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Industry 5.0 and Sustainable Competitiveness among Indian MSMEs: Toward an Integrated Model of Digital and Human Centric Innovation

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ABSTRACT

Industry 5.0 emphasises a human-centric approach, sustainability, and adaptability to change in digital transformation, extending the philosophy of Industry 4.0. For Indian micro, small and medium enterprises (MSMEs), this paradigm is highly pertinent yet under-theorised. This conceptual review synthesises research on sustainable digital transformation in MSMEs, Industry 5.0, and MSME competitiveness to propose an integrated model for Indian MSMEs. Systematic and comprehensive reviews highlight the mediating role of stakeholders, organisational capabilities, and technologies—particularly big data, IoT, and AI—in achieving sustainability through digital transformation (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024; Machado et al., 2024). Studies on digitisation and MSME competitiveness identify key factors (technological readiness, institutional support, innovation capacity) and barriers (resource constraints, skills gaps, regulatory complexity) (Singh & Anees, 2025; Putranto, 2025; Syaifullah et al., 2025; Nautiyal et al., 2025). Industry 5.0 literature emphasises that Industry 4.0 has improved economic and some environmental outcomes, while often undermining social and macro-level sustainability, motivating a human-centred, sustainable, and resilient agenda (Ghobakhloo et al., 2024; Hein-Pensel et al., 2023).Building on these strands, the paper proposes a seven-pillar conceptual model for Indian MSMEs: enabling environment, strategic orientation, human-centric capabilities, digital capabilities, process and business-model innovation, sustainability and resilience mechanisms, and sustainable competitiveness outcomes. The model aligns Industry 5.0 values with people–process–technology mechanisms and triple-bottom-line performance in MSME supply chains (Melo et al., 2023; Martínez-Peláez et al., 2024; Mick et al., 2024; Machado et al., 2024). It also identifies India-specific barriers to green and digital transformation and highlights research gaps regarding Industry 5.0 in MSMEs, measurement of social sustainability, and heterogeneous pathways for micro versus small and medium firms (Melo et al., 2023; Hein-Pensel et al., 2023; Nautiyal et al., 2025; Machado et al., 2024). The paper concludes with implications for policymakers, support institutions and MSME managers seeking to operationalise Industry 5.0 as sustainable, human-centric digital innovation in India..

Keywords: Industry 5.0; sustainable digital transformation; MSMEs; India; human-centric innovation; competitiveness; Industry 4.0; supply chains

INTRODUCTION:

MSMEs account for the majority of firms and a large share of employment worldwide, and are central to inclusive growth and regional development (Martínez-Peláez et al., 2023; Melo et al., 2023). Digital transformation has become a critical determinant of MSME competitiveness, enabling efficiency, innovation and new market access (Singh & Anees, 2025; Putranto, 2025; Syaifullah et al., 2025). However, most digitalisation agendas are framed within Industry 4.0, which emphasises automation and economic performance while only partially addressing social and environmental sustainability (Melo et al., 2023; Ghobakhloo et al., 2024; Machado et al., 2024).

The emerging Industry 5.0 paradigm responds to these shortcomings by placing human-centricity, sustainability and resilience at the core of industrial transformation (Ghobakhloo et al., 2024; Hein-Pensel et al., 2023). For Indian MSMEs, which face structural constraints in finance, skills and infrastructure, yet operate in an environment of rapiddigitalisation and ambitious sustainability goals, Industry 5.0 offers both opportunities and challenges (Singh & Anees, 2025; Putranto, 2025;, 2024; Nautiyal et al., 2025).

This paper develops a conceptual model that links Industry 5.0 principles with sustainable competitiveness among Indian MSMEs through digital and human-centric innovation. It asks:

1. How does existing research conceptualise sustainable digital transformation and Industry 5.0 for MSMEs?
2. What are the key drivers and barriers of digital and sustainable competitiveness in MSMEs, especially in India?
3. How can these insights be integrated into an Industry 5.0-aligned model tailored to Indian MSMEs?

2. LITERATURE REVIEW

2.1 Sustainable Digital Transformation in MSMEs

Sustainable digital transformation (SDT) is understood as digitalisation that explicitly integrates economic, environmental and social objectives (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024). A review of 59 MSME-focused publications (2019–2023) shows that owners and managers should first reshape organisational culture toward sustainability, leverage stakeholders in innovation, and prioritise technologies—especially big data—that support sustainability goals (Martínez-Peláez et al., 2023). Stakeholders (customers, suppliers, communities, regulators) act as mediators enabling SDT and competitiveness (Martínez-Peláez et al., 2023; Martínez-Peláez et al., 2024).

Systematic reviews of SDT performance measurement in SMEs reveal that research intensified after 2016 and is still maturing (Melo et al., 2023). Many tools emphasise economic indicators, with environmental and social dimensions relatively under-developed; a conceptual framework is proposed to better integrate triple-bottom-line (TBL) performance (Melo et al., 2023). Another study develops a five-stage SDT framework—setting objectives, stakeholder engagement, defining sustainability dimensions, modelling and project execution—and validates it in an SME case, demonstrating tangible operational and sustainability benefits (Martínez-Peláez et al., 2024). A complementary roadmap (SDT-SMEs) uses six dimensions (Digital Technologies, Customer Focus, Organisational Culture, Governance, People, Sustainability) and a maturity model across strategic, tactical and operational levels (Mick et al., 2024).

Overall, SDT literature converges on the importance of organisational culture and leadership, stakeholder engagement, and digital capabilities (e.g., big data analytics) as foundations of sustainable competitiveness (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024; Mick et al., 2024).

2.2 Industry 4.0, Industry 5.0 and Human-Centricity

Industry 4.0 has driven notable gains in economic and, to some extent, environmental sustainability through automation, integration and data-driven optimisation (Ghobakhloo et al., 2024; Machado et al., 2024). A content-centric synthesis shows that Industry 4.0 mainly benefits organisational and supply-chain-level economic and environmental values, but often harms micro- and meso-social values (e.g., job quality, inequality) and macro-level sustainability (e.g., growth equality) (Ghobakhloo et al., 2024). These contradictions underpinthe rise of Industry 5.0, which seeks a human-centric, sustainable and resilient digital society (Ghobakhloo et al., 2024).

Industry 5.0 scholarship identifies "sustainability functions" of Industry 4.0, and specifies how and in what order they should be leveraged under different levels of business uncertainty to realise Industry 5.0 goals (Ghobakhloo et al., 2024). For instance, under high uncertainty, firms should first exploit automation and integration for cost savings, resource efficiency and antifragility, then progressively introduce sustainable innovations into their business models (Ghobakhloo et al., 2024).

A review of Industry 4.0 maturity models assesses whether they address Industry 5.0's human-centric requirements and SME applicability. From 297 publications, only 24 maturity models meet quality criteria; most insufficiently address human-centred aspects (e.g., worker participation, well-being) and are not fully suited to SMEs with limited resources (Hein-Pensel et al., 2023). This indicates the need for new Industry 5.0-aligned maturity models tailored to smaller firms.

2.3 Digital Transformation, Competitiveness and MSMEs

Bibliometric and narrative reviews show that digital transformation enhances MSME competitiveness through improved efficiency, innovation, market access and resilience (Singh & Anees, 2025; Putranto, 2025; Syaifullah et al., 2025; Bai et al., 2021).

A bibliometric analysis of 4,374 articles (2014–2023) reveals that innovation, sustainability, and technology adoption are key themes; digital transformation is positioned as a strategic shift, not just a technological one, that enables new markets and flexibility, especially during COVID-19 (Saifullah et al., 2025; Bai et al., 2021).However, SMEs face a number of challenges, including inadequate infrastructure, cybersecurity risks, skills gaps, and financial constraints (Singh & Anis, 2025; Putranto, 2025). Strategic implications highlight the need for supportive policies that promote capacity building, innovation-oriented leadership, and sustainable digital ecosystems (Singh & Anis, 2025; Putranto, 2025; 2024; Saifullah et al., 2025). COVID-19-focused analyses identify digital payments (especially mobile money) and virtual channels as crucial for the continued growth and sustainability of micro and small enterprises (Bai et al., 2021)

2.4 Integrating Industry 4.0 and Sustainability in MSME Supply Chains

An integrated framework for small and medium enterprises (MSMEs) combines Industry 4.0 and sustainability through people, processes and technology (PPT) mechanisms within a TBL perspective (Machado et al., 2024). A mixed-method design identifies 32 indicators of barriers and enablers and differentiates pathways for micro and small enterprises (MSEs) versus medium enterprises (MEs). People-related factors (skills, leadership, culture) emerge as important; process reengineering and appropriate technology selection are

essential to capture value from digital tools; and firm size determines the adoption trajectory (Machado et al., 2024).

This framework demonstrates that sustainable competitiveness is co-produced by human, organisational and technological factors, resonating with Industry 5.0's human-centric vision.

2.5 Barriers to Green and Sustainable Transformation in Indian MSMEs

A recent study systematically identified and ranked the barriers to green and sustainable transformation in Indian MSMEs using a literature review (2001–2024) and fuzzy AHP (Notiyal et al., 2025). Four categories emerged: organisational, government policy and regulations, technological, and financial barriers.Organisational barriers—such as weak environmental capabilities and cultures—are most critical, followed by regulatory complexity, technological readiness and financial constraints (Nautiyal et al., 2025). The study stresses that because eco-friendly measures are largely non-mandatory, MSMEs may rationally prioritise profit over environmental sustainability, challenging simplistic narratives of negligence (Nautiyal et al., 2025).

2.6 Synthesis

The literature jointly suggests that:

- Digital transformation can strongly support MSME competitiveness and elements of sustainability, but requires adequate organisational and ecosystem capabilities (Martínez-Peláez et al., 2023; Singh & Anees, 2025; Melo et al., 2023; Syaifullah et al., 2025).
- Industry 4.0 tools must be strategically sequenced and governed to realise Industry 5.0's human-centric, socio-environmental objectives (Ghobakhloo et al., 2024; Hein-Pensel et al., 2023; Machado et al., 2024).
- MSMEs—particularly in developing contexts like India—face intertwined organisational, regulatory, technological and financial barriers to green and digital transformation (Singh & Anees, 2025; Putranto, 2025;, 2024; Nautiyal et al., 2025).

These insights underpin the conceptual model developed for Indian MSMEs.

3. Conceptual Framework and Methodological Positioning

This paper uses a conceptual review approach, integrating findings from systematic and scoping reviews, bibliometrics, and conceptual frameworks on SDT, Industry 4.0/5.0 and MSMEs (Martínez-Peláez et al., 2023; Melo et al., 2023; Ghobakhloo et al., 2024; Hein-Pensel et al., 2023; Martínez-Peláez et al., 2024; Mick et al., 2024; Machado et al., 2024). It does not conduct a new systematic review but draws on existing high-quality syntheses as secondary evidence.

Key theoretical lenses include:

- Resource-based view and dynamic capabilities, highlighting organisational capabilities and learning as foundations of sustainable digital competitiveness (Martínez-Peláez et al., 2023; Melo et al., 2023; Machado et al., 2024).
- Business model theory, stressing value creation, delivery and capture in digital-sustainability transitions (Parida et al., 2019).
- Triple bottom line, which frames economic, environmental and social performance as integrated goals (Melo et al., 2023; Martínez-Peláez et al., 2024; Machado et al., 2024).

The resulting model (Section 4) is therefore a theory-building contribution that adapts global evidence to the specific constraints and policy context of Indian MSMEs identified in empirical studies (Singh & Anees, 2025; Putranto, 2025;, 2024; Syaifullah et al., 2025; Nautiyal et al., 2025).

4. Proposed Industry 5.0–Sustainable Competitiveness Model for Indian MSMEs

The model comprises seven interlinked pillars.

4.1 Enabling Environment and Institutional Support

First, Indian MSMEs require an ecosystem that jointly supports digitalisation and sustainability:

- Digital and physical infrastructure: reliable connectivity, logistics and energy are prerequisites for adopting IoT, platforms and data-driven tools (Singh & Anees, 2025; Putranto, 2025; Syaifullah et al., 2025).
- Integrated policy frameworks: coordination between MSME, industrial, digital and environmental policies is needed; fragmented regulations currently form major barriers (2024; Syaifullah et al., 2025; Nautiyal et al., 2025).
- Green and digital finance: concessional credit, guarantees and blended finance instruments can ease financial constraints for investments in sustainable digital technologies (Martínez-Peláez et al., 2023; Nautiyal et al., 2025; Machado et al., 2024).

4.2 Strategic Orientation and Organisational Culture

Leadership and culture set the direction for Industry 5.0-aligned transformation:

- Owners and managers should explicitly align strategies with sustainability, embedding it into digital decisions and investments (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024).
- Organisational cultures that value learning, experimentation and stakeholder engagement facilitate SDT (Martínez-Peláez et al., 2023; Melo et al., 2023; Mick et al., 2024).
- Roadmap tools like the SDT-SMEs model illustrate how to cascade strategy into tactical and operational plans grounded in sustainability (Mick et al., 2024).

4.3 Human-Centric Capabilities

Human-centricity is central to Industry 5.0:

- Continuous up-skilling and re-skilling in digital tools and sustainability practices are necessary for MSME employees (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024).
- Worker participation in technology design and process changes improves acceptance, creativity and job quality, yet is often absent from existing maturity models (Hein-Pensel et al., 2023; Machado et al., 2024).
- Attention to health, safety and work-life balance ensures that automation complements rather than displaces meaningful work, supporting social sustainability (Ghobakhloo et al., 2024; Hein-Pensel et al., 2023).

4.4 Digital and Technological Capabilities

Industry 5.0 builds on Industry 4.0 technologies:

- MSMEs should adopt cost-effective combinations of big data, IoT, AI, cyber-physical systems, e-commerce and platforms tailored to their size and sector (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024; Mick et al., 2024; Machado et al., 2024).
- Big data, in particular, supports decision-making across sustainability dimensions by analysing diverse data streams (Martínez-Peláez et al., 2023; Melo et al., 2023).
- Integration along the supply chain—traceability, real-time information, collaboration—is critical for realising sustainability functions (e.g., resource efficiency, circularity) (Ghobakhloo et al., 2024; Machado et al., 2024).

4.5 Process and Business-Model Innovation

Digital and sustainability goals must be embedded in processes and business models:

- Process redesign using digital tools can reduce waste, energy use and resource consumption, supporting environmental and cost performance (Melo et al., 2023; Machado et al., 2024).
- Business-model innovation (e.g., servitisation, platform participation, circular services) enables new value propositions and resilience (Melo et al., 2023; Machado et al., 2024; Parida et al., 2019).
- Customer-centric practices, enabled by digital channels and analytics, enhance experience and loyalty, reinforcing competitiveness (Melo et al., 2023; Mick et al., 2024; Parida et al., 2019).

4.6 Sustainability and Resilience Mechanisms

Industry 5.0 emphasises long-term viability:

- Environmental practices (cleaner production, eco-design, renewable energy) and social practices (fair work, inclusion) should be integrated with digital initiatives (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024; Machado et al., 2024).
- Lessons from COVID-19 show the importance of digital payments, virtual channels and crisis-ready business models for sustaining micro and small enterprises (Bai et al., 2021).
- Continuous monitoring via TBL-based indicators allows feedback and adaptation; several frameworks propose integrated performance metrics for SDT (Melo et al., 2023; Martínez-Peláez et al., 2024; Mick et al., 2024; Machado et al., 2024).

4.7 Outcomes: Sustainable Competitiveness

When the above pillars align, Indian MSMEs can achieve:

- Higher productivity, quality and innovation;
- Enhanced market reach, export readiness and reputation;
- Lower environmental footprints and better regulatory compliance;
- Stronger social licence and contribution to inclusive development (Martínez-Peláez et al., 2023; Singh & Anees, 2025; Melo et al., 2023; Syaifullah et al., 2025; Machado et al., 2024).

4.8 Mapping Levers to Outcomes

Key Industry 5.0 Levers and Expected MSME Outcomes

Lever	MSME Mechanisms	Expected Outcomes	Citations
Human-centric capabilities	Skills, participation, decent work	Innovation, lower resistance, retention	(Martínez-Peláez et al., 2023; Ghobakhloo et al., 2024; Hein-Pensel et al., 2023; Machado et al., 2024)
Digital technologies (I4.0)	Big data, IoT, AI, platforms	Efficiency, eco-efficiency, traceability	(Martínez-Peláez et al., 2023; Melo et al., 2023; Ghobakhloo et al., 2024; Martínez-Peláez et al.,

			2024; Mick et al., 2024; Machado et al., 2024)
Process & business-model change	Circular, service-oriented, customer-centric	New revenues, differentiation, resilience	(Melo et al., 2023; Machado et al., 2024; Parida et al., 2019)
Ecosystem & policy support	Infrastructure, incentives, finance, regulation	Adoption, lower barriers, legitimacy	(Singh & Anees, 2025; Putranto, 2025; , 2024; Syaifullah et al., 2025; Nautiyal et al., 2025)
Integrated PPT–TBL management	People–process–technology aligned to TBL metrics	Balanced sustainability performance	(Melo et al., 2023; Martínez-Peláez et al., 2024; Mick et al., 2024; Machado et al., 2024)

Figure 1: Industry 5.0 levers linked to MSME sustainable competitiveness.

5. Discussion and Research Agenda

5.1 Implications for Indian MSMEs and Policymakers

For MSME managers, the model highlights the need to treat digitalisation as strategic, human-centric SDT, not isolated technology purchases. Prioritising culture change, stakeholder engagement and basic data capabilities is as important as acquiring advanced tools (Martínez-Peláez et al., 2023; Melo et al., 2023; Martínez-Peláez et al., 2024; Mick et al., 2024).

For policymakers and support institutions, findings underscore that fragmented interventions (e.g., hardware subsidies without skills or regulatory reform) are insufficient. Coordinated policies must tackle organisational, regulatory, technological and financial barriers simultaneously (2024; Syaifullah et al., 2025; Nautiyal et al., 2025; Machado et al., 2024). Differentiated strategies for micro, small and medium firms are also required (Machado et al., 2024).

5.2 Research Gaps

Several gaps remain:

- Few studies explicitly analyse Industry 5.0 in MSMEs; most frame issues in Industry 4.0 terms, with limited treatment of human-centric AI and social sustainability (Ghobakhloo et al., 2024; Hein-Pensel et al., 2023; Machado et al., 2024).
- India-specific empirical work linking integrated digital and sustainability strategies to long-term performance is scarce; many studies focus on adoption barriers rather than outcomes (Singh & Anees, 2025; Putranto, 2025;, 2024; Syaifullah et al., 2025; Nautiyal et al., 2025).
- Social sustainability indicators (e.g., job quality, inclusion) are weakly represented in SDT performance tools (Melo et al., 2023; Mick et al., 2024).
- Pathways for different MSME sizes and sectors, including informal and rural enterprises, need longitudinal and mixed-methods investigation (Melo et al., 2023; Machado et al., 2024; Bai et al., 2021).

6. CONCLUSION

Industry 5.0 reframes digital transformation as a human-centric, sustainable and resilient process. Synthesising evidence on sustainable digital transformation, Industry 4.0/5.0 and MSME competitiveness, this paper proposes a seven-pillar conceptual model for Indian MSMEs that integrates enabling ecosystems, strategic orientation, human-centric and digital capabilities, process and business-model innovation, and sustainability and resilience mechanisms. The model highlights how Industry 4.0 technologies can be harnessed within Industry 5.0 values to deliver sustainable competitiveness, while exposing organisational and systemic barriers in the Indian context. Future empirical work should operationalise and test this model in Indian MSME clusters, refine performance metrics, and inform integrated policy and support programmes that translate Industry 5.0 from concept into practice...

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