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Industry 4.0 and Digital Transformation: Enablers, Barriers, and Organisational Pathways to Performance

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Abstract:

This study critically examines the evolving relationship between Industry 4.0, digital transformation, and organisational performance, with a particular focus on the enablers, barriers, and socio-technical processes that shape successful transformation. The aim of the study is to clarify how organisations can convert the technological potential of Industry 4.0 into tangible and sustainable value. To achieve this, the study adopts a systematic literature review SLR approach, synthesising evidence from eighty-two peer-reviewed articles published between 2014 and 2024. The review followed a structured and transparent process, combining keyword-based searches in Scopus with filters for open-access, English-language publications, and journal articles. Thematic synthesis was then employed to extract insights from the findings, theoretical framings, and contextual discussions of the selected studies. The results indicate that digital transformation is not a purely technological upgrade but a holistic process of organisational change requiring the integration of strategy, culture, leadership, and governance with digital technologies. Key findings show that organisational readiness and maturity are decisive predictors of transformation success, while leadership commitment, cultural alignment, and business process management act as crucial enablers. Technologies such as IoT, AI, and analytics improve performance only when embedded in systems that enhance integration, visibility, and resilience across supply chains and organisational boundaries. Conversely, transformation is frequently stalled by human resistance, conceptual ambiguity, skill gaps, and weak governance structures.

Keywords:

Industry 4.0, Digital Transformation, Organisational Readiness, Strategic Leadership, Dynamic Capabilities

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Introduction and Background

The accelerating pace of technological innovation has ushered in what scholars and practitioners widely describe as the fourth industrial revolution, or Industry 4.0 (I4.0). Initially launched as a German policy initiative in 2011, I4.0 has evolved from a narrow focus on advanced manufacturing to a broader discourse encompassing business transformation, supply chains, services, and even public administration (Madsen, 2019). Its foundation rests on the integration of cyber-physical systems, the Internet of Things (IoT), big data analytics, cloud computing, and artificial intelligence (AI) into organisational processes, enabling hyper-connectivity, automation, and data-driven decision-making (Fatorachian & Kazemi, 2018). While the rhetoric around I4.0 is often associated with the promise of "smart factories" and "smart enterprises," the literature cautions that its diffusion is uneven and its impacts are highly context-dependent (Govindan & Arampatzis, 2023; Reaidy et al., 2024). Crucially, Industry 4.0 is not synonymous with digital transformation (DT). Whereas I4.0 is often tied to specific technologies and industrial applications, DT is a broader socio-technical process that reshapes strategies, structures, cultures, and business models alongside technological adoption (Ramadan et al., 2023). Case studies and surveys confirm that the most significant performance gains emerge not merely from deploying tools, but from aligning them with leadership, organisational agility, and workforce skills (Van Doorn et al., 2022; Ahmed et al., 2024). In this sense, DT is both an organisational and institutional journey, conditioned by sectoral logics, regulatory signals, and stakeholder expectations (Perotti et al., 2024; Neri et al., 2023). Research across diverse industries highlights that readiness and maturity shape the trajectory of transformation. Firms straddling legacy and digital regimes so-called "Industry 3.5" organisations face unique challenges, requiring leaders to assess maturity levels, prioritise barriers, and build adaptive capabilities rather than pursue wholesale adoption (Govindan & Arampatzis, 2023; Antony et al., 2023). Readiness is not only technological but also cultural: employees' openness to innovation, trust, and collaborative norms often mediate whether digital initiatives succeed or stall (Cadden et al., 2022). Conversely, barriers such as resistance to change, inadequate training, and conceptual ambiguity around Quality 4.0 or AI adoption continue to undermine progress (Ito et al., 2021; Antony et al., 2024).

At the operational level, I4.0 has shown measurable impact on supply chain performance when technologies are embedded in integrated systems that enhance visibility and resilience. For instance, AI-driven practices in Vietnamese SMEs improved resilience through better integration, which in turn boosted firm performance (Dey et al., 2024). Similar findings emerge in healthcare and food supply chains, where IoT and analytics enhanced resource efficiency, waste reduction, and adaptive capacity during crises such as COVID-19 (Tortorella et al., 2024; Ada et al., 2023). Yet, scholars agree that these benefits are mediated not direct effects, realised only when digital adoption is accompanied by integration across organisational and inter-organisational boundaries (Reaidy et al., 2024). Beyond

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technology and operations, the human dimension is central. Studies on worker-AI coexistence show that misaligned job design fosters stress and fear, whereas well-designed systems that preserve autonomy and embed learning create complementarities between humans and machines (Lundgren et al., 2023). HRM research confirms that AI's role in recruiting, workforce planning, and employee experience depends on data governance, ethical safeguards, and continuous capability building (Venugopal et al., 2024). Middle managers, in particular, emerge as pivotal actors, translating strategic intent into practice while mediating employee concerns (Van Doorn et al., 2022). Sectoral illustrations further reveal the diversity of transformation pathways. In the built environment, digitalisation requires multi-actor coordination and project-level governance (Papadonikolaki et al., 2022). In retail, COVID-19 accelerated omnichannel integration, showing that agility and speed of response, rather than tools alone, determine performance (Acquila-Natale et al., 2022). Procurement functions in the Gulf are being reshaped by AI, blockchain, and business intelligence, but governance and regulatory alignment remain critical (Ashal & Morshed, 2024). Meanwhile, circular economy transitions highlight how digital tools enable eco-industrial networks and sustainable practices, contingent on stakeholder coordination and supportive institutional contexts (Neri et al., 2023; Perotti et al., 2024).

Looking forward, scholars highlight future trajectories such as Quality 4.0, digital servitisation, Organisation 4.0, and hybrid human-AI decision-making. These avenues indicate that transformation will increasingly involve governance frameworks blending standards with analytics, platform-based business models, agile and collaborative organisational designs, and workflows where human judgment and machine intelligence complement one another (Carvalho et al., 2024; Minaya et al., 2024; Gonzalez et al., 2024; Trunk et al., 2020). Collectively, this evolving body of knowledge positions Industry 4.0 not as a static technological project but as a dynamic, multi-level process of organisational adaptation and capability building shaping the competitiveness, resilience, and sustainability of firms in the digital age. Although Industry 4.0 and digital transformation have been widely promoted as pathways to competitiveness, resilience, and sustainability, the translation of these concepts from rhetoric into organisational practice remains inconsistent and uneven. Much of the discourse around I4.0 highlights its technological building blocks cyber-physical systems, IoT, AI, and analytics yet empirical evidence reveals that performance improvements depend less on the technologies themselves and more on the readiness, governance, and human-centred enablers that support their adoption (Govindan & Arampatzis, 2023; Reaidy et al., 2024). The research problem emerges from this disconnect between promise and practice. On the one hand, scholarly and managerial narratives depict I4.0 as a revolutionary transformation; on the other, many firms remain stuck in transitional states "Industry 3.5" struggling to align legacy systems, workforce capabilities, and organisational culture with digital demands Antony et al., (2023). Barriers such as employee resistance, conceptual ambiguity, and capability gaps continue to undermine transformation efforts (Ito et al., 2021; Antony et al., 2024).

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Sectoral studies further reveal that transformation pathways are highly path-dependent, mediated by industry logics, regulatory pressures, and inter-organisational coordination, meaning that a one-size-fits-all approach is not viable (Papadonikolaki et al., 2022; Do et al., 2022; Neri et al., 2023). The research problem lies in the need to understand and synthesise the enablers, barriers, and sectoral trajectories of Industry 4.0 and digital transformation, so as to clarify how organisations can convert technological potential into realised value. The main research question of this study is, What organisational and socio-technical conditions enable or constrain the conversion of Industry 4.0 and digital transformation initiatives into sustained organisational performance?

Methodology

This study employed a systematic literature review approach to synthesise and critically evaluate the state of knowledge on Industry 4.0 and digital transformation, with particular emphasis on their organisational implications for productivity, value creation, competitive advantage, and performance management. The SLR methodology was adopted because it allows for a transparent, replicable, and comprehensive assessment of existing scholarship, thereby reducing bias and enabling meaningful aggregation of findings across multiple contexts and sectors.

The review process was guided by a carefully constructed search string combining concepts of Industry 4.0, digital transformation, and organisational performance. The following Boolean logic was applied: (“introduction to industry 4.0” OR “emergence of industry 4.0” OR “smart manufacturing” OR “digital transformation”) AND (business OR organisation) AND (“impact” OR productivity OR “value creation” OR “competitive advantage”) AND (“artificial intelligence” OR “machine learning” OR “big data” OR “predictive analytics”) AND (“performance management” OR “performance measurement”). This formulation was deliberately broad to capture both the technological and managerial dimensions of Industry 4.0 and its intersections with business performance.

The initial search returned 3,159 records, which were subsequently filtered to enhance relevance and quality. First, a temporal filter was applied to restrict the scope to articles published between 2014 and 2024. This timeframe was selected as it corresponds with the diffusion of the I4.0 paradigm since its formal launch in Germany in 2011 and captures the most recent decade of empirical and conceptual developments. The restriction reduced the pool to 2,345 articles. A second level of filtering was performed using the specified keywords, with additional criteria limiting the selection to open access and English-language articles, to ensure accessibility and comparability across the dataset. This step yielded 148 articles. Subsequent screening was carried out in two stages. First, titles were assessed to exclude irrelevant or tangentially related studies, reducing the dataset to 102 articles. Abstracts were then reviewed to further refine the selection, leaving 90 articles deemed to align substantively with the research focus. Of these, 82 articles were successfully downloaded and incorporated into the review,

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while 8 could not be accessed due to institutional or publisher restrictions. The final sample of 82 articles thus forms the empirical foundation of this study.

Data extraction and analysis focused primarily on the findings sections of the included studies, but relevant insights from introductions, theoretical framings, and background discussions were also considered. Emphasis was placed on capturing the conceptualisation of Industry 4.0 and digital transformation, the enabling and constraining factors identified across contexts, and the documented impacts on organisational performance. Thematic synthesis was used to identify patterns, contradictions, and knowledge gaps, with particular attention to recurring themes such as readiness and maturity, leadership and governance, human-centred adaptation, operational integration, and sectoral variations. This approach enabled not only a summary of the existing state of knowledge but also a critical interpretation of its implications for both theory and practice. In line with best practices for SLRs, the process adhered to principles of rigour, transparency, and reproducibility. Each stage of the search and filtering process was systematically documented to ensure clarity. While the review is limited to open access and English-language studies, which may exclude relevant contributions published in other languages or formats, these criteria were necessary to ensure consistency and accessibility within the scope of this project. The final selection of 82 articles offers a sufficiently rich and diverse evidence base to generate robust insights into the evolving relationship between Industry 4.0, digital transformation, and organisational performance.

Findings

Framing Industry 4.0 and Digital Transformation

Despite this meteoric rise, the conceptual spread of I4.0 has often outpaced its practical operationalisation. Studies consistently warn against treating I4.0 as a technological panacea. For example, Govindan and Arampatzis (2023) demonstrate that readiness levels and contextual barriers differ significantly across organisations, making simplistic technology-driven narratives misleading. Similarly, Ito et al. (2021) show that workplace resistance stemming from anxieties about surveillance, loss of autonomy, or role change can undermine implementation, revealing that technological sophistication alone does not guarantee transformation. This recognition has prompted scholars to reframe I4.0 as part of a broader digital transformation DT journey. Unlike I4.0, which is often framed around technologies and industrial contexts, DT encompasses organisational strategy, leadership, culture, structures, and processes alongside technological adoption (Ramadan et al., 2023). Empirical studies of SMEs in Lebanon, for instance, confirm that leadership fostering organisational agility and knowledge transfer is central to sustaining digital transformation and business model innovation (Ramadan et al., 2023). Similar findings emerge from Malaysian manufacturing, where firms' success

in leveraging change-sensing and seizing capabilities, rather than technologies alone, determines the effectiveness of transformation Ahmed et al., 2024).

The socio-technical character of transformation is further highlighted in sector-specific reviews. In the built environment, Papadonikolaki et al. (2022) find that digitalisation unfolds unevenly across projects, firms, and ecosystems, depending on governance, capability building, and collaborative mechanisms. Likewise, Gonzalez et al. (2024) introduce the notion of "Organisation 4.0," emphasising that innovation, business intelligence, and empowered digital employees are key antecedents of transformation, suggesting that people and organisational systems not just technologies drive outcomes. The literature also acknowledges that I4.0 and DT must be understood as capability-building processes. For example, Scriven et al. (2024) argue that the integration of Lean principles with digital transformation termed Lean Digital Transformation offers a structured approach to eliminate waste and enhance efficiency while embedding digital tools. Moreover, bibliometric analyses (Chatterjee et al., 2024) reveal that while the dominant discourse revolves around manufacturing and supply chains, emerging areas such as healthcare, food systems, and public administration are increasingly incorporating I4.0 logics, albeit with varied levels of maturity and success. While I4.0 originated as a manufacturing-focused policy agenda, its contemporary relevance extends to a much broader digital transformation paradigm. The evidence suggests that DT is not a mere technological upgrade but a multi-layered process where governance, leadership, organisational agility, and socio-technical integration determine success. This framing calls for moving beyond hype towards nuanced, context-sensitive operationalisation of I4.0 principles, ensuring that the transformation delivers tangible performance and sustainability outcomes.

Theoretical Lenses, From Systems Thinking to Institutional Dynamics

Scholarly work on Industry 4.0 (I4.0) and digital transformation frequently draws upon theoretical lenses that illuminate both the internal dynamics of organisations and the broader institutional environments in which they operate. Two prominent perspectives systems thinking and institutional dynamics stand out, though others such as the resource-based view RBV and dynamic capabilities often complement them.

Systems-Thinking Perspective

Industry 4.0 is often conceptualised through a socio-technical systems lens, wherein organisations are viewed as interdependent entities of people, machines, processes, and digital technologies (Fatorachian & Kazemi, 2018). This perspective stresses integration across levels linking cyber-physical systems with manufacturing execution systems MES, management operations MOM, and enterprise resource planning platforms into a coherent architecture. Gonzalez et al. (2024) argue that the realisation of "Organisation 4.0" requires not only technological adoption but also systemic innovation and business intelligence that support digital employees and empower decision-making. Similarly, Scriven et al. (2024) show that lean digital transformation frameworks integrate lean principles with digital enablers,

illustrating systems thinking in action by highlighting how efficiency gains emerge from aligning technological, organisational, and process subsystems. Systems perspectives also extend to supply chains. Reaidy et al. (2024) demonstrate that the positive performance effects of I4.0 technologies are mediated by integration and visibility system-level attributes that cannot be achieved by piecemeal technological deployments. This resonates with Ada et al. (2023), who argue that the adoption of I4.0 in food supply chains only creates sustainability gains when technologies are embedded into holistic circular systems that integrate data flows, waste reduction mechanisms, and partner coordination. Thus, systems theory indicates that transformation success depends not on isolated tools but on interdependencies across the organisational ecosystem.

Institutional Dynamics Perspective

Complementing systems thinking, institutional theory highlights how external pressures regulatory, normative, and cultural shape organisational adoption of I4.0 and digital technologies. Perotti et al. (2024), in their study of circular businesses, find that SMEs' sequencing of digital initiatives is strongly influenced by regulatory incentives, stakeholder expectations, and industry norms, rather than purely internal efficiency concerns. This echoes findings by Neri et al. (2023), who emphasise that in the circular economy context, digital adoption is catalysed by external legitimacy pressures and policy frameworks. Cultural and normative forces also play a central role. Cadden et al. (2022) demonstrate that the integration of AI in supply chains depends significantly on cultural enablers, such as openness to innovation, collaboration, and trust, which mediate the impact of technology adoption on operational outcomes. Similarly, Van Doorn et al. (2022) show that middle managers' roles in digital transformation are shaped not only by organisational structures but also by institutionalised expectations of managerial responsibility and authority, which influence how they interpret and enact transformation initiatives.

Complementary Perspectives

While systems theory and institutional dynamics dominate, other perspectives provide complementary insights. The dynamic capabilities framework explains how firms develop sensing, seizing, and reconfiguring abilities to thrive amid technological turbulence (Ahmed et al., 2024). In parallel, the resource-based view positions digital skills, data management, and leadership as critical intangible assets that underpin competitive advantage in transformation contexts (Ramadan et al., 2023). These perspectives converge with institutional and systems lenses in showing that digital transformation is not simply technological implementation but a multi-level process requiring alignment of internal subsystems with external environments. Taken together, these theoretical lenses clarify why identical technologies often lead to divergent trajectories. Success emerges when digital technologies are aligned with organisational subsystems processes, people, and structures while also resonating with institutional

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contexts, including regulations, cultural norms, and stakeholder pressures. Transformation, therefore, is simultaneously a systems integration challenge and an institutional adaptation journey.

Readiness and Maturity

A recurring theme across the Industry 4.0 (I4.0) and digital transformation literature is that organisational *readiness* strongly predicts transformation outcomes. Firms rarely transition in a linear fashion from analogue to digital; instead, they progress through maturity stages, where technological, organisational, and cultural capabilities must align. This explains why two firms with access to similar technologies can experience divergent results, the level of readiness and the maturity of enabling systems condition the trajectory. Numerous frameworks have emerged to assess readiness and maturity. Early attempts such as IMPULS, Connected Enterprise, and the Industry 4.0 Maturity Index provide diagnostic structures that help firms locate themselves on a maturity ladder (Antony et al., 2023). Subsequent syntheses caution, however, that these models cannot be applied mechanically; measurement heterogeneity across studies reflects different assumptions about what constitutes readiness (strategy, technology, people, operations, or culture), and a “one-size-fits-all” approach risks oversimplification (Antony et al., 2023; Gonzalez et al., 2024). Scriven et al. (2024) further note that maturity is best understood as *dynamic capability development*, where lean and digital principles co-evolve, rather than as static stages on a checklist.

Barriers Relative to Starting Point

Case-based research reinforces the importance of contextualised readiness assessments. Govindan and Arampatzis (2023), in a Danish manufacturing case, identified the firm as effectively “Industry 3.5” straddling legacy and digital systems. Of 21 candidate barriers, policy and organisational factors, especially leadership commitment and vision, were most influential. This illustrates that readiness assessments should not only map technological assets but also account for governance, leadership, and workforce preparedness. Similarly, Vimal et al. (2023) show that in functional circular economy networks, barriers such as lack of awareness, inadequate infrastructure, and negative perceptions towards digitalisation weigh more heavily at early stages of maturity. Addressing such barriers requires sequencing transformation efforts according to readiness rather than pursuing wholesale digitalisation. Empirical studies confirm that readiness is highly sector- and context-dependent. Ahmed et al. (2024) studying Malaysian manufacturers, find that change-sensing and seizing capabilities determine readiness for DT, with firms exhibiting strong dynamic capabilities able to advance more rapidly along the maturity spectrum. In supply chain contexts, Reaidy et al. (2024) argue that readiness is not just a firm-level property but also depends on the maturity of partner ecosystems, since integration and visibility mediate I4.0’s performance effects. Likewise, Ada et al. (2023) demonstrate that in food supply

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chains, readiness involves embedding circular practices through IoT, cloud, and analytics but only when firms have already invested in basic digital infrastructure and cultural openness to collaboration.

Human and Cultural Enablers

Readiness is also shaped by workforce and cultural dimensions. Gonzalez et al. (2024) emphasise that "digital employees" with the right skills, empowered by business intelligence systems, are critical antecedents of Organisation 4.0. However, their contribution to organisational maturity is often underestimated, with more research needed on how employee knowledge, skills, and attitudes evolve across readiness stages. Similarly, Cadden et al. (2022) highlight that cultural enablers such as openness to innovation, collaboration, and trust mediate AI adoption in supply chains, serving as invisible maturity indicators that complement technical readiness. Recent reviews suggest moving beyond static readiness indices to more adaptive frameworks. Scriven et al. (2024) propose a lean digital transformation value research framework that incorporates both lean efficiency drivers and digital enablers, allowing firms to adapt maturity models to their own sectoral realities. This aligns with broader calls to see readiness not as a fixed benchmark but as a fluid capacity to sense, adapt, and reconfigure capabilities over time (Ahmed et al., 2024). Readiness and maturity determine not only *where* firms begin their transformation journey but also *how* they should prioritise investments, sequence adoption, and manage barriers. Firms that treat maturity models as diagnostic tools for reflection rather than rigid benchmarks are more likely to tailor strategies effectively, align with institutional contexts, and achieve sustainable Industry 4.0 outcomes.

Enablers and Capabilities

A growing body of research highlights that the success of Industry 4.0 (I4.0) and digital transformation initiatives depends less on the availability of advanced technologies and more on the development of organisational enablers and capabilities. Findings consistently highlight leadership, culture, governance processes, lean-digital synergies, and multi-level capability development as critical to transforming technological adoption into sustained business value.

Leadership and Culture

Leadership is repeatedly identified as both a barrier and an enabler of transformation. Govindan and Arampatzis (2023) demonstrate that leadership commitment is a decisive factor in overcoming barriers to I4.0 adoption, with weak leadership resulting in inertia even when technologies are available. Van Doorn et al. (2022) further show that middle managers become pivotal in DT by spanning boundaries between strategic ambitions and operational practices, though role ambiguity and lack of support can limit their effectiveness. Transformational leadership has also been shown to foster innovative performance and sustainability outcomes in I4.0 contexts by promoting experimentation and knowledge-

sharing (Nasir et al., 2022). Moreover, Gonzalez et al. (2024) introduce the concept of "Organisation 4.0," stressing that digital employees thrive when leadership cultivates organisational agility and a supportive cultural environment. In SMEs, Ramadan et al. (2023) highlight that leadership's role in knowledge transfer and cultural agility is central to embedding digital transformation and business model innovation.

Business Process Management (BPM) and Governance

Studies stress that technology adoption generates value when integrated into formalised business process management structures. The creation of AI-enabled business models requires business process management capabilities such as process monitoring, continuous improvement, and governance mechanisms to convert isolated pilots into repeatable business value (Climent et al., 2024). Evidence from "Creating AI business value through BPM capabilities" confirms that business process management acts as a bridge between digital technologies and organisational performance by embedding data and AI lifecycles into decision-making. Similarly, Neri et al. (2023) emphasise governance structures in circular economy transitions, showing that digital tools only enable sustainable practices when supported by clear rules, accountability frameworks, and collaborative process management. Thus, governance and business process management emerge as necessary complements to technology in order to align DT with broader strategic objectives.

Lean, Six Sigma, and Automation

The coupling of lean and digital transformation is another widely documented enabler. Scriven et al. (2024) propose a lean digital transformation framework that integrates lean principles with digital tools to eliminate waste and increase efficiency. Reviews stress that Lean/Six Sigma redesigns stabilise processes, while digital tools such as IoT, analytics, and robotic process automation amplify gains by adding scalability and real-time responsiveness. Antony et al. (2024) caution, however, that Quality 4.0 efforts can fail without adequate conceptual clarity and workforce readiness, indicating that lean approaches must be embedded into organisational culture to succeed. Evidence from financial services illustrates that lean six sigma provides structured methodologies for robotic process automatio adoption, ensuring error-proofing and accelerating cycle times when accompanied by effective change management (Emerald, 2024). This reinforces the view that lean and automation should not be seen as substitutes but as complementary pathways that drive efficiency and innovation simultaneously.

Capability Development

Transformation success hinges on multi-level capability development. Papadonikolaki et al. (2022) highlight that in the built environment, capabilities must be developed at the level of individuals (digital skills), projects (alignment of objectives and tools), firms (strategic alignment), and ecosystems (inter-

organisational collaboration). Ahmed et al. (2024) similarly show that Malaysian manufacturers with robust sensing and seizing capabilities are better positioned to capture digital transformation opportunities. Cadden et al. (2022) stress the cultural enablers trust, collaboration, openness that underpin capability development for AI integration in supply chains. These findings suggest that DT requires both hard capabilities (infrastructure, digital tools) and soft capabilities (skills, learning, culture) working in tandem.

Data Governance and Analytics Capabilities

Another critical enabler lies in the development of robust data management and analytics capabilities. Reaidy et al. (2024) demonstrate that the performance impact of I4.0 technologies in supply chains is mediated by visibility and integration, both of which depend on effective data governance. Ada et al. (2023) show that in food supply chains, circular economy practices such as waste reduction and resource efficiency only materialise when data-driven insights from IoT and cloud platforms are shared across actors. Climent et al. (2024) argue that organisations must build business intelligence and analytics capabilities alongside technological investments to capture sustained value. Without governance frameworks to ensure data quality, transparency, and accountability, advanced tools like AI and big data analytics risk reinforcing silos rather than enabling transformation. Leadership, business process management, lean principles, and data governance are convergent enablers that condition the outcomes of Industry 4.0 adoption. Organisations that invest in these capabilities are more likely to convert technological opportunities into operational excellence, sustainable practices, and competitive advantage.

Barriers and Resistance

Despite the transformative potential of Industry 4.0 (I4.0) and digital transformation (DT), many organisations encounter substantial barriers that stall or derail progress. Evidence across empirical and conceptual studies shows that these barriers are multidimensional, spanning human and cultural resistance, conceptual and skills-related gaps, as well as sector- and context-specific constraints. Resistance at the human level remains one of the most persistent obstacles to digital transformation. Ito et al. (2021) identify key factors such as perceived over-supervision, lack of perceived value, job insecurity, and work overload as central to employee reluctance in production settings. In the context of smart working in public organisations, Todisco et al. (2023) highlight how unclear expectations and fears of reduced autonomy generate ambivalence toward digitalisation. Collectively, these findings stress the importance of transparent communication, employee participation, and targeted training to build trust and mitigate resistance. Beyond resistance, conceptual misunderstandings and inadequate capabilities frequently undermine transformation initiatives. Antony et al. (2024) demonstrate that Quality 4.0 efforts often fail due to limited understanding of concepts, lack of training, and inadequate top management

support. Ahmed et al. (2024) show that the absence of dynamic sensing and seizing capabilities in Malaysian manufacturing firms restricts their ability to translate digital tools into competitive advantage. These findings highlight that capability gaps whether in leadership, workforce skills, or data management are as detrimental as technological deficiencies.

Circular-Economy and Sustainability Contexts

In sustainability-driven transformations, barriers manifest differently. Vimal et al. (2023) note that functional circular economy networks are hindered by unclear benefits, negative perceptions of technology, and poor infrastructure. Neri et al. (2023) add that in circular economy transitions, barriers also stem from weak governance and misaligned stakeholder incentives, which slow down the integration of digital solutions into sustainable practices. Ada et al. (2023) highlight that in food supply chains, the adoption of circular digital practices often fails when small actors lack the resources or capabilities to align with digital standards, leading to uneven progress and systemic inefficiencies.

Governance, Ethical, and Infrastructural Barriers

Studies also stress the importance of governance and ethics in overcoming barriers. Venugopal et al. (2024) argue that concerns over data privacy, algorithmic bias, and the lack of ethical governance frameworks hinder the acceptance of AI in HRM functions, fuelling mistrust among employees. In the procurement sector, Ashal and Morshed (2024) observe that regulatory complexity across jurisdictions, uncertainty over data ownership, and skill shortages impede digital adoption in Gulf economies. Reaidy et al. (2024) further note that infrastructural immaturity particularly in data integration and visibility often prevents firms from achieving the promised performance benefits of I4.0 technologies. Barriers vary not only by type but also by sectoral and regional context. For example, Ahmed et al. (2024) demonstrate that in emerging economies, readiness is closely tied to government support and institutional conditions, meaning that external barriers can be as significant as internal ones. In healthcare supply chains, Tortorella et al. (2024) note that the complexity of resilience-building through digital tools is amplified by resource shortages and the urgency imposed by crises such as COVID-19. Similarly, Acquila-Natale et al. (2022) find that in retail, legacy IT systems and organisational silos often act as major impediments to channel integration during digital transformation. Taken together, the literature reveals that barriers to transformation are not confined to technological deficiencies; they are embedded in human behaviour, organisational culture, governance frameworks, and infrastructural ecosystems. Successful digital transformation requires recognising these barriers early, sequencing interventions according to readiness levels, and prioritising both technical and social systems to ensure adoption.

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Operational and Supply Chain Impacts

The operational and supply chain (SC) implications of Industry 4.0 (I4.0) adoption are among the most widely studied outcomes of digital transformation. Findings across sectors consistently show that advanced technologies create potential for efficiency and responsiveness, but realised outcomes emerge only when firms achieve integration, enhance visibility, and build resilience into their networks. Supply chain integration both horizontal across partners and vertical across organisational levels has been repeatedly shown to mediate the impact of I4.0 technologies. Reaidy et al. (2024) demonstrate that technologies such as IoT, cloud platforms, and advanced analytics only translate into performance improvements when embedded in integrated processes that connect suppliers, manufacturers, and customers. Similarly, Tortorella et al. (2024) in healthcare SCs during COVID-19 highlight that the adoption of I4.0 tools improved performance not directly, but through resilience-building integration mechanisms that linked procurement, logistics, and service delivery. In the manufacturing context, Horváth & Szabó (2019) found that multinational enterprises achieve superior I4.0 benefits compared to SMEs because of stronger inter-organisational integration capabilities, which allow them to synchronise global supply chains more effectively.

Differential Dynamics of Industry 4.0 Adoption Between SMEs and Large Enterprises

The findings reveal that Industry 4.0 adoption is not uniform across firms, with small and medium-sized enterprises (SMEs) experiencing structurally different opportunities and constraints compared to large organisations (Horváth & Szabó, 2019). Evidence consistently indicates that while multinational enterprises benefit from stronger resource bases, SMEs face limitations related to financial capacity, technological expertise, and organisational readiness, which shape their adoption trajectories (Horváth & Szabó, 2019; Stentoft et al., 2021). However, the findings also demonstrate that SMEs are not merely disadvantaged actors; rather, they possess unique adaptive advantages such as flexibility, niche market positioning, and the ability to experiment with incremental digital innovations (Müller et al., 2018). This suggests that Industry 4.0 adoption in SMEs is often more evolutionary than revolutionary, progressing through staged readiness rather than large-scale transformation (Mittal et al., 2018). Importantly, the findings highlight that managerial perception plays a critical role in shaping adoption, as SMEs are more likely to engage with Industry 4.0 when clear business value is identified, rather than purely in response to technological pressure (Stentoft et al., 2021). Overall, firm size is not only a structural variable but also a strategic lens that influences how Industry 4.0 is understood, adopted, and implemented across organisational settings (Moeuf et al., 2020).

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Interplay Between Drivers, Barriers, and Organisational Readiness

The findings reveal that Industry 4.0 implementation is shaped by a complex interaction between enabling drivers and constraining barriers, rather than a linear adoption process (Müller, Kiel, & Voigt, 2018). Strategic, operational, environmental, and social opportunities act as important drivers where firms seek improved efficiency, flexibility, competitiveness, and sustainability through digital integration (Müller, Kiel, & Voigt, 2018). At the same time, barriers such as lack of skilled personnel, financial constraints, short-term strategic thinking, and technological incompatibility continue to limit the pace and depth of adoption, especially among SMEs (Horváth & Szabó, 2019; Moeuf et al., 2020). These barriers are not purely technical but are embedded in organisational structures, cultures, managerial assumptions, and strategic orientations (Mittal et al., 2018; Stentoft et al., 2021). Crucially, readiness for Industry 4.0 is less about the absence of barriers and more about the organisation's ability to interpret and respond to them, as firms that perceive clear value propositions are more willing to engage despite existing constraints (Stentoft et al., 2021). This reinforces the view that adoption is driven by perceived strategic relevance rather than technological availability alone (Warner & Wäger, 2019).

Business Model Transformation as a Core Outcome of Industry 4.0

The findings demonstrate that Industry 4.0 extends beyond operational efficiency and fundamentally reshapes organisational business models (Müller, Buliga, & Voigt, 2018). Digital technologies enable new forms of value creation, value delivery, and value capture, allowing firms to move towards more integrated, service-oriented, and data-driven business models (Müller, Buliga, & Voigt, 2018; Verhoef et al., 2021). For SMEs, this transformation is often gradual and context-dependent, with firms adopting hybrid models that combine traditional manufacturing with digital capabilities rather than fully replacing existing structures (Müller, Buliga, & Voigt, 2018). The role of firms within the Industry 4.0 ecosystem, whether as users or providers, also influences the nature and direction of business model innovation (Müller, Buliga, & Voigt, 2018). This suggests that Industry 4.0 should not be conceptualised solely as a technological shift, but as a strategic reconfiguration of how organisations create, deliver, and sustain value in increasingly digital environments (Vial, 2019; Verhoef et al., 2021).

Strategic and Capability-Based Foundations of Digital Transformation

The findings highlight that successful Industry 4.0 implementation is underpinned by the development of organisational capabilities rather than the mere adoption of technologies (Warner & Wäger, 2019). Dynamic capabilities such as sensing opportunities, seizing them, and transforming organisational processes are critical for navigating digital transformation (Warner & Wäger, 2019). This is reinforced by broader digital transformation literature, which conceptualises transformation as a multidimensional process involving changes in strategy, organisational structures, business models, and value creation

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mechanisms (Vial, 2019; Verhoef et al., 2021). Technological adoption without corresponding organisational adaptation is therefore unlikely to produce meaningful transformation outcomes (Vial, 2019). Furthermore, digital transformation requires continuous strategic renewal, where organisations must align technological initiatives with long-term strategic objectives, collaborative practices, and organisational culture (Warner & Wäger, 2019). These insights strengthen the current study by situating Industry 4.0 within a broader theoretical framework of digital transformation and strategic capability development (Vial, 2019; Warner & Wäger, 2019).

Circular Economy, Sustainability Through Digital Enablers

The circular economy provides another fertile domain for illustrating the interplay between DT and sustainability. Neri et al. (2023) find that digital technologies enable eco-industrial networks by supporting material take-back schemes, green packaging innovations, and waste-to-resource exchanges. Perotti et al. (2024) demonstrate that SMEs moving along “going circular” pathways rely on digital enablers to sequence their transitions, but progress depends on regulatory incentives and stakeholder expectations. In food supply chains, Ada et al. (2023) show that IoT, analytics, and cloud-based platforms enhance circular practices such as waste reduction and resource efficiency, provided coordination spans the full design-to-distribution process. These cases indicate that circularity is not achieved by technology alone, but by embedding digital tools within governance frameworks, partnerships, and systemic redesigns of value chains. Sectoral illustrations reinforce the path-dependent and context-sensitive nature of digital transformation. In the built environment, the focus is on multi-actor coordination; in retail, on agility and responsiveness; in procurement, on governance and transparency; and in circular economy domains, on sustainability and systemic integration. Together, these examples reveal that successful transformation is always mediated by sectoral logics that determine how technologies are absorbed and translated into performance and sustainability outcomes.

Comparative Dynamics of Industry 4.0 Adoption Between SMEs and Large Corporations

The findings indicate that firm size significantly shapes the trajectory, priorities, and outcomes of Industry 4.0 adoption. Large corporations generally possess stronger financial resources, advanced technological infrastructure, and specialised human capital, enabling them to implement large-scale digital transformation initiatives more rapidly and comprehensively (Horváth & Szabó, 2019). Their greater access to global supply chain networks and established governance systems also enhances their ability to integrate advanced technologies such as AI, IoT, and predictive analytics across organisational functions. In contrast, SMEs often face more severe barriers related to limited financial capacity, shortage of digital expertise, infrastructural limitations, and uncertainty regarding return on investment (Moeuf et al., 2020; Stentoft et al., 2021). However, the findings also suggest that SMEs

possess unique adaptive strengths, including organisational flexibility, faster decision-making structures, and greater responsiveness to niche market opportunities (Müller et al., 2018). Rather than pursuing radical transformation, SMEs tend to adopt Industry 4.0 incrementally through staged and evolutionary approaches aligned with their operational realities (Mittal et al., 2018). The literature further demonstrates that the prioritisation of digital transformation enablers differs according to firm size. Large organisations place greater emphasis on system integration, advanced analytics, governance structures, and supply chain visibility, whereas SMEs prioritise affordability, workforce skills development, managerial support, and practical business value (Horváth & Szabó, 2019; Stentoft et al., 2021). Similarly, barriers associated with resistance to change, capability gaps, and technological uncertainty tend to be more pronounced in SMEs due to resource constraints and lower digital maturity levels (Moeuf et al., 2020). These findings reinforce the argument that Industry 4.0 implementation should not be approached through universal models, but through context-sensitive strategies that account for differences in organisational scale, readiness, and strategic priorities.

Dimension	SMEs	Large Corporations
Financial resources	Limited budgets constrain large-scale digital investment	Greater financial capacity enables comprehensive digital transformation
Technological infrastructure	Often dependent on legacy systems and gradual upgrades	More advanced digital infrastructure and integration capabilities
Skills and expertise	Limited access to specialised digital talent	Greater access to skilled workforce and dedicated IT teams
Decision-making	Faster and more flexible decision-making structures	More formalised but slower decision-making processes
Transformation approach	Incremental and evolutionary adoption	Large-scale and strategic transformation initiatives
Key enablers	Managerial support, flexibility, affordability, workforce adaptability	Governance structures, analytics, integration, innovation capability
Major barriers	Financial constraints, capability gaps, technological uncertainty	Organisational complexity, integration challenges, resistance across departments
Strategic focus	Survival, operational efficiency, niche competitiveness	Global competitiveness, scalability, supply chain optimisation

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Readiness level	Generally lower digital maturity	Higher digital maturity and readiness

Table 1: Comparative Dynamics of Industry 4.0 Adoption Between SMEs and Large Corporations (Source: Developed by the authors based on Horváth and Szabó (2019), Moeuf et al. (2020), Stentoft et al. (2021), Müller et al. (2018), and Mittal et al. (2018))

Future Trajectories: From Quality 4.0 to Organisation 4.0

The future trajectory of Industry 4.0 is increasingly moving beyond automation toward intelligent, adaptive, and human-centred organisational systems. Within this transition, Quality 4.0 has emerged as a framework that integrates traditional quality management with advanced digital technologies such as artificial intelligence, IoT, cloud computing, and predictive analytics (Sony et al., 2022). Unlike conventional quality systems that focus primarily on inspection and correction, Quality 4.0 promotes real-time monitoring, predictive quality control, and data-driven decision-making. Recent studies indicate that successful implementation requires organisations to develop digital quality capabilities, analytical skills, leadership support, and integrated digital infrastructures rather than relying solely on technological investment (Dias et al., 2022; Javaid et al., 2023). Practical implementation examples are becoming increasingly visible across industries. In manufacturing, AI-supported systems are being used for predictive maintenance and automated quality monitoring, while blockchain technologies are improving traceability and transparency in supply chains (Frederico et al., 2021). Similarly, healthcare organisations are integrating intelligent digital systems to improve operational responsiveness and service quality (Tortorella et al., 2022). These developments demonstrate that Quality 4.0 is evolving through integrated digital ecosystems rather than isolated technological applications. The emergence of Organisation 4.0 extends this transformation to the broader organisational environment. Organisation 4.0 refers to digitally intelligent organisations that integrate people, technologies, and agile decision-making systems into adaptive organisational structures (Flores et al., 2023). This includes digitally empowered employees, collaborative work environments, and hybrid human-AI decision-making systems. Scholars further emphasise that future transformation will increasingly depend on organisational competencies such as digital governance, innovation capability, continuous learning, and workforce adaptability (Raisch & Krakowski, 2021). Consequently, the future of Industry 4.0 is likely to depend not only on technological sophistication but also on organisations' ability to combine digital intelligence with human-centred leadership and adaptive organisational cultures.

Discussion

The findings of this study demonstrate that Industry 4.0 and digital transformation are not merely technological developments, but broader organisational transformation processes. Although technologies such as AI, IoT, analytics, and cloud systems are often associated with improved efficiency and competitiveness, the findings indicate that their success depends largely on organisational

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readiness, leadership support, workforce capabilities, governance structures, and process integration. This suggests that digital transformation should be viewed less as technology adoption and more as organisational adaptation and capability development. One of the most significant findings is the central role of organisational readiness and maturity. The study shows that organisations differ considerably in their ability to implement digital transformation due to variations in infrastructure, culture, strategic alignment, employee preparedness, and leadership commitment. As a result, transformation outcomes are uneven across organisations. This implies that many digital transformation failures are not necessarily caused by technological limitations, but rather by a mismatch between organisational capabilities and transformation ambitions. The findings therefore highlight the importance of phased and context-sensitive transformation strategies. The study further reveals that leadership plays a critical role in shaping successful transformation environments. Effective leadership supports strategic direction, organisational agility, employee engagement, and collaboration during periods of change. This reinforces the view that digital transformation is not only a technical process, but also a human and managerial challenge. Organisations that focus exclusively on technological implementation while neglecting organisational culture and employee involvement may struggle to achieve sustainable outcomes. Another important finding concerns the differences between SMEs and large organisations. Large corporations generally possess stronger financial resources, advanced infrastructure, and specialised expertise, enabling them to implement large-scale digital initiatives more effectively. In contrast, SMEs often experience challenges related to limited budgets, lower digital maturity, and shortages of technical expertise. However, SMEs also demonstrate important strengths such as flexibility, adaptability, and faster decision-making processes. This suggests that digital transformation pathways should not be universal, but should instead reflect organisational size, capabilities, and operational realities. The findings also indicate that barriers to transformation are largely socio-organisational rather than purely technical. Resistance to change, skills shortages, weak governance, and uncertainty regarding digital value emerged as major obstacles across sectors. This demonstrates that technological investment alone is insufficient for successful transformation. Organisations must simultaneously invest in communication, workforce development, training, and trust-building initiatives to strengthen employee support and reduce uncertainty during digital transitions. In addition, the study found that digital technologies generate value mainly through improved integration, coordination, and organisational responsiveness. Technologies become valuable when they enhance collaboration, improve visibility across operations and supply chains, strengthen decision-making, and increase organisational resilience. The findings therefore challenge assumptions that technological sophistication alone guarantees improved performance. The study further highlights the growing relationship between digital transformation and sustainability objectives. Digital technologies are increasingly being used to improve resource efficiency, supply-chain transparency, and circular economy practices. However, sustainability benefits are not automatic outcomes of digitalisation. They depend on governance

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systems, organisational commitment, and the alignment of digital initiatives with broader sustainability goals. Finally, the emergence of concepts such as Quality 4.0, Organisation 4.0, and human-AI collaboration suggests that the future trajectory of Industry 4.0 is becoming increasingly intelligent, adaptive, and human-centred. Future competitiveness is likely to depend not only on technological capability, but also on organisations' ability to combine digital systems with human judgement, organisational learning, ethical governance, and workforce adaptability. The discussion demonstrates that successful digital transformation depends on the alignment of technological, organisational, strategic, and human dimensions. Organisations that achieve meaningful outcomes are those that integrate technology adoption with leadership support, workforce development, governance, and adaptive organisational cultures. Industry 4.0 should therefore be understood as a continuous organisational transformation process rather than a once-off technological intervention.

Conclusion

The findings show that successful transformation depends on organisational readiness, leadership support, workforce capability, governance, and process integration. The study further highlights that transformation outcomes vary across organisational and sectoral contexts, particularly between SMEs and large corporations due to differences in resources, digital maturity, and operational capacity.The findings also demonstrate that digital technologies generate meaningful value when integrated into organisational systems that support collaboration, agility, and resilience. At the same time, barriers such as resistance to change, skills shortages, and limited readiness continue to constrain transformation efforts. Emerging trajectories such as Quality 4.0, Organisation 4.0, and human-AI collaboration further suggest that the future of digital transformation is becoming increasingly adaptive and human-centred. Although this review provides a broad synthesis across multiple sectors, the reviewed literature remains uneven across industries and contexts, with many studies being exploratory and cross-sectional. In addition, the rapid evolution of digital technologies means that some findings may become time-sensitive over time. Nevertheless, the integration of conceptual, empirical, and review-based studies strengthens the overall robustness of the analysis.

Recommendations

Organisations should approach Industry 4.0 and digital transformation as long-term organisational capability-building processes rather than short-term technological projects. Before implementing digital technologies, organisations should assess their readiness, workforce capability, infrastructure, and strategic alignment to support more sustainable transformation outcomes. The study further recommends stronger integration between digital technologies, organisational systems, and supply-chain processes through improved governance, coordination, and collaboration mechanisms. Organisations should also prioritise workforce development, employee engagement, and leadership

support to reduce resistance and improve adaptability during transformation. Finally, policymakers and industry stakeholders should strengthen support mechanisms for SMEs, particularly in areas such as digital skills development, infrastructure support, and technology access.

Future research should focus on how organisations translate digital transformation strategies into measurable operational, financial, and sustainability outcomes across different sectors and contexts. More longitudinal and empirical studies are also needed to examine how organisational readiness, leadership capability, and workforce adaptability evolve throughout transformation processes. Further studies could explore emerging areas such as Quality 4.0, Organisation 4.0, digital servitisation, and human-AI collaboration, particularly regarding their implications for organisational structures, workforce roles, and sustainability. Additional research within SMEs and developing economies would also provide important context-specific insights into digital transformation challenges and opportunities.

References

Ahmed, S., Abd Aziz, N., Haque, R., Bin S. Senathirajah, A. R., & Qazi, S. Z. (2024). Digital transformation in Malaysian manufacturing: a study of change sensing and seizing capabilities. *Cogent Business & Management*, *11*(1), 2392046.

Antony, J., Kaul, A., Bhat, S., Sony, M., Kaul, V., Zulfiqar, M., & McDermott, O. (2024). Critical failure factors for Quality 4.0: An exploratory qualitative study. *International Journal of Quality & Reliability Management, 41*(4), 1044–1062.

Antony, J., Sony, M., & McDermott, O. (2023). Conceptualizing Industry 4.0 readiness model dimensions: an exploratory sequential mixed-method study. *The TQM Journal*, *35*(2), 577-596

Antony, J., Sony, M., Furterer, S., McDermott, O., & Pepper, M. (2022). Quality 4.0 and its impact on organizational performance: an integrative viewpoint. *The TQM Journal*, *34*(6), 2069-2084.

Cadden, T., Dennehy, D., Mantymaki, M., & Treacy, R. (2022). Understanding the influential and mediating role of cultural enablers of AI integration to supply chain. *International Journal of Production Research, 60*(14), 4592–4620.

Carvalho, A. M., Dias, A. R., Dias, A. M., & Sampaio, P. (2024). The Quality 4.0 Roadmap: Designing a capability roadmap toward quality management in Industry 4.0. *Quality Management Journal*, *31*(2), 117-137. Scriven, P., Ledwith, A., & Nagle, T. (2024). Towards a lean digital transformation research framework: A literature review. *Journal of Decision Systems, 33*(sup1), 63–77.

Climent, R. C., Haftor, D. M., & Staniewski, M. W. (2024). AI-enabled business models for competitive advantage. *Journal of Innovation & Knowledge*, *9*(3), 100532.

Dias, A. M., Carvalho, A. M., & Sampaio, P. (2022). Quality 4.0: literature review analysis, definition and impacts of the digital transformation process on quality. *International Journal of Quality & Reliability Management*, *39*(6), 1312-1335.

Fatorachian, H., & Kazemi, H. (2018). A critical investigation of Industry 4.0 in manufacturing: Theoretical operationalisation framework. *Production Planning & Control, 29*(8), 633–644.

Flores, E., Xu, X., & Lu, Y. (2020). Human Capital 4.0: a workforce competence typology for Industry 4.0. *Journal of Manufacturing Technology Management*, *31*(4), 687-703.

Frederico, G. F., Garza-Reyes, J. A., Kumar, A., & Kumar, V. (2021). Performance measurement for supply chains in the Industry 4.0 era: a balanced scorecard approach. *International journal of productivity and performance management*, *70*(4), 789-807.

Gonzalez, R., Gasco, J., & Llopis, J. (2024). Towards Organisation 4.0: An empirical study. *International Journal of Information Management, 75*, 102746.

Govindan, K., & Arampatzis, G. (2023). A framework to measure readiness and barriers for the implementation of Industry 4.0: A case approach. *Electronic Commerce Research and Applications, 59*, 101249.

Horváth, D., & Szabó, R. Z. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? *Technological Forecasting and Social Change, 146*, 119–132.

Horváth, D., & Szabó, R. Z. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?. *Technological forecasting and social change*, *146*, 119-132.

Ito, A., Ylipää, T., Gullander, P., Bokrantz, J., Centerholt, V., & Skoogh, A. (2021). Dealing with resistance to the use of Industry 4.0 technologies in production disturbance management. *Journal of Manufacturing Technology Management, 32*(9), 285–303.

Javaid, M., Haleem, A., Singh, R. P., Suman, R., & Gonzalez, E. S. (2022). Understanding the adoption of Industry 4.0 technologies in improving environmental sustainability. *Sustainable operations and computers*, *3*, 203-217.

Lundgren, C., Berlin, C., Skoogh, A., & Källström, A. (2023). How industrial maintenance managers perceive socio-technical changes in leadership in the Industry 4.0 context. *International Journal of Production Research*, *61*(15), 5282-5301.

Madsen, D. Ø. (2019). The emergence and rise of Industry 4.0 viewed through the lens of management fashion theory. *Administrative Sciences, 9*(3), 71.

Mittal, S., Khan, M. A., Romero, D., & Wuest, T. (2018). A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for SMEs. *Journal of Manufacturing Systems, 49*, 194–214.

Moeuf, A., Lamouri, S., Pellerin, R., Tamayo-Giraldo, S., Tobon-Valencia, E., & Eburdy, R. (2020). Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs. *International Journal of Production Research, 58*(5), 1384–1400.

Müller, J. M., Buliga, O., & Voigt, K.-I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change, 132*, 2–17.

Müller, J. M., Kiel, D., & Voigt, K.-I. (2018). What drives the implementation of Industry 4.0? The role of opportunities and challenges in the context of sustainability. *Sustainability, 10*(247), 1–24.

Nasir, A., Zakaria, N., & Zien Yusoff, R. (2022). The influence of transformational leadership on organizational sustainability in the context of industry 4.0: Mediating role of innovative performance. *Cogent Business & Management*, *9*(1), 2105575.

Papadonikolaki, E., Krystallis, I., & Morgan, B. (2022). Digital technologies in built environment projects: Review and future directions. *Project Management Journal, 53*(5), 512–526.

Raisch, S., & Krakowski, S. (2021). Artificial intelligence and management: The automation–augmentation paradox. *Academy of management review*, *46*(1), 192-210.

Ramadan, M., Bou Zakhem, N., Baydoun, H., Daouk, A., Youssef, S., El Fawal, A., Elia, J., & Ashaal, A. (2023). Toward digital transformation and business model innovation: The nexus between leadership, organizational agility, and knowledge transfer. *Administrative Sciences, 13*(8), 185.

Reaidy, P. J., Marqués, L., Mzougui, I., Khelifi, S., Dweiri, F., & Alzoubi, Y. I. (2024). Unveiling the impact of Industry 4.0 on supply chain performance: The mediating role of integration and visibility. *International Journal of Production Research*.

Stentoft, J., Wickstrøm, K. A., Philipsen, K., & Haug, A. (2021). Drivers and barriers for Industry 4.0 readiness and practice: Empirical evidence from small and medium-sized manufacturers. *Production Planning & Control, 32*(10), 811–828.

Todisco, L., Tomo, A., Canonico, P., & Mangia, G. (2023). The bright and dark side of smart working in the public sector: employees' experiences before and during COVID-19. *Management Decision*, *61*(13), 85-102.

Tortorella, G., Giglio, R., Fogliatto, F. S., & Sawhney, R. (2020). Mediating role of learning organization on the relationship between total quality management and operational performance in Brazilian manufacturers. *Journal of Manufacturing Technology Management*, *31*(3), 524-541.

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Trunk, A., Birkel, H., & Hartmann, E. (2020). On the current state of combining human and artificial intelligence for strategic organizational decision making. *Business Research*, *13*(3), 875-919.

Van Doorn, J., Heyden, M. L. M., & Volberda, H. W. (2022). Opportunity or threat? Exploring middle manager roles in the face of digital transformation. *Journal of Management Studies, 59*(5), 1213–1241.

Venugopal, M., Madhavan, V., Prasad, R., & Raman, R. (2024). Transformative AI in human resource management: Enhancing workforce planning with topic modeling. *Cogent Business & Management, 11*(1), 2432550.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Dong, J. Q., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research, 122*, 889–901.

Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *Journal of Strategic Information Systems*.

Warner, K. S. R., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning, 52*(3), 326–349.

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