

# Past, Present, and Future Barriers to Digital Transformation in Small Business Enterprises in Manufacturing Sector: A State - of - Art Review

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**Abstract:** *This article delves into the dynamic landscape of digital transformation in the manufacturing sector, particularly in the context of complex adaptive systems and the imperative posed by the COVID - 19 pandemic. It highlights the multifaceted nature of digital transformation, encompassing changes in business models, innovation strategies, and digital maturity, while emphasizing the pivotal role of mindset and culture within organizations. The pandemic underscored the significance of digital maturity in crisis management and offers valuable lessons for the future. The article also explores the potential of Strategic Doing, an agile leadership approach, to address the critical barrier of mindset change in digital transformation. It concludes by emphasizing that digital transformation is an ongoing journey, requiring continuous adaptation and alignment of human aspects with technological advancements, thus shaping the future of manufacturing and beyond.*

**Keywords:** Digital Transformation, Manufacturing, Complex Adaptive System, Organizational Culture, COVID - 19 Pandemic

## 1. Introduction

Manufacturing, often perceived as a realm of routine and predictability, has undergone a remarkable evolution over the last century (Lynch, et al., 2019; Mcmenamin, 2015). It transcends the confines of mere production lines and mechanized systems. In a more abstract context, manufacturing takes on the character of an organic, creative process, integral to bringing innovative products to life (Morgan, 2006). This perspective paints the manufacturing industry as a complex adaptive system (CAS) (Miller, 2016), characterized by self - organization, chaotic behavior, and adaptive interactions (Holland, 2014). In essence, it is a dynamic and fragile ecosystem, more adaptable and responsive than conventionally believed. Recent catalysts, such as rapid digital technology advancements and the disruptive wave of the COVID - 19 pandemic, have left manufacturing firms with a clear ultimatum: adapt or face obsolescence (Chen, et al., 2016; Openheimer, 2016).

Our paper explores digital transformation in manufacturing within the context of this dynamic and organic complexity (Kane, et al., 2019; Miller, 2016). Digital transformation, an ongoing challenge, gains a unique dimension in light of the COVID - 19 pandemic, prompting a critical reevaluation of organizational change. It is our contention that viewing manufacturing as a complex adaptive system enables organizations to surmount the barriers to digital transformation in the wake of a global crisis. "Wicked problems, " intrinsic to complex systems, defy straightforward solutions, demanding ongoing management rather than resolution (Rittel and Webber, 1973). Digital transformation, inherently a wicked challenge, defies one - size - fits - all solutions or uniform outcomes (Kane, et al., 2019). Rather, it unfolds as a continuous journey, characterized by the pursuit of greater digital maturity, much like the organic growth of a living organism. Amidst the multitude of barriers to digital transformation, none is as formidable and detrimental as the latent, pervasive mindsets within organizational culture. Therefore, addressing these challenges necessitates strategic tools that accommodate the

complexity of adaptive systems (wicked problems) while unearthing and transforming hidden organizational mindsets.

In response to the increasing complexity of modern products, distributed manufacturing processes, and elevated expectations from customers and partners, companies are transitioning to a more digital approach. This shift towards digital innovation is not just a choice but an imperative for maintaining competitiveness in a landscape marked by globalized markets. Resilience and sustainability, essential attributes for businesses, now encompass the digital domain (Zhang and Luttervelt, 2011). The supply chain ecosystem is now irrevocably intertwined with digital technology. Virtually no organization can escape the wave of digital architectural and operational modifications necessary to thrive in the digital age.

This literature review argues that digital transformation goes beyond the integration of technology into production lines; it encompasses a holistic transformation from processes to culture, rooted in pervasive mindsets held at the individual and organizational levels. To navigate this evolution successfully, new strategic initiatives must be implemented.

Our paper begins by assessing the impact of COVID - 19 on manufacturing, highlighting the urgency for a paradigm shift in response to the crisis. Next, we delve into the concept of digital transformation, identifying the persistent barriers that have hampered progress for years. These barriers are not categorized as static hindrances but rather as evolving obstacles that have gained prominence amid the COVID - 19 pandemic.

While various strategies exist to facilitate digital transformation, many focus on isolated aspects of an organization, overlooking the overarching need for a fundamental reimagining of the entire business. Understanding the complexity of the manufacturing industry, we assert that true transformation necessitates a comprehensive reevaluation of the system as a whole.

Furthermore, we scrutinize the impact of COVID - 19 on businesses' digital transformation efforts, highlighting the importance of digital readiness in weathering the storm, adapting, optimizing performance, ensuring business continuity, and thriving in the face of adversity.

The globalization of the business landscape has intensified the demand for change, prompting businesses to integrate digital processes and collaborative tools for survival and success. Digital transformation transcends technology and encompasses a broad spectrum of business perspectives, impacting multiple facets of an organization. It is not just a technological shift but a holistic endeavor, encompassing the entire organizational structure and culture. Industries and companies must adapt to disruptive innovations in digital technologies, introducing transformation requirements into their strategies to stay competitive in rapidly evolving markets.

### Examining the Definition for Digital Transformation

The concept of digital transformation has garnered substantial attention in recent literature (Mahmood, et al., 2019; Reis, et al., 2018), with several literature reviews aiming to provide insights into its broad spectrum, outcomes, and implications (Ismail, et al., 2017; Hausberg, et al., 2019; Vial, 2019). These reviews often approach the topic from diverse angles, encompassing domains like technological disruption and corporate entrepreneurship (Nadkarni and Prugl, 2020). The urgency of digital transformation is underscored by phrases like "Innovate or die!" (Getz and Robinson, 2003) and "Digitize or drown!" (Schreckling and Steiger, 2017). Schwab posits that we are entering the fourth industrial revolution, distinct from its predecessors by its fusion of digital technology with biological and physical systems (Schwab, 2016a; Schwab, 2016b). This transformative shift is altering the way we live and work (Pflaum, et al., 2018; Schwab, 2016b; Thomson, 2016), compelling industries to undergo complete digital transformation or risk obsolescence (Kane, et al., 2019). The advent of COVID - 19 has further accelerated the imperative to innovate or perish and digitize or face obsolescence.

The definition of digital transformation varies across sources (Henriette, et al., 2015; Morakanye, et al., 2017; Osmundesen, et al., 2018), leading to a lack of clarity regarding the scope of digital technologies (Singh and Hess, 2017) and the levels at which it operates, whether organizational, societal, or industrial (Agarwal, et al., 2010; Fitzgerald, et al., 2014; Khitskov, et al., 2017). Vial's extensive literature review yielded a more encompassing definition: "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies" (Vial, 2019). This definition stands out for several reasons: it doesn't confine digital transformation to a specific organization but allows for societal and industrial applications; it emphasizes improvement as the primary objective rather than inherent success; and it omits the term "digital technologies" to better align with existing literature and remain adaptable to evolving contexts.

While advanced digital technologies play a vital role in digital transformation, merely adopting and using digital tools doesn't encapsulate the full process. Digital transformation necessitates a holistic approach, considering a broad spectrum of technologies such as additive manufacturing, cloud computing, connectivity, robotics, automation, big data, artificial intelligence, digital twins, and Model - Based Enterprise environments (Hansen and Bogh, 2020; Lu, et al., 2020; Camba, et al., 2017). However, digital transformation extends beyond technology adoption, reaching into strategic, organizational, and cultural domains. It necessitates changes in business elements, encompassing strategy, business models, processes, organizational structures, and culture (Vukzic, et al., 2018). Scholars like Kane (2017) stress that addressing digital disruption primarily requires an organizational and managerial approach rather than a narrow focus on technical aspects.

In line with Govindarajan and Immelt's perspective, digital transformation involves reimagining products and services as digitally enabled assets, generating value through the interplay of physical and digital assets and data, and establishing ecosystems to facilitate these changes. It demands fundamental alterations in business and organizational activities, processes, competencies, and models, potentially transforming an organization's identity (Govindarajan and Immelt, 2019; Wessel. Et al., 2020). Throughout this transformative journey, people remain at the forefront, serving as the true agents of change and facilitators of digital transformation (Kane, et al., 2019; Larjovuori, et al., 2016).

### Manufacturing in the Post COVID - 19 Environment: Resilience and Digital Transformation

Because to the COVID - 19 epidemic, the manufacturing and industrial sectors have seen a dramatic change, with businesses adopting a "new normal" of "social distancing", "remote work requirements", and "lockdowns" (Aldrighetti et al.2021; Belhadi et al.2021; Dubey et al.2021; Dwivedi et al.2020; Ivanov and Dolgui 2021; Wang and Wang 2021). The industrial sector has shown resilience in the face of adversity before (Okorie et al., 2020); examples from the past include natural catastrophes, trade wars, political threats, and contagious illnesses. But the COVID - 19 pandemic is far worse than anything that has come before it, and it threatens the world economy in ways that have never been seen before (Handfield et al., 2020). For example, in January of 2020, the United States saw the largest monthly decline in industrial production since World War II (Rapaccini et al., 2020), and in the United Kingdom, the manufacturing sector faced severe economic shocks in the face of exit from the European Union and deindustrialization (Harris et al., 2020). The industrial sector, which was already struggling with a worldwide economic slowdown before the pandemic (Teng et al., 2021), is now facing a full - blown catastrophe as a result of the spread of the COVID - 19 virus. Although the manufacturing sector has faced difficulties in the past, it has not learned from those experiences (Handfield et al., 2020; Javaid et al., 2020).

COVID - 19 has increased manufacturers' exposure to economic shocks (Juergensen et al., 2020), a problem that has plagued the industry for some time. Companies in the

manufacturing sector are currently experiencing a severe downturn in business, with orders being cancelled (Wuest et al., 2020), revenues falling (Handfield et al., 2020), and stock values tumbling (Tian et al., 2021). These fluctuations and unpredictability have caused widespread concern in the business and have influenced the supply and demand curves in unexpected ways (Khoo & Hock, 2020). To succeed in this environment, one must have a deep comprehension of the obstacles in order to develop effective solutions that will ensure the longevity of manufacturing firms. This analysis draws on contemporary literature to compile the problems that manufacturers face today and to investigate possible solutions to these problems. Future strategic business choices and government regulation of manufacturing and international commerce will undoubtedly be affected by the pandemic (Dür et al., 2020; Pinna & Lodi, 2021). Future uncertainty and emergencies will likely necessitate changes to supply chains, more flexibility, and creative product planning (Sakhardande & Gaonkar, 2021).

The COVID - 19 pandemic's repercussions have been felt across the global economy, affecting virtually every industry and displacing millions of workers worldwide. In the manufacturing sector, the upheavals stemming from the pandemic and the resultant measures enforced by health and government authorities have compelled companies to adapt. This adaptation has encompassed changes to production lines, supply chains, and work environments, often entailing substantial investments in terms of time and capital.

The pandemic has spurred a wealth of research across various disciplines, particularly in the realm of manufacturing (Malik, et al., 2020; Tareq, et al., 2021; Wang and Wang, 2021). Manufacturing has emerged as a pivotal force in pandemic management and mitigation, as exemplified by the rapid reconfiguration, repurposing, and mass production efforts by manufacturers to produce essential medical supplies such as ventilators and personal protective equipment (PPE) (Okorie, et al., 2020). Additionally, studies have focused on manufacturing resilience and risk management, recognizing that resilience is a critical factor in ensuring success, even amid disruptions (Ivanov and Dolgui, 2020). Manufacturing resilience denotes an organization's capacity to adapt and maintain desired performance levels in the face of adversities, including pandemics. Axioms and design principles for resilient business information systems were suggested by researchers like Zhang & Lin (2010). While this discussion focuses on information systems and technology, the underlying ideas are applicable in many other contexts as well. In the context of manufacturing, however, it is unclear how much varying system components affect resilience. Ninety percent or more of manufacturers, according to recent polls, are setting aside funds for workforce digital transformation initiatives that emphasise resilience (Chemmeveau, et al., 2020). However, manufacturers face obstacles on the road to digital enterprise adoption due to the complex web of organisational viewpoints that converge at the shop floor (Govindarajan and Immelt, 2019). Most businesses are aware of technology advances, but few fully adopt them. This is typically due to a reactionary fear of falling behind the competition.

Experts like Kusiak have hailed the link between digital revolution and resilient manufacturing as a "opportunity" (2020). By definition, digital transformation necessitates the adjustment of processes, one of which may be to boost resilience (ibid.). The "design - for - resilience" approach aligns well with the concepts of digital transformation, allowing the many dimensions of industrial resilience to be incorporated into digitalization programmes. Improving "digital resilience" is critical, say Casalino et al. (2019), and should be central to any company's goals and objectives (ibid.).

The COVID - 19 disaster has highlighted the significance of manufacturing's digital revolution. Automation, networking, data analytics, cutting - edge communication, and manufacturing technologies are all part of the industry's fast digital transformation ambitions. Companies who are further along in their digital transformation path were better able to respond quickly and adapt to the epidemic than their less advanced competitors (Agarwal, et al., 2020).

Companies in the manufacturing sector have been forced to rethink their strategic structure in the wake of the crisis caused by the COVID - 19 epidemic (Rajesh 2021). Even while the pandemic has posed significant challenges, it has also created opportunity for businesses to develop new strategies and adapt to the market (Seetharaman 2020). Lockdowns and social distance have transformed customer behaviour, leading to a shift towards online business conducted through e - commerce portals (Moon et al., 2021), necessitating adjustments to current company structures. Partnership strategies have undergone a major overhaul as a result of companies adopting new forms of alliance and networking with other businesses (Telukdarie et al., 2020).

Industries have turned to technology as a crucial instrument in their fight against the pandemic's detrimental effects on the bottom line (Seetharaman 2020). Up the value - added curve and secure long - term profits with digital transformation (Priyono et al., 2020). The ability to quickly adjust to new working conditions and gain an edge in the market is a key benefit of digitally enabled business models.

Manufacturing companies have been able to weather the storm because of a trend known as servitization (Rapaccini et al., 2020). Servitization strategies can operate as income stabilisers in times of disruption and economic volatility (Ardolino et al.2018; Eloranta et al.2021), so reducing the severity of the epidemic.

The COVID - 19 pandemic has accelerated the need for digital transformation and resilience in the manufacturing sector. Companies that have embraced these principles are better positioned to adapt to the dynamic economic landscape and withstand disruptions. Manufacturing's response to the crisis underscores the importance of being agile, technologically savvy, and capable of reconfiguring business models. As the manufacturing industry charts its course in the post - COVID - 19 world, it is clear that digital transformation and resilience will be fundamental to its continued success. The lessons learned during this crisis will help guide the industry as it prepares for future challenges.

### Past, Present, and Future Barriers to Digital Transformation

Digital transformation in industries, especially those deeply rooted in the physical world, confronts a multitude of challenges. These barriers often hinder organizations from successfully integrating digital elements into their traditional business models, thereby changing the properties and operations of these entities. To better understand these barriers, it's essential to delve into their origins, significance, and evolving nature, with a specific focus on the key barriers identified by Tripathi and Gupta (2021).

Numerous taxonomies and lists of barriers to digital transformation have emerged from extensive literature reviews. These barriers are often ranked in terms of their significance and the difficulty they pose for organizations seeking transformation. Although several factors contribute to these barriers, technology - related challenges appear to be the most prevalent, as indicated by Tripathi and Gupta's findings.

Furthermore, Mahmood et al. (2019) emphasized the importance of an effective strategy and the challenges posed by technology disruption. In their study, these factors emerged as the highest - ranked barriers to digital transformation. This underscores the complexity of implementing digital technology effectively and underscores the importance of sound strategic planning in addition to technical considerations.

Tripathi and Gupta (2021) have outlined twelve significant barriers that are particularly relevant, of which six were also validated in subsequent studies (Kraus, et al., 2021; Meir, 2020; Raj, et al., 2020):

- 1) **Data Insufficiency and Unreliability:** This encompasses issues with data and its collection, transfer, processing, storage, and interoperability. Industries often lack the instrumentation to collect data without human intervention, leading to unreliable data, which is susceptible to malicious influences.
- 2) **Absence of Benchmarks and Reference Architecture:** A lack of standard protocols and terminology often creates confusion, impeding a clear understanding of Industry 4.0 concepts. Reference architectures are scarce, making it challenging for organizations to streamline their transformation processes.
- 3) **Complexity in Integrating Systems:** In order to upgrade to smart systems, current systems must be integrated with one another and the new technology. Interoperability problems and terminology disputes, caused by a lack of shared standards, might slow down the transformation process.
- 4) **Low Maturity Levels of Technology:** Most technologies are still in their early stages, and their applications are limited to innovative industries. These technologies are somewhat hyped and disruptive, but they often lack suitable business models to generate revenue.
- 5) **Cybersecurity and IPR Threats:** The past decade has seen an increasing concern about business models being affected by the theft of industrial data, intellectual properties, security breaches, and cyber - attacks. As

digitalization increases with Industry 4.0, the security of intangible assets and intellectual property is crucial.

- 6) **Unsuitable Infrastructure:** The availability of fast internet, cutting - edge machinery, pervasive sensor networks, reliable security measures, and cutting - edge R&D facilities are all essential for a successful transition. Industry 4.0 capabilities must be designed either on the foundation of already existing infrastructure or in parallel with the development of a more sophisticated infrastructure.

However, these barriers are not the only challenges organizations encounter in their digital transformation journey. In addition to recognizing these barriers, researchers have explored the causal relationships between them, identifying the extent to which one barrier influences or exacerbates others. This holistic understanding helps organizations develop comprehensive strategies to overcome these challenges.

Addressing the human element in digital transformation is another key concern. Vogelsang et al. (Vogelsang, et al., 2019) conducted interviews with experts in manufacturing industries and found that the greatest barrier was a lack of necessary skills. This is consistent with the finding that over 50% of companies lack the digital competencies required for successful transformation. Yet, there's a growing consensus that hiring individuals with the right mindset and adaptability is equally crucial.

Essentially, financial, logistical, and technological factors are seen as the primary obstacles to digital transformation in manufacturing by top - level executives. These issues are real and need multi - tiered solutions. More information is needed to determine the order in which these obstacles should be overcome, especially in terms of training and education.

Barriers consistent with a complex adaptive system approach have been found in recent research. For example, Stentoft et al. (Stentoft, et al., 2020) looked at medium - sized businesses specifically and found legislative/standards hurdles, management barriers, and personnel barriers. These challenges show how digital transformation is less about technology and more about making fundamental adjustments to an organization's strategy, business model, procedures, organisational structures, and culture. The power to effect change lies at the crossroads of these factors.

Boaz and Fox (Boaz and Fox, 2014) emphasized the importance of addressing pervasive mindsets within organizations when initiating digital transformation. Research suggests that organizations capable of identifying and addressing these mindsets at the outset of their transformation journey are more likely to succeed. This points to the significance of the cultural aspect of change. Understanding and adapting organizational culture, particularly mindset, is paramount in the success of digital transformation efforts.

While technology undoubtedly plays a central role in digital transformation, the barriers organizations face are often deeply rooted in organizational culture and mindset.

Recognizing the interconnectedness of these factors and prioritizing adaptable thinking as a key skill can significantly contribute to the success of digital transformation initiatives. This view emphasizes the importance of understanding the human aspect of change and aligning it with technological advancements for truly effective transformation, which includes overcoming the specific barriers highlighted by Tripathi and Gupta (2019).

### **Digital Transformation Efforts in Manufacturing**

Digital transformation in the manufacturing sector has brought about profound changes, not only in technological aspects but also in business models, innovation strategies, and the ability to manage critical events like the COVID - 19 pandemic. In this section, we will explore the various dimensions of digital transformation efforts in manufacturing, focusing on business model strategies, changes in the context of innovation, digital transformation, and digital maturity in managing the pandemic, and the lessons these experiences provide for the future.

### **Business Model Strategies**

The adoption of digital technologies in manufacturing does not necessarily entail a complete overhaul of established business models. Rather, organizations often expand their existing models by incorporating digital aspects to align with the evolving digital landscape. For instance, in the automotive industry, digital initiatives have been used to cater to the changing digital lifestyle of customers (Hanelt, et al., 2015). While digital transformation may alter certain aspects of an organization's identity, the process is often more incremental and subtle than a complete identity overhaul.

To develop effective strategies for digital transformation, researchers have drawn from various theories and models. Kaltenecker, Hess, and Huesig (2015), for instance, utilized Christensen's theory of disruptive innovation to outline management strategies for digital transformation. These strategies, including developing spin - off technologies, talent recruitment, and forming strong technical partnerships, provide valuable insights for incumbent software organizations navigating disruptive innovation (ibid.). However, it's essential to recognize that the effectiveness of these strategies may vary depending on the context in which they are applied.

A Customer Engagement Strategy (CES) and a Digital Solutions Strategy were recognised as two promising directions for digital strategy in this setting (DSS). The former prioritises the improvement of the customer service experience, while the latter emphasises the redesign of the firm's value proposition through the integration of products, services, and data (Ross, et al., 2017). Companies should pick one approach to pursue initially and expand upon, keeping in mind that the various options available to them may and should be used together (Sebastian, et al., 2017).

Holotiuk and Beimborn analysed 21 company reports to determine key success indicators for a digital transformation plan. Factors like as sales and customer experience, organisational agility, culture and leadership, capabilities and HR skills, vision and foresight, data and IT, operations,

and partners all play a role in ensuring success. That the culture and the people inside a business are so crucial to the success of a digital transformation is highlighted by this fact (Holotiuk and Biernborn, 2017).

Nonetheless, the complexity of digital transformation, particularly within manufacturing organizations, requires a strategic approach that encompasses more than just adding digital technologies. The key challenge lies in changing how leaders and employees perceive their roles in the context of a digitally - enhanced world and how they act strategically based on this new perspective. A shift in mindset, culture, and experience is paramount to the successful adoption of new technologies and methodologies (Kane, 2017).

### **Changes in Innovation**

Digital transformation extends beyond the incorporation of technology; it also signifies a significant change in the innovation landscape. Traditional innovations, which focus on improving existing products or processes, are augmented by digital innovations that redefine the value proposition and introduce new ways of doing business. This change is crucial in an increasingly connected and post - pandemic world (Ismail, et al., 2017).

While organizational leaders often rely on past successes as indicators of future success, this approach can lead to a "competency trap." This trap is a belief that the factors responsible for past successes will continue to lead to success in the future. Digital disruption poses a significant threat, particularly when organizations are unable or unwilling to adapt quickly. Therefore, digital transformation within manufacturing SMEs necessitates a change in mindset, followed by a shift in culture, which ultimately facilitates the adoption of new technologies (Kane, et al., 2019).

### **Digital Transformation and Digital Maturity in Managing the Pandemic**

The COVID - 19 pandemic highlighted the value of digital maturity and change in crisis management. Companies who had already advanced in their use of digital technologies were better able to weather the storm and get back to business as usual. As a result of the pandemic, digital solutions were more widely used, and companies had to adjust their operations to deal with the new reality. While digital transformation has far - reaching effects on the nature of work, it did highlight the importance of people in these efforts (Papadoupoulos, et al., 2020).

Many of the tasks mentioned as essential for pandemic crisis management by Lee and Trimi (2020) are also made easier by digital transformation. Agile innovation, flexible and robust operating systems, data visioning via big data analytics and collaboration platforms, and the use of remote services are all examples (Lee and Trimi, 2020). Increased productivity in the post - crisis era can be aided by lessons learnt during the epidemic, particularly in regards to remote work and the need of digital preparedness (Papadoupoulos, et al., 2020).

Digital transformation in manufacturing is a multifaceted process that encompasses changes in business models,

innovation strategies, and digital maturity. It not only involves adopting digital technologies but also necessitates a shift in mindset and culture within organizations. The experiences of managing the COVID - 19 pandemic emphasize the role of digital maturity in ensuring business continuity and offer valuable lessons for the future.

## 2. Conclusion

Digital transformation is no longer a choice but a necessity for organizations in the contemporary landscape. The constant and increasing rate of change, coupled with a globalized society and economy, has made digital transformation imperative for survival. The manufacturing sector, which was already undergoing planned digital transformation, faced a sudden and dramatic crisis - induced transformation during the COVID - 19 pandemic. This crisis exposed the digital divide within the sector, challenging organizations to reevaluate their digitization strategies, adapt to rapid changes, and view manufacturing as a dynamic, evolving system.

The urgency brought about by the pandemic has significant implications for digital transformation research and practice. It underscores the importance of people in the transformation process and the need to eradicate unhealthy mindsets, foster agile leadership, and develop strategies that infuse agility and adaptability into the organization. Digital transformation is not merely about adding new technologies but necessitates a holistic approach that embraces a new mindset and management style—one that is open, agile, collaborative, and experimental.

To facilitate successful digital transformation, strategic frameworks and tools exist to assess digital readiness and guide organizations toward increasing maturity. However, these frameworks often fall short in addressing the critical barrier of mindset change. This paper has explored the potential of Strategic Doing, an agile leadership approach validated in various contexts over the past two decades, to manage the complexity of digital transformation effectively. Strategic Doing presents a promising solution for overcoming the barriers faced by manufacturing industries.

Future research should focus on implementing Strategic Doing in digital transformation settings, particularly in small - to - medium enterprises (SMEs). This will contribute to a deeper understanding of how this effective discipline can help organizations prepare for the uncertain challenges that lie ahead in the ever - evolving digital landscape. Digital transformation is not a destination but an ongoing journey, and the insights gained from such research will be instrumental in shaping the future of manufacturing and beyond.

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