational learning, decision-making quality, and innovation culture.

Parallel to internal leadership, institutional and policy support is seen as the external scaffolding of I4.0 diffusion. National initiatives such as *Make in India* and *Digital India* have created enabling conditions through policy clarity, incentives, and public–private collaborations (Luthra et al., 2019; Pandey & Khurana, 2024). Recent studies stress that ecosystem readiness linking industry, academia, and government determines the depth of technological absorption (Pasi et al., 2022). The literature implies that India's I4.0 trajectory is most effective when internal strategic intent aligns with external policy momentum, highlighting a *dual-engine model* of transformation.

- **Persistent Barriers and Contextual Constraints**

Despite policy momentum, the transition remains uneven. Studies converge on three structural barriers: human-capital limitations, financial constraints, and infrastructural gaps (Borana et al., 2024; Kumar et al., 2022). The human-resource challenge has evolved from a shortage of digital skills to a broader issue of change management and workforce adaptability. Empirical HRM analyses show that resistance to automation, fear of job loss, and limited digital literacy slow adoption (James et al., 2022). Financial barriers, especially for SMEs, persist as *high-impact causal factors* in DEMATEL and ISM models where high upfront investment and uncertain ROI discourage long-term digital planning. Meanwhile, infrastructural weaknesses such as inconsistent power supply and internet connectivity continue to restrict small firms' participation in the digital ecosystem (Joshi et al., 2024). These recurring barriers underline that India's challenge is not technological feasibility but *institutional inclusivity* ensuring that smaller, resource-constrained firms are not excluded from the digital transformation wave.

- **From Efficiency to Sustainability: Shifting Performance Narratives**

A clear evolution is visible in how performance outcomes are framed. Earlier studies associated I4.0 with operational efficiency and productivity, while recent empirical works link it directly to sustainability and resilience. Integration with Circular Economy (CE) principles now dominates the discourse, confirming that I4.0 technologies enhance *eco-innovation* and *resource circularity* (Kamble & Gunasekaran, 2021; Sahoo & Jakhar, 2024). Quantitative evidence shows that combining digital tools with Quality Management Practices (QMP) improves both operational performance and agility (Pandey et al., 2025; Prajapati et al., 2024). Furthermore, Dynamic Capability (DC) and Business Model Innovation (BMI) frameworks explain how digitalization enables firms to adapt strategically while aligning with *Sustainable Development Goal 12 (SDG 12)* (Krishnan et al., 2025; Sharma et al., 2024). The literature signals a paradigmatic shift from viewing I4.0 as a cost-efficiency mechanism to positioning it as a driver of sustainable competitiveness, integrating environmental, social, and economic objectives. Across studies, two broader research gaps remain evident. First, most evidence is cross-sectional, limiting understanding of long-term transformation patterns. Second, the sectoral diversity of Indian manufacturing ranging from high-tech automotive to resource-intensive MSMEs remains underexplored in empirical depth. Consequently, there is scope for

longitudinal, multi-sectoral studies that validate causal mechanisms between adoption maturity, innovation capability, and sustainability performance. Although research on Industry 4.0 in India has expanded in recent years, it remains largely fragmented across disciplines and sectors. Most studies focus on individual factors such as adoption drivers, barriers, or performance outcomes without integrating them into a cohesive empirical narrative. Additionally, much of the existing evidence is conceptual or limited to small, sector-specific samples, offering little generalizable insight into the broader industrial landscape.

This study seeks to bridge these gaps by consolidating empirical findings published between 2019 and August, 2025, providing a structured synthesis of how Indian manufacturing firms are adopting Industry 4.0 technologies, the challenges they encounter, and the sustainability-oriented outcomes achieved. In doing so, it contributes to a clearer understanding of the evolving empirical landscape of Industry 4.0 in India.

Methodology

This paper adopts a bibliometric review methodology to ensure a comprehensive, rigorous, and reproducible analysis of the empirical landscape of Industry 4.0 (I4.0) in Indian manufacturing. The methodology, outlined below, follows the standard phases of identification, screening, eligibility, and inclusion, primarily referencing the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher et al. 2009) guidelines to document the review process transparently, shown in Table1.

- **Data Source and Search Strategy**

The foundational literature search was conducted using the Scopus database, renowned for its broad coverage of high-quality, peer-reviewed journals in business, engineering, and technology management. The definitive search query, TITLE-ABS-KEY ("Industry 4.0" AND "India" AND "Manufacturing") was formulated to capture the convergence of the core research focus. The raw search results were initially constrained by the following filters within the Scopus platform: English language, Article document type, and the primary subject area of Business, Management and Accounting. This initial step yielded a total of 67 records related to the topic.

- **Screening and Eligibility**

Following the initial identification, the collected dataset was managed and processed using Microsoft Excel for preliminary analysis and cleaning. Further systematic refinement was carried out to ensure the remaining literature met the stringent focus of this review, resulting in the following stages:

  - **Contextual Filtering:** Papers whose primary focus within India only those were included.
  - **Methodological Filtering (Inclusion Criterion):** To ensure a focus on *validated* strategic guidance, the core inclusion criterion was that the paper must be empirical meaning it relies on primary data collection (e.g., surveys, interviews, case studies).

Through this comprehensive screening process, the initial 67 records were narrowed down, resulting in a total of 60 articles deemed eligible for the qualitative synthesis phase of this review. This final set of 60 articles represents the core empirical landscape of I4.0 in Indian manufacturing.

- **Data Analysis and Synthesis**

The final corpus of 60 empirical papers was subjected to in-depth study using Bibliometric Analysis, The metadata of the collected papers were imported into the R environment and analyzed using the biblioshiny package given by Aria, M., & Cuccurullo, C. (2017). This tool facilitated descriptive analysis, identifying key authors, source journals, co-citation networks, and temporal trends in the research. Including thisThe abstracts and full texts (where necessary for complex methodologies) of the 60 included papers were analyzed using a thematic approach. This focused on extracting and categorizing the validated empirical variables into three main themes corresponding to the research questions: (1) Drivers and Enablers, (2) Barriers and Challenges, and (3) Sustainability and Performance Outcomes. This thematic synthesis forms the basis of the discussion presented in Section 4.

Table 1: Summary of PRISMA Screening Steps (2019–2025)

Stage	Process	Records
I. Identification	Articles identified via Scopus database search: TITLE-ABS-KEY ("Industry 4.0" AND "India" AND "Manufacturing")	**N = 67**
II. Screening	Records screened by title and abstract, including initial filtering by language, document type, and subject area.	

Exclusions	Records excluded based on screening (Total Excluded: 7):	**N = 7**
	- Removed for Contextual Misfit (e.g., non-Indian focus, non-manufacturing sector)	4
	- Removed for Methodological Misfit (e.g., purely conceptual, systematic review, or bibliometric focus)	3
III. Eligibility	Full-text articles assessed for methodological rigor and strict inclusion criteria (Empirical focus).	
IV. Inclusion	Articles deemed eligible and included for qualitative and bibliometric synthesis.	**N = 60**

Source: Author's compilation based on Scopus database search results (August 2025).

Results and Findings

The systematic review of the 60 empirical articles provides robust evidence regarding the thematic and quantitative characteristics of I4.0 research focusing on Indian manufacturing. This section first presents the bibliometric overview of the field and then synthesizes the core empirical evidence, categorized into the primary themes of drivers, barriers, and sustainability outcomes.

- **Bibliometric Overview**

The analysis of the metadata (Timespan: 2019– August, 2025) confirms that I4.0 research in the Indian manufacturing context is a nascent but highly dynamic and influential field as shown in Table 2. There were no studies before 2019.

- **Temporal Trends and Research Growth**

The field is characterized by an Annual Growth Rate of 36.61%, signaling a period of aggressive scholarly momentum since 2019. The rapid expansion highlights a direct correlation between the 'Make in India' and 'Digital India' initiatives and the subsequent academic investigation into the efficacy of I4.0 technologies at the firm level.

Table 2: Descriptive summary of bibliometric dataset (2019–2025)

Description	Result
Timespan	2019 to August, 2025
Sources (journals etc.)	34
Documents	60
Annual growth rate	36.61 %
Average citations per doc	41.43
References analyzed	508
Co-authors per document	3.55
International co-authorship	50 %

Source: Author's computation from Biblioshiny

- **Influence and Collaboration**

The average influence of the included studies is high, evidenced by an Average Citations per Document of 41.43. Collaboration is a defining feature of the field, marked by a high average team size and significant International Co-authorship (50%).

Table 3. Most Relevant authors (2019–2025)

Author	Articles
Kumar R	6
Kumar A	5
Kumar S	5
Kumar V	5
Kamble S.S.	4
Prashar A	4
Tortorella G.L.	4
Ajmera P	3
Garza-Reyes J.A.	3
Jain V	3

Source: Author's computation from Biblioshiny

- **Most Relevant Authors**

As shown in Table 3, the most relevant authors contributing to empirical research on Industry 4.0 adoption in Indian manufacturing include Kumar R (6 articles), who focuses on the application of I4.0 technologies in SMEs and uses Interpretive Structural Modeling (ISM) to analyze adoption barriers. The three authors with five articles Kumar V, Kumar S, and Kumar A, examine I4.0 adoption through complementary approaches: Kumar V applies graph-theoretic and SAP-LAP models to assess organizational factors; Kumar S develops frameworks for manufacturing transformation, including the Indian sports goods sector; and Kumar A studies I4.0-related risks, innovation, and circular-economy integration. Authors with four papers, Prashar A, Tortorella G.L., and Kamble S.S., explore quality management, organizational culture, and performance-measurement systems for I4.0-enabled sustainable manufacturing. Finally, Jain V, Sharma M, and Garza-Reyes J.A. (three articles each) focus on modeling I4.0 enablers and barriers through fuzzy TISM and MICMAC, emphasizing frameworks and success factors for Quality 4.0 and sustainable industrial transitions.

- **Key Publishing Outlets**

The 60 articles are disseminated across 34 sources, reinforcing the interdisciplinary nature of the research. Key outlets include high-impact journals in sustainability (*Journal of Cleaner Production*, *Business Strategy and the Environment*) and operational management (*TQM Journal*, *Production Planning and Control*).

- **Cluster-wise Co-Occurrence Analysis**

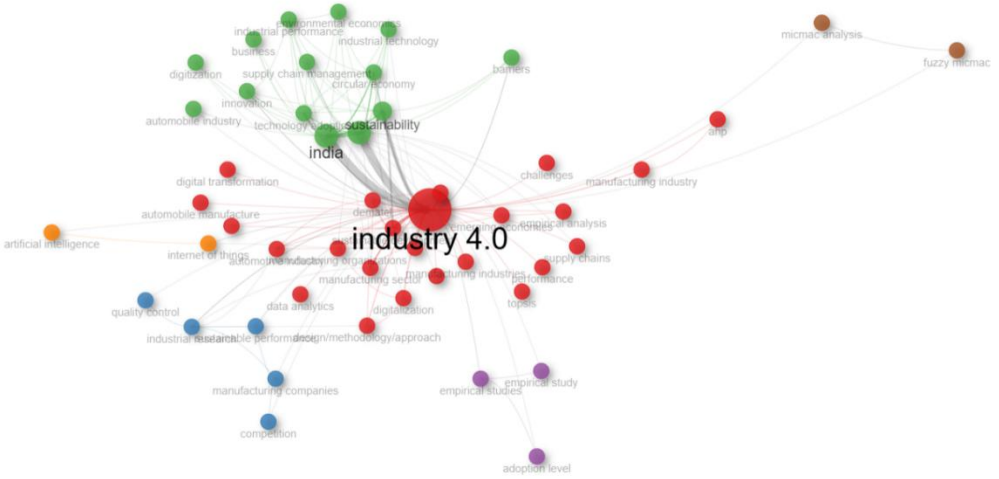
The co-occurrence network (Figure 1) identifies six interlinked thematic clusters that define the intellectual structure of Industry 4.0 (I4.0) research in Indian manufacturing. Each cluster reflects a distinct focus area ranging from strategic modeling to sustainability and technology adoption derived using *Betweenness Centrality*, *Closeness*, and *PageRank* metrics (Table 4).

Table 4: Cluster-wise Summary of Co-Occurrence Network

Cluster / Theme	Representative Keywords	Top Nodes (Betweenness / PageRank)	Interpretation Focus
1 – Strategic Modeling and SMEs	Industry 4.0, sustainable development, decision making, SMEs, DEMATEL, AHP	Industry 4.0 (982.7 / 0.22); Sustainable development (6.9 / 0.037)	Central cluster emphasizing strategic and managerial modeling for I4.0 adoption in SMEs.
2 – Quality 4.0 and Operational Performance	Industrial research, manufacturing companies, quality control, sustainable performance	Industrial research (3.17 / 0.021)	Focus on operational excellence and process improvement through digital quality management.
3 – Sustainability and Circular Economy	India, manufacturing, sustainability, circular economy, innovation, barriers	India (44.6 / 0.079); Manufacturing (29.5 / 0.074)	Largest and policy-aligned cluster linking I4.0 with CE and sustainable development goals.
4 – Empirical and Adoption Studies	Empirical studies, adoption level, empirical analysis	Empirical studies (0.5 / 0.014)	Reflects increasing methodological rigor and quantitative validation of adoption maturity.
5 – Enabling Digital Technologies	Internet of Things, Artificial Intelligence	IoT (0.33 / 0.012)	Highlights IoT and AI as emerging enablers of real-time, data-driven manufacturing.
6 – Methodological and Causal Modeling	Fuzzy MICMAC, MICMAC analysis	Fuzzy MICMAC (0 / 0.008)	Captures methodological sophistication through hybrid MCDM and causal mapping tools.

Source: Author's computation from Biblioshiny.

Figure 1: Co-occurrence Network of Author Keywords in Industry 4.0 Literature (2019–2025)



Source: Author's computation from Biblioshiny (2025)

- **Cluster-wise Interpretation**
  - Cluster 1: Strategic Modeling and SMEs, The dominant cluster with *Industry 4.0* as the central integrator. It reflects managerial and decision-analytic approaches emphasizing leadership, strategic planning, and adoption modeling in SMEs.
  - Cluster 2: Quality 4.0 and Operational Performance, represents outcome-focused research linking I4.0 tools to quality control and efficiency improvement, marking the shift from conceptual quality frameworks to measurable performance.
  - Cluster 3: Sustainability and Circular Economy, this thematic group connecting I4.0 to sustainability and policy goals. High-frequency nodes (*India*, *manufacturing*, *CE*) show growing emphasis on eco-innovation and resource efficiency.
  - Cluster 4: Empirical and Adoption Studies, Indicates the field's methodological maturity where research increasingly applies SEM and quantitative validation to measure adoption levels post-2021.
  - Cluster 5: Enabling Digital Technologies, Includes *IoT* and *AI*, the technological backbone of digital transformation, enabling data integration, transparency, and intelligent manufacturing.
  - Cluster 6: Methodological Tools and Causal Modeling, though peripheral, this cluster underpins analytical rigor through fuzzy-logic and MCDM-based modeling of interdependencies.
- **Cross-Cluster Discussion**

The six clusters form a hierarchically connected system:

- Cluster 1 acts as the conceptual core,
- Clusters 2 & 3 represent performance and sustainability outcomes,
- Cluster 5 provides technological enablers,
- Cluster 6 offers methodological grounding, and
- Cluster 4 ensures empirical validation.

Together, these interconnections show that Indian I4.0 research has evolved from conceptual modeling (pre-2020) to empirical and sustainability-focused inquiry (2021– August, 2025). The co-dominance of *Industry 4.0* and *Sustainability* nodes confirms that digital transformation and sustainable development are now co-evolving priorities in Indian manufacturing.

Table 5: Frequently Occurring Keywords in Industry 4.0 Research (2019–2025)

Frequency	Keywords (Terms)
53	Industry 4.0
19	India, Manufacturing
14	Sustainability
11	Sustainable development
9	Circular economy
8	Decision making, Technology adoption
6	Manufacturing sector, SMEs
5	Barriers, DEMATEL, Industrial research, Internet of Things, Manufacturing industries, Manufacturing industry
4	Automotive industry, Design/Methodology/Approach, Digitalization, Emerging economies, Empirical studies, Industrial performance, Industrial technology, Manufacturing organizations, Supply chain management
3	AHP, Automobile industry, Challenges, Data analytics, Digital transformation, Digitization, Empirical analysis, Empirical study, Environmental economics, Fuzzy AHP, Fuzzy MICMAC, Manufacturing companies, MICMAC analysis, Performance, Quality control, Supply chains, Sustainable manufacturing, Sustainable performance, TOPSIS, Innovation
2	Adoption level, Artificial intelligence, Automobile manufacture, Business, Competition

Source: Author's computation from Biblioshiny.

- **Empirical Insights on Industry 4.0 Adoption in Indian Manufacturing**
  - **Drivers and Enablers**

Figure 2 and Table 5 which presents the word-cloud visualization and frequency distribution of keywords and the co-occurrence network, Figure 1 together show that "Technology Adoption" and "Internet of Things (IoT)" are among the most important and recurrent technological terms (8 and 5 occurrences respectively), confirming their central enabling role. Empirical studies consistently highlight Top Management Commitment and Government Supportive Policies as the strongest strategic drivers (Krishnan et al., 2021; Luthra et al., 2019). These high-frequency enablers reflect India's policy-backed push toward digital transformation under *Make in India* and *Digital India*. The IoT, frequently linked with *real-time data* and *industrial performance*, appears in both the co-occurrence clusters (Cluster 5) and the word cloud, indicating its status as the most embedded digital enabler. The term "Innovation" (3 occurrences) also coexists with "Performance" and "Sustainability," suggesting that firms adopting these technologies view innovation as a mediating mechanism for achieving superior results. In summary, bibliometric evidence confirms that leadership commitment, supportive governance, and IoT deployment jointly drive Indian firms toward early stages of I4.0 maturity.

Figure 2: Word-Cloud Visualization of Frequent Keywords in Industry 4.0 Research (2019–2025)

Source: Author's computation from Biblioshiny.

- **Critical Barriers and Challenges**

The high frequency of “Barriers” (5) and “SMEs” (6) in the keyword analysis underscores the contextual and structural challenges within Indian manufacturing. Cluster 1 (Strategic Modeling) and Cluster 3 (Sustainability Context) jointly depict these constraints as *cause variables* in adoption models (Borana et al., 2024; Jain & Ajmera, 2022). Empirical studies using DEMATEL (5 occurrences) and MICMAC (3) approaches show that human capital limitations, financial risks, and infrastructural gaps remain persistent obstacles, particularly for small and medium enterprises. The repetition of “Challenges,” “Digital Transformation,” and “Skill Gap” in the word cloud reinforces that managerial inertia and resource scarcity are widely acknowledged impediments rather than isolated cases. Barriers are multidimensional i.e. financial, human, and infrastructural and their recurrence in the bibliometric corpus (appearing in both word-frequency and cluster data) validates them as core impediments to I4.0 diffusion in emerging economies like India.

- **Performance and Sustainability Outcomes**

The word-frequency results place “Sustainability” (11 occurrences) and “Circular Economy” (9) among the most dominant terms, indicating a clear research priority on linking I4.0 with sustainable manufacturing. Co-occurrence data further show these nodes possess high PageRank and Betweenness, emphasizing their bridging role between digital adoption and long-term socio-environmental outcomes. Empirical evidence (Sahoo & Jakhar, 2024; Harikannan et al., 2025; Tiwari et al., 2025) confirms that I4.0 technologies especially IoT and data analytics, act as mediators enabling green procurement, remanufacturing, and eco-innovation. The prominence of “Sustainable Development” and “Performance” terms in the word cloud indicates that research focus has shifted from technological feasibility to sustainable competitiveness. The synthesis of frequency and co-occurrence metrics demonstrates that the Indian I4.0 discourse is driven not only by efficiency concerns but by Triple Bottom Line (TBL) outcomes environmental, economic, and social, making sustainability an empirically validated endpoint of digital transformation**.**

The bibliometric and thematic analyses collectively demonstrate how Industry 4.0 research in Indian manufacturing has evolved from conceptual foundations toward data-driven, sustainability-oriented inquiry. The six identified clusters ranging from strategic modeling and quality management to sustainability and enabling technologies—reveal an integrated research structure that connects managerial, technological, and environmental dimensions of digital transformation. Together, these findings highlight that the discourse on Industry 4.0 in India has matured from descriptive explorations to empirically validated models addressing competitiveness and sustainable performance. This progression provides a strong analytical base for deriving theoretical insights and policy directions, as discussed in the following section

Conclusion, Theoretical, and Managerial Implications

Conclusion

This bibliometric and empirical review consolidates six years of research (2019– August, 2025) on Industry 4.0 adoption in Indian manufacturing. The analysis of sixty empirical studies shows that the field has evolved rapidly, moving from conceptual discussions to evidence-based insights emphasizing performance and sustainability. The author analysis highlights a concentrated yet collaborative research network led by contributors such as Kumar R, Kumar A, Kumar S, Kumar V, Kamble S.S., and Prashar A, along with international collaborators like Tortorella G.L. and Garza-Reyes J.A. Their collective work has advanced understanding of digital transformation, sustainable operations, and organizational readiness in Indian manufacturing. Leadership commitment, supportive government policy, and technological capability emerge as the strongest drivers of adoption, while human resource gaps, financial risks, and infrastructural deficiencies remain persistent challenges. The performance results confirm that Industry 4.0 technologies significantly enhance operational efficiency, supply-chain integration, and sustainability outcomes through green procurement, remanufacturing, and circular-economy initiatives.

The cluster and thematic analyses further reveal six dominant research streams strategic modeling and SME readiness, sustainability, circular economy, quality management, innovation capability, and automotive-sector application showing that the Indian I4.0 research landscape has become both methodologically diverse and sustainability-driven. Overall, this study bridges fragmented empirical evidence and provides a structured understanding of how digital transformation is reshaping Indian manufacturing. It reaffirms that India’s Industry 4.0 journey is led by strong academic collaboration and driven by a balanced combination of technology, policy support, and human-centered innovation, forming the foundation for sustainable and competitive industrial growth.

Theoretical Implications

The findings add to existing knowledge by showing that Industry 4.0 adoption in manufacturing is shaped by both technological and organizational readiness. Successful transformation depends not only on digital tools but also on leadership support, skills, and culture. The results confirm that digital technologies strengthen a firm's innovative and collaborative capabilities and can act as a bridge between operational performance and sustainability. By connecting digital adoption with long-term environmental and social outcomes, the study expands the theoretical understanding of how technology can drive sustainable competitiveness in emerging economies.

Managerial and Policy Implications

The results provide practical guidance for managers and policymakers to accelerate Industry 4.0 adoption in Indian manufacturing. Managers should strengthen leadership commitment, invest in human-capital development, and align digital initiatives with measurable sustainability outcomes. A phased and well-prioritized approach to implementing core technologies such as IoT, cloud computing, and cybersecurity can reduce financial risks while improving operational performance. Building digital capabilities and fostering collaboration across supply chains are also critical for achieving long-term competitiveness. On the policy front, efforts must prioritize the expansion of digital infrastructure, affordable connectivity, and clear incentive frameworks to extend Industry 4.0 benefits to SMEs and regional industries. Strengthening industry–academia partnerships and linking national initiatives such as *Make in India* and *Digital India* with circular economy objectives will further ensure that digital transformation contributes to sustainable and inclusive industrial growth.

Limitations and Future Research

This review is confined to empirical studies up to August, 2025 focusing on I4.0 and manufacturing within India. Future research can:

- Broaden scope to include comparative or global analyses of manufacturing ecosystems;
- Expand the sample size by incorporating more interdisciplinary and non-indexed sources.
- Refine analytical techniques through network mapping and mixed-method bibliometric–text-mining approaches to deepen understanding of evolving I4.0 sustainability linkages.

Indian I4.0 research is transitioning from fragmented empirical efforts to a coherent sustainability-driven paradigm. As the global discourse widens, integrating India's experience within broader international comparisons will be key to shaping the next phase of Industry 4.0 scholarship.

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