# AI-driven digital transformation in SMEs: pathways to resilience, value co-creation, and sustainable performance

# AI-Driven Digital Transformation in SMEs: Pathways to Resilience, Value Co-Creation, and Sustainable Performance

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## Abstract

**Purpose-** This study examines the interrelationships among AI-enabled digital ecosystems, digital maturity, organizational resilience, sustainable value co-creation, and sustainable performance within Small and Medium-Sized Enterprises (SMEs) in Pakistan's manufacturing sector. By doing so, it addresses critical gaps in the literature on how these constructs collectively shape resilience and long-term sustainability in information-intensive business environments.

**Design/Methodology/Approach-** A quantitative research design was employed, with data collected from 476 SMEs through structured questionnaires. Structural Equation Modeling (SEM) using SmartPLS was applied to test the hypothesized relationships and assess the mediating and moderating roles of organizational resilience, sustainable value co-creation, and digital maturity.

**Findings-** Results show that AI-driven digital ecosystems have a significant positive effect on both organizational resilience and sustainable value co-creation, which in turn drive sustainable performance. Digital maturity acts as both an enabler and a moderator, amplifying the benefits of AI ecosystems. Among the predictors, sustainable value co-creation emerges as the strongest driver of sustainable performance, while the reciprocal relationship between resilience and co-creation highlights their self-reinforcing nature.

**Theoretical and Practical Contributions-** The study extends the Resource-Based View, Dynamic Capability Theory, and Stakeholder Theory by integrating AI-driven ecosystems and sustainability into a unified framework. Digital maturity is reconceptualized as a multi-dimensional construct encompassing technological, behavioral, and strategic readiness, offering a more nuanced understanding of its role in enabling resilience and Value Co-Creation. Practically, the findings provide guidance for SMEs to pursue phased digital transformation, build collaborative stakeholder networks, and embed sustainability-oriented practices. Policy recommendations include targeted programs to enhance SMEs' digital readiness and resilience.

**Originality/Value-** This research advances knowledge by redefining SME performance to include economic, social, and environmental dimensions. It offers a holistic pathway for how AI ecosystems and digital maturity can

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foster resilience and sustainability, enabling SMEs in resource-constrained contexts to remain competitive while contributing to global sustainability goals such as the SDGs and ESG metrics.
**Keywords:** AI-Driven Digital Ecosystems; Digital Maturity; Organizational Resilience; Sustainable Value Co-Creation; Sustainable Performance; Digital Transformation

## 1. Introduction

In today's rapidly evolving business environment, digital transformation has become a strategic priority for Small and Medium Enterprises (SMEs). These organizations, which represent a substantial portion of the global economy, face mounting pressure to adopt advanced digital technologies to remain competitive (Omrani et al., 2024). However, digital transformation is more than simply adopting new tools; it involves a fundamental shift in organizational operations, value creation, and sustainable value co-creation, redefining how firms collaborate with stakeholders to generate shared economic, social, and environmental outcomes (Skare et al., 2023).

AI-driven ecosystems encompassing technologies such as machine learning, predictive analytics, and natural language processing have emerged as key enablers of this transformation, empowering SMEs to optimize decision-making, automate processes, and enhance operations in ways that contribute directly to sustainable performance (Zhang et al., 2021). This study clarifies that it focuses on functionality-type AI (e.g., predictive, analytical and decision-support applications) embedded in digital platforms, rather than on AI as an abstract organizational capability.

This study specifically targets Pakistan's manufacturing sector, where SMEs encounter unique challenges in adopting digital technologies due to limited financial resources, underdeveloped digital infrastructure, and organizational resistance to change. According to Small and Medium Enterprises Development Authority (SMEDA, 2023), SMEs in Pakistan are defined as organizations with 10–250 employees, annual turnover between USD 1 million and 5 million, and balance-sheet totals between USD 0.5 million and 3 million. The study specifically focuses on product-oriented manufacturing SMEs, particularly those producing consumer goods, as these firms are at the forefront of digital transformation initiatives in Pakistan and are central to national competitiveness.

This study integrates four key constructs AI ecosystems, digital maturity, organizational resilience, and sustainable value co-creation into a unified empirical model. While these constructs have been explored individually in previous research, their combined integration

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within the context of SMEs, particularly in emerging markets like Pakistan, remains insufficiently explored. This novel approach not only integrates these constructs but also examines how they interact to drive SME performance and sustainability. A particularly innovative aspect of this research is the integration of digital maturity as a moderator between AI ecosystems and organizational resilience. While these relationships have been explored individually, no prior study has fully integrated them into a single framework that examines their combined impact on SME sustainability.

Furthermore, the context of Pakistan's manufacturing SMEs adds novelty to this study, as emerging markets remain underrepresented in the literature on AI-driven digital ecosystems. The challenges SMEs face in Pakistan, including resource constraints, technological barriers, and infrastructure limitations, provide a unique setting for this research. This context-specific focus enriches the understanding of how digital ecosystems can drive resilience and sustainability in SMEs in resource-constrained environments, offering new insights for both academics and practitioners.

Despite the potential of AI, SMEs in emerging economies face considerable barriers to digital integration, including technological, financial, and cultural constraints. In this context, digital maturity, defined as the degree to which an SME has successfully adopted and embedded digital technologies, becomes a pivotal enabler of transformation. This study advances existing literature by clarifying how digital maturity not only facilitates AI-driven ecosystems but also functions as a moderator that strengthens the relationship between AI ecosystems and organizational resilience, an area insufficiently explored in prior research (Khan et al., 2024).

Organizational resilience, defined as an organization's capacity to anticipate disruptions, adapt to crises, and recover from shocks, has become essential for sustaining competitiveness in volatile environments (Rai et al., 2021). Through the integration of AI tools such as predictive analytics and machine learning, SMEs can more effectively anticipate market disruptions, mitigate risks, and stabilize operations, thereby enhancing their resilience. This study extends the Dynamic Capability Theory (Quansah et al., 2022), by demonstrating how AI-enabled digital maturity allows firms to continuously adapt and reconfigure resources to sustain competitive advantage during turbulent conditions.

Furthermore, SMEs are under increasing pressure from a broad range of stakeholders including customers, employees, regulators, and the broader community to incorporate

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sustainability into their core operations. AI-driven ecosystems present SMEs with opportunities to optimize resource usage, reduce environmental impact, and strengthen social responsibility, which in turn fosters sustainable value co-creation (Khan et al., 2024). In this study, value creation refers to internally generated economic outcomes, while sustainable value co-creation represents the collaborative process of generating shared environmental, social, and economic value through stakeholder engagement (Prahalad & Ramaswamy, 2004). This distinction improves conceptual clarity and aligns the research with co-creation theory and stakeholder perspectives.

Despite the significant potential of AI-driven ecosystems in SMEs, the interrelationships among AI ecosystems, organizational resilience, digital maturity, and sustainable value co-creation remain underexplored, particularly within SMEs in emerging markets. Prior studies have often examined these constructs separately, overlooking their combined impact on sustainability performance. To bridge this gap, this study develops a unified and integrative framework that empirically examines how AI-enabled digital maturity interacts with resilience and sustainable value co-creation to enhance SME sustainability.

This study aims to answer the following research questions:

**RQ1:** How do AI-driven digital ecosystems influence organizational resilience and sustainable value co-creation in manufacturing SMEs?

**RQ2:** How does organizational resilience relate to sustainable value co-creation and SME sustainability performance?

**RQ3:** What role does digital maturity play in shaping these relationships?

**RQ4:** What is the combined effect of organizational resilience and sustainable value co-creation on SME sustainability performance?

This study contributes to the literature by advancing the resource-based view (Barney, 1991), Dynamic Capability Theory (Teece, 2007), and stakeholder theory (Freeman et al., 2021). It integrates these perspectives to show how AI ecosystems and digital maturity function as strategic and dynamic capabilities that drive resilience, value co-creation, and sustainability in SMEs. The study provides actionable insights for SME managers and policymakers by outlining context-specific strategies for enhancing digital adoption, strengthening resilience, and improving sustainability outcomes in resource-constrained environments. Beyond combining related constructs, this study makes three contributions. First, we theorize and test digital maturity as a boundary condition that strengthens the resilience benefits of AI-driven

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digital ecosystems (AIE × DM → OR), clarifying when AI ecosystems translate into resilience in resource-constrained SMEs. Second, we refine the mechanism through which AI ecosystems relate to sustainability performance by showing that AIE's influence is primarily indirect through organizational resilience and sustainable value co-creation, rather than operating through a large direct effect. Third, we provide a theory-bridged explanation that aligns our constructs with RBV (AI ecosystems as access to valuable data/analytics resources), DCT (digital maturity as routines enabling sensing–seizing–transforming and reconfiguration into resilience), and Stakeholder Theory (sustainable value co-creation as the relational process through which resilience and digital capabilities translate into shared sustainability outcomes). Together, these contributions extend prior SME research by specifying a conditional, mechanism-based explanation and grounding it in evidence from Pakistan's manufacturing SMEs.

In this study, sustainable value co-creation refers to the stakeholder-involved process through which SMEs collaboratively generate shared economic, social, and environmental value, whereas sustainable performance captures the triple-bottom-line outcomes of those efforts. We therefore model SVC as an inter-organizational process construct and SP as an outcome construct to avoid conceptual overlap and to clarify the mechanism through which AI-driven digital ecosystems and digital maturity influence sustainability outcomes. Although previous research examined digital maturity, resilience, and sustainability individually, few studies have integrated them into a cohesive model connecting AI ecosystems, digital maturity, organizational resilience, and sustainable value co-creation particularly within the SME context of developing economies. This study addresses that gap by providing a new theoretical synthesis and empirical evidence from Pakistan's manufacturing SMEs.

Methodologically, this research employs Structural Equation Modeling (SEM) using SmartPLS, suitable for complex models involving latent constructs. This approach enables rigorous testing of the multidimensional relationships among AI ecosystems, resilience, and sustainable value co-creation.

Overall, this study proposes a holistic and integrated model positioning AI-driven ecosystems, digital maturity, organizational resilience, and sustainable Value Co-Creation as mutually reinforcing factors driving SME performance. By connecting digital transformation, dynamic capabilities, and stakeholder engagement, it provides both theoretical advancement and practical direction for SMEs navigating the digital era in emerging economies.

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## 2. Literature review

To improve conceptual clarity and avoid repetition, we define our key constructs up front. AI-driven digital ecosystems refer to interconnected networks of functional, operations-facing AI tools (e.g., predictive analytics, automation, and decision-support systems) embedded across internal processes and partner platforms. Digital maturity reflects the extent to which an SME has embedded digital technologies, skills, and routines into core operations. Organizational resilience is an SME's capability to anticipate disruptions, respond effectively, adapt, and recover under turbulence. Sustainable value co-creation is the stakeholder-involved process of generating shared economic, social, and environmental value, whereas sustainable performance (SP) represents the triple-bottom-line outcomes of those efforts. These definitions guide the theoretical development below and are used consistently throughout the manuscript.

The integration of AI into organizational processes has evolved from fragmented applications to holistic ecosystems, greatly enhancing business operations (George & Schillebeeckx, 2022). AI-driven digital ecosystems are defined as interconnected networks of AI tools, predictive analytics, and automation platforms designed to optimize organizational resources, processes, and decision-making (Steiber & Alvarez, 2024). These systems are especially relevant to small and medium-sized enterprises (SMEs), which, though often resource-constrained, remain vital to global economic and social development. AI-driven ecosystems have the potential to transform sustainability, enhance resilience, and drive performance outcomes; however, the mechanisms through which AI-enabled ecosystems interact with organizational resilience and sustainability objectives remain underexplored, particularly in emerging-market contexts.

Recent scholarship further underscores the pivotal role of artificial intelligence in enabling digital ecosystems that integrate sustainability and resilience objectives (Al Naqbi et al., 2024; Aydin et al., 2024). Studies such as Badghish & Soomro, (2024) and Sohu *et al.*, (2025) emphasize that digital maturity moderates how effectively SMEs leverage AI-driven ecosystems to achieve sustainable outcomes. Yet, most prior research focuses on developed economies and treats digital transformation, resilience, and sustainability as separate streams of inquiry. Limited empirical work has examined how these dimensions interact simultaneously to shape SME sustainability performance particularly in developing economies like Pakistan. Drawing on RBV and DCT, we view AI-enabled data, skills, and routines as strategic, reconfigurable resources that underpin resilience (Barney, 1991; Teece, 2007).

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*2.1 AI-Driven Digital Ecosystems and Sustainable Value Co-Creation*

Artificial intelligence is increasingly integrated into digital ecosystems and has lately attracted a considerable amount of interest in light of the contribution it can make to sustainable Value Co-Creation (Leone et al., 2021). The disruption of traditional business models came from the technologies that underpin AI: machine learning, natural language processing, and data analytics, which enabled organizations to perform more effectively and innovate on a continuous basis (Akter et al., 2022a). These technologies enable real-time decision-making and drive operational efficiencies, therefore embracing sustainability in business. AI allows the integration of the goals of sustainability into the operational functions of organizations by making better use of resources and reducing waste, which again reinforces the fact that AI-driven digital ecosystems are playing a major role in sustainably realizing Value Co-Creation (Jacobides et al., 2021; Kulkov et al., 2024).

In this study, AI-driven digital ecosystems refer to functional, operations-facing AI (e.g., predictive analytics, automation, and decision-support systems embedded across processes and partner platforms clarifying the scope of AI most relevant for SMEs. Digital ecosystems, in this context, represent the connections between digital platforms and stakeholders, central to collaborative development. These ecosystems have been recognized for their contribution to innovative initiatives (Oliveira-Duarte et al., 2021). AI facilitates knowledge sharing and co-creation among businesses, consumers, and regulatory institutions, enabling collaboration to address sustainability challenges through the combination of different resources and expertise.

Sustainable value co-creation refers to the collaborative process of creating shared value with stakeholders, while sustainable performance focuses on the outcomes of these collaborations, particularly in terms of economic, social, and environmental impact (Banik & Rabbanee, 2023; Chatterjee et al., 2023; Prahalad & Ramaswamy, 2004). By modeling sustainable value co-creation as an inter-organizational process construct and sustainable performance as a triple-bottom-line outcome construct, this study clarifies the strong relationship between these two constructs while demonstrating their empirical distinction, thereby addressing the potential conceptual overlap.

Several empirical studies validate the role of AI in promoting the process of Value Co-Creation sustainably. (Mir et al., 2022) showed that companies using AI within a digital ecosystem structure displayed improved sustainability performance and greater stakeholder engagement. Similarly, (Jankovic & Curovic, 2023) indicate that organizations integrating AI

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technologies into their digital strategies are more likely to achieve long-term sustainable growth. While these studies demonstrate individual relationships, a gap remains in understanding their joint operation within an integrated ecosystem for SMEs, particularly in emerging economies. This study, therefore, tests these relationships collectively, extending prior work. This gap forms the basis for the first hypothesis:

**H1:** *AI-driven digital ecosystems positively influence sustainable value co-creation.*

### *2.2 AI-Driven Digital Ecosystems and Organizational Resilience*

The interplay between AI and organizational resilience has become a prominent area of research, especially for SMEs. Organizational resilience refers to a firm's capacity to anticipate disruptions, prepare, respond, and recover effectively. AI technologies, including machine learning and data analytics, enable entities with unique sets of capabilities through the rapid processing of humongous datasets (Rahmani et al., 2021; Sohu *et al.*, 2024). This predictive ability is particularly crucial for SMEs, which often have fewer resources to cope with disruptions and may suffer significantly (Cubric & Li, 2024).

Moreover, AI supports the real-time processing of information, allowing organizations to adapt their strategies dynamically in response to changing market conditions (Cao, 2022). The literature indicates that AI-driven digital ecosystems improve the resilience capability of SMEs by providing predictive analytics and facilitating agile decision-making. Grounded in the resource-based view and dynamic capability theory (Barney, 1991; Teece, 2007) view AI-enabled data, skills, and routines as strategic, reconfigurable resources that underpin resilience making explicit the theoretical basis. While earlier studies discuss aspects of this link, empirical tests that position resilience within an AI-ecosystem model for SMEs in emerging economies remain scarce. The observation provides grounds for the second hypothesis:

**H2:** *AI-driven digital ecosystems positively impact organizational resilience.*

### *2.3 Sustainable Value Co-Creation and SME Performance*

Value co-creation refers to the process through which companies create economic, social, and environmental value in the long term, resulting in contributing to sustainable development (Moreno-Monsalve et al., 2023; Hongyun *et al.*, 2025). SMEs that adopt sustainable practices improve performance across multiple dimensions. For instance, (Basnet, 2024; Wu et al., 2024) found that companies involved in green product development not only improve environmental performance but also gain a competitive edge in the marketplace. These

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advantages often manifest as improved customer loyalty, brand reputation, and operational efficiencies. Empirical studies also show that sustainable practices result in cost savings, improving economic performance.

Moreover, the community and stakeholder theory (Buchholz & Rosenthal, 2005), suggests that SMEs with socially responsible behaviors gain community trust and enhanced relationships with stakeholders, which contributes to their sustainable performance. In this context, AI-driven ecosystems support these social dimensions of Value Co-Creation by enhancing efficiency and reducing waste, ultimately contributing to sustainable performance. This provides grounds for the third hypothesis:

**H3:** *Sustainable Value Co-Creation positively influences SME sustainable performance.*

*2.4 Organizational Resilience and SME Performance*

Organizational resilience is crucial for SMEs in a volatile business environment (Garrido-Moreno et al., 2024). Resilient SMEs are better able to anticipate, prepare for, and recover from disruptions. Studies show that resilient SMEs integrate sustainability into their core strategies, which positively impacts long-term growth (Őri et al., 2024). Resilient organizations are better positioned to implement sustainable practices, improving reputation and customer loyalty, and ultimately financial performance (Pongtanalert & Assarut, 2022), for example, it has been identified that during the economic downturn, resilient SMEs are able to draw from their adaptive capacities in the development of innovative strategies that realize sustained performance. This flexibility will make it possible not only to safeguard immediate operations but also to make long-term growth and sustainability a reality.

It is further argued that there is a positive relationship between organizational resilience and sustainable performance insofar as resilient organizations have the potential to integrate sustainability into their core business strategies (Ciasullo et al., 2024). This is what is referred to as sustainable performance, having an economic, environmental, and social dimension that has lately become imperative for the longevity of the SME group of firms (Oduro, 2024). Resilient SMEs are better positioned to implement sustainable practices that will result in improved reputation and customer loyalty and, finally, improved financial performance (Suriyankietkaew et al., 2022). Resilience has also been claimed to be one of the important elements constituting an organization's dynamic capability in adapting to market turbulence. As noted by (Razavi Hajiagha et al., 2024), a resilience culture will definitely enable SMEs to

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develop the capabilities that they need to manage crises effectively for sustainable performance over a while. Therefore, hypothesis is formulated as:

**H4:** *Organizational resilience positively influences SME sustainable performance.*

*2.5 Digital Maturity, AI-Driven Digital Ecosystems and Sustainable Value Co-Creation*

AI-driven ecosystems represent transformative frameworks that enable organizations to reach new levels of operational efficiency, product/service innovation, and collaborative network relationships (Díaz-Arancibia et al., 2024). However, AI ecosystems' contribution to sustainable Value Co-Creation depends on the organization's digital maturity. The findings indicate that SMEs with higher digital maturity are better equipped to use AI ecosystems for sustainability initiatives (Madanaguli et al., 2024). This maturity allows SMEs to take a more proactive approach to sustainability, optimizing resource utilization and reducing waste The interaction between digital maturity and AI ecosystems enhances SMEs' capabilities to innovate sustainably, creating competitive advantages in eco-conscious markets (Martínez-Peláez et al., 2024). From this interaction, hypothesis can be formulated as follows:

**H5**: *Digital maturity moderates the relationship between AI-driven digital ecosystems and sustainable Value Co-Creation.*

*2.6 Digital Maturity, AI-Driven Digital Ecosystems and Organizational Resilience*

Building on the definitions provided in Section 2.0, we conceptualize digital maturity as the organizational routines and capabilities that enable SMEs to effectively deploy AI-driven digital ecosystems and rapidly reconfigure resources during turbulence. In resource-constrained settings, digitally mature SMEs are more likely to translate ecosystem-enabled data/analytics into timely sensing, seizing, and transforming actions, thereby strengthening organizational resilience (Aldoseri et al., 2024; Kitsios & Kamariotou, 2021).

According to (Petzolt et al., 2022), digitally mature SMEs are likely to possess the relevant skills, resources, and cultural alignment that will ensure the effective implementation of AI-driven solutions. This allows the building of adaptive capacities, which, in turn, enhance resilience against uncertainty. The hypothesis is:

**H6:** *Digital Maturity moderates the relationship between AI-driven digital Ecosystems and Organizational Resilience.*

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This literature review forms the basis for the hypotheses of this study, filling significant gaps in the literature on AI ecosystems, organizational resilience, and sustainable Value Co-Creation in the context of SMEs operating in emerging markets like Pakistan. By synthesizing Resource-Based View, Dynamic Capability Theory, and Stakeholder Theory, this study contributes both contextual and theoretical novelty to the field of AI-enabled digital transformation in SMEs.

*2.7 Research Gap*

Prior SME studies have examined AI adoption, digital maturity, or resilience largely in isolation and often without specifying the mechanism through which AI ecosystems translate into sustainability outcomes. This study advances the literature by (a) testing a unified model that connects AI-driven digital ecosystems with sustainable performance through organizational resilience and sustainable value co-creation, and (b) introducing digital maturity as a boundary condition that strengthens ecosystem-to-capability conversion in a resource-constrained, emerging-market setting (Pakistan). As outlined in Table 1, this study takes a multi-theoretical approach to understand the interconnectedness of these constructs, offering valuable insights into the digital transformation of SMEs in emerging markets.

*Table.1 Research Gap (Source: Authors' own work)*

| Research Area | Gap Identified | Studies Addressing the Gap | How This Study Addresses the Gap |
|---|---|---|---|
| **AI-driven Digital Ecosystems and SMEs** | Limited empirical studies on AI ecosystems' impact on SMEs in emerging markets. Most studies focus on large firms in developed economies. | (Basnet, 2024; Falahat et al., 2022) | This study explores AI ecosystems within SMEs in Pakistan, focusing on their role in sustainability. |
| **Organizational Resilience** | Few studies have empirically tested how resilience interacts with AI ecosystems in SMEs, particularly in resource-constrained environments. | (Aggarwal & Agarwala, 2022; Rosyafah et al., 2025) | This study examines how AI ecosystems and digital maturity influence organizational resilience in SMEs. |
| **Digital Maturity and AI Ecosystems** | Lack of research on how digital maturity moderates the relationship between AI ecosystems and SME | (Andersen et al., 2022; Bhuiyan et al., 2024) | The study introduces digital maturity as a moderator in the relationship between AI |

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| | | | |
|---|---|---|---|
| | performance, especially in developing economies. | | ecosystems and SME resilience. |
| **Sustainable Value Co-Creation** | Research on value co-creation in SMEs, especially in terms of sustainability, is fragmented. | (Cheung & To, 2019; Moreno-Monsalve et al., 2023) | This study develops a comprehensive model of sustainable value co-creation in SMEs enabled by AI ecosystems. |

## 3. Methodology

### *3.1 Sample and data collection*

This study adopted a quantitative approach to investigate the impact of an AI-driven digital ecosystem on sustainable performance through the mediating role of organizational resilience and sustainable value co-creation under the boundary condition of digital maturity. The research context was manufacturing SMEs in Pakistan.

Given the absence of a comprehensive and publicly accessible sampling frame from the small and medium enterprises development authority (SMEDA), this study employed purposive sampling to reach information-rich manufacturing SMEs and knowledgeable key informants (e.g., CEOs/managers) who are directly involved in digital and sustainability-related decisions. To reduce selection bias, we applied consistent screening criteria (firm age, managerial tenure, and SME classification thresholds) and restricted the sampling frame to product-oriented manufacturing SMEs to ensure comparability for assessing AI ecosystem engagement, digital maturity, resilience, and sustainability outcomes.

The data collection involved a self-administered online survey targeting CEOs and managers of manufacturing SMEs. SMEs from the two most populous provinces of Punjab and Sindh were selected, as they represent 82.3% of all SMEs in Pakistan. The SMEDA assisted in obtaining contact details for the SMEs. The survey was distributed between April 2024 and July 2024, and a total of 859 questionnaires were sent to the targeted participants. The response rate was 67.87%, yielding 583 valid responses, of which 107 responses were discarded due to incomplete data. After removing invalid responses, 476 valid responses remained, meeting the sample size threshold calculated using G-power (Lakens, 2022).

### *3.2 Measurement Scales*

The construct AI-driven digital ecosystem was measured using six items adapted from (Peretz-Andersson et al., 2024) and (Rojas & Chiappe, 2024) focusing on the use of functionality-type AI such as machine learning, predictive analytics, and natural language

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processing (NLP) within organizations. For digital maturity, six items were adapted from He et al. (2023), capturing the use of advanced digital technologies in enhancing operational processes and supporting customers more effectively. Sustainable value co-creation was measured using three items adapted from (Cossío-Silva et al., 2016a) and (Lacoste, 2016a) focusing on how firms integrate sustainability goals with partners and creates innovative, resource-effective solutions.

Organizational resilience was measured through six items focused on proactive monitoring, resource readiness, and the capacity to respond during crises. Sustainable performance was measured using four items from (Ishaq et al., 2023b), specifically assessing environmental performance in SMEs. The full list of measurement items, including all adaptations for the SME manufacturing context, is provided in Appendix A. Across constructs, the measurement items were adopted from validated prior studies and contextualized to Pakistani manufacturing SMEs through minor wording refinements to improve clarity and fit with the study setting (e.g., aligning item phrasing with SME-level digital practices and AI-enabled collaboration with ecosystem partners).

*3.3 Demographics*

Table Error**! Use the Home tab to apply 0 to the text that you want to appear here.**2 provides the demographic characteristics of the study participants. The majority of respondents were male (80.46%), with female participants making up 19.54%. Most participants held master's degrees (49.79%), followed by graduates (25.84%). In terms of professional role, 58.19% were managers, and 41.81% were CEOs. The majority of participants had 5-10 years of managerial experience, with SMEs from Punjab accounting for 61.97% of the responses.

*Table **Error! Use the Home tab to apply 0 to the text that you want to appear here.**2. Demographics (Source: Authors' own work)*

| Demographics | | Frequency | Percentage |
|---|---|---|---|
| **Gender** | Male | 383 | 80.46 |
| | Female | 93 | 19.54 |
| **Age** | 21–30 years | 71 | 14.92 |
| | 31–40 years | 193 | 40.55 |
| | 41–50 years | 147 | 30.88 |
| | 51+ years | 66 | 13.87 |
| **Education** | Intermediate | 56 | 11.76 |
| | Graduation | 123 | 25.84 |
| | Masters | 237 | 49.79 |
| | Others | 61 | 12.82 |
| **Position** | Manager | 277 | 58.19 |

| | | | |
|---|---|---|---|
| | CEO | 199 | 41.81 |
| **Years of Experience** | 5–10 years | 147 | 30.88 |
| | 11–15 years | 143 | 30.04 |
| | 16–20 years | 103 | 21.64 |
| | 21–25 years | 83 | 17.44 |
| **Region** | Punjab | 295 | 61.97 |
| | Sindh | 181 | 38.03 |

*3.4 Data Analysis*

For statistical analysis, the PLS-SEM technique was applied using the SmartPLS 4 version (Cheah et al., 2024). This method was chosen due to its ability to handle complex relationships among latent variables, including mediation and moderation effects, which are central to the hypothesized model. PLS-SEM is particularly advantageous in this study as it allows for greater flexibility in handling non-normal data and smaller sample sizes, making it suitable for this research context (Becker et al., 2023). In addition, non-normality and lower sample size requirements in PLS-SEM offer the flexibility needed to analyze the data effectively, especially when working with SME datasets in emerging economies (Al Issa & Abdelsalam, 2021; Becker et al., 2023). The measurement model was first assessed for reliability and validity. Reliability was tested using Composite Reliability (CR), Average Variance Extracted (AVE), and Heterotrait-Monotrait Ratio (HTMT), ensuring the model's robustness. Following the measurement model assessment, the structural model was tested to examine the hypothesized relationships among the constructs.

To address potential common method bias associated with single-respondent survey data, we applied the full-collinearity VIF approach, where each latent construct is regressed on all others and VIF values are examined against recommended thresholds. The resulting full-collinearity VIF values indicated no evidence of problematic common method bias (see Results, Section 4.3, where VIF diagnostics are reported).

We also assessed non-response bias by comparing early and late respondents on key study constructs and firm characteristics using mean-difference tests; the results did not indicate systematic differences, suggesting that non-response bias is unlikely to threaten representativeness (see Results, Section 4.3).

Regarding moderation, we explicitly distinguish statistical significance from practical magnitude. Although the interaction effect is statistically significant, its magnitude is small; therefore, we interpret digital maturity primarily as a boundary condition that incrementally

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strengthens how AI ecosystem engagement translates into resilience in resource-constrained SMEs, rather than as a dominant driver of outcomes.

## 4. Results

### *4.1 Construct Reliability and Validity*

Table 3 provides key metrics assessing reliability and validity using Cronbach's alpha (α), composite reliability (CR), and average variance extracted (AVE). These metrics establish the robustness of the measurement model, ensuring consistency and convergent validity across constructs (Hair et al., 2021). All AIE indicators show strong outer loadings (range: 0.820–0.928), surpassing the recommended threshold of 0.7, indicating high indicator reliability.

Similarly, DM, OR, and SVC constructs' exhibit loadings ranging from 0.779 to 0.925, 0.764-0.918, and 0.815-0.866, respectively, reflecting solid alignment with their respective constructs. Cronbach's alpha for all the constructs exceeds 0.7, demonstrating good internal consistency, with DM showing the highest reliability (α = 0.929). The Composite Reliability (CR) values range from 0.881 to 0.944, all above the threshold of 0.7, confirming construct reliability. AVE values for AIE (0.734) and DM (0.739) are exceptional, indicating that these constructs capture a large portion of variance in their indicators. These findings increase confidence in the reliability and validity of our measurement model.

*Table 3: Construct reliability and validity (Source: Authors' own work)*

| Construct reliability and validity | | | | | |
|---|---|---|---|---|---|
| | Outer loadings | Constructs | Alpha | CR | AVE |
| AIE1 | 0.851 | AI-Driven Ecosystem | 0.909 | 0.932 | 0.734 |
| AIE2 | 0.928 | | | | |
| AIE3 | 0.843 | | | | |
| AIE4 | 0.820 | | | | |
| AIE5 | 0.837 | | | | |
| DM1 | 0.833 | Digital Maturity | 0.929 | 0.944 | 0.739 |
| DM2 | 0.858 | | | | |
| DM3 | 0.779 | | | | |
| DM4 | 0.845 | | | | |
| DM5 | 0.909 | | | | |
| DM6 | 0.925 | | | | |
| OR1 | 0.813 | Organizational Resilience | 0.919 | 0.937 | 0.715 |
| OR2 | 0.918 | | | | |
| OR3 | 0.902 | | | | |
| OR4 | 0.815 | | | | |
| OR5 | 0.764 | | | | |
| OR6 | 0.851 | | | | |

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| | | | | | |
|---|---|---|---|---|---|
| SP1 | 0.799 | Sustainable Performance | 0.873 | 0.914 | 0.728 |
| SP2 | 0.752 | | | | |
| SP3 | 0.922 | | | | |
| SP4 | 0.926 | | | | |
| SVC1 | 0.866 | Sustainable Value Co-Creation | 0.798 | 0.881 | 0.712 |
| SVC2 | 0.815 | | | | |
| SVC3 | 0.850 | | | | |

*4.2 Discriminant Validity*

The relationship between sustainable performance and sustainable value Co-Creation is 0.835, which approaches the upper threshold of 0.85 but remains below it, maintaining validity. This overlap is theoretically consistent, as both constructs contribute to the overall sustainability goals within the model. We acknowledge that sustainable value co-creation and sustainable performance are conceptually related and therefore may show high correlation. This association is expected because co-creation represents the process mechanism through which sustainability outcomes are produced; however, the constructs remain distinct because SVC captures collaborative practices and stakeholder engagement activities, whereas SP captures realized triple-bottom-line outcomes. We therefore retain both constructs to represent process–outcome separation and interpret their relationship accordingly.

Table 4 shows the test of discriminant validity through the so-called HTMT ratio, which is a critical measure for the distinctiveness of the constructs in the model. HTMT values below 0.85 (or 0.90 in exploratory research) are indicative of adequate discriminant validity, meaning that the constructs would be sufficiently different from one another (Saeed et al., 2022).

The AI-Driven digital ecosystem (AIE) demonstrates adequate discriminant validity, with an HTMT value of 0.561 when compared to Digital Maturity (DM), which is well below the threshold of 0.85. The relationships between AIE and Organizational Resilience (OR) (0.719), Sustainable Performance (SP) (0.735), and Sustainable Value Co-Creation (SVC) (0.768) also remain well within acceptable limits. This suggests that AIE is a distinct construct while still exhibiting strong correlations with the other variables in the model. The relationship between sustainable performance and sustainable value Co-Creation is 0.835, which approaches the upper threshold of 0.85 but remains below it, maintaining validity. This overlap is theoretically consistent, as both constructs contribute to the overall sustainability goals within the model. We acknowledge that sustainable value co-creation and sustainable performance are conceptually related and therefore may show high correlation. This association is expected because co-creation represents the process mechanism through which

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sustainability outcomes are produced; however, the constructs remain distinct because SVC captures collaborative practices and stakeholder engagement activities, whereas SP captures realized triple-bottom-line outcomes. We therefore retain both constructs to represent process–outcome separation and interpret their relationship accordingly.

*Table 4: Discriminant validity (Source: Authors' own work)*

| Heterotrait-monotrait ratio (HTMT) – Matrix | | | | | |
|---|---|---|---|---|---|
| | AIE | DM | OR | SP | SVC |
| AI-Driven Ecosystem | | | | | |
| Digital Maturity | 0.561 | | | | |
| Organizational Resilience | 0.719 | 0.762 | | | |
| Sustainable Performance | 0.735 | 0.775 | 0.812 | | |
| Sustainable Value Co-Creation | 0.768 | 0.812 | 0.768 | 0.835 | |

*4.3 Inner Model VIF and f-Square*

The variance Inflation Factor (VIF) measures multicollinearity in the inner model. Values below 5 indicate no significant multicollinearity issues, ensuring reliable estimations (Gupta et al., 2024). The VIF values for AIE (1.383-1.866) across OR, SP, and SVC suggest minimal collinearity, confirming that AIE contributes independently to these constructs. However, the VIF values for OR (4.801) and SVC (4.702) with SP are slightly high but still within the acceptable threshold, indicating their strong predictive role for sustainable performance.

As data were collected from single respondents using a self-administered survey, we assessed the risk of common method bias (CMB) and non-response bias. Following recent PLS-SEM guidance, we employed the full collinearity variance inflation factor (VIF) approach, in which each latent construct is regressed on all other constructs in the model. All full collinearity VIF values were below the recommended threshold of 5, suggesting that CMB is unlikely to pose a serious threat to the validity of our results. To assess non-response bias, we compared early and late respondents on firm size and the key study variables using independent sample t-tests. The analyses revealed no statistically significant differences ($p > 0.05$), indicating that non-response bias is unlikely to be a major concern.

The f-square assesses the effect size of independent constructs on dependent constructs. The f-square for AIE and OR is 0.334 (Table.5), indicating a medium to large effect, while the f-square for AIE and SP is 0.008, suggesting a negligible effect. This highlights that AIE indirectly affects SP through other constructs like OR and SVC. Digital maturity exhibits the

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highest effect sizes (f-square) for OR and SVC, underscoring its moderating and enabling role in digital transformation.

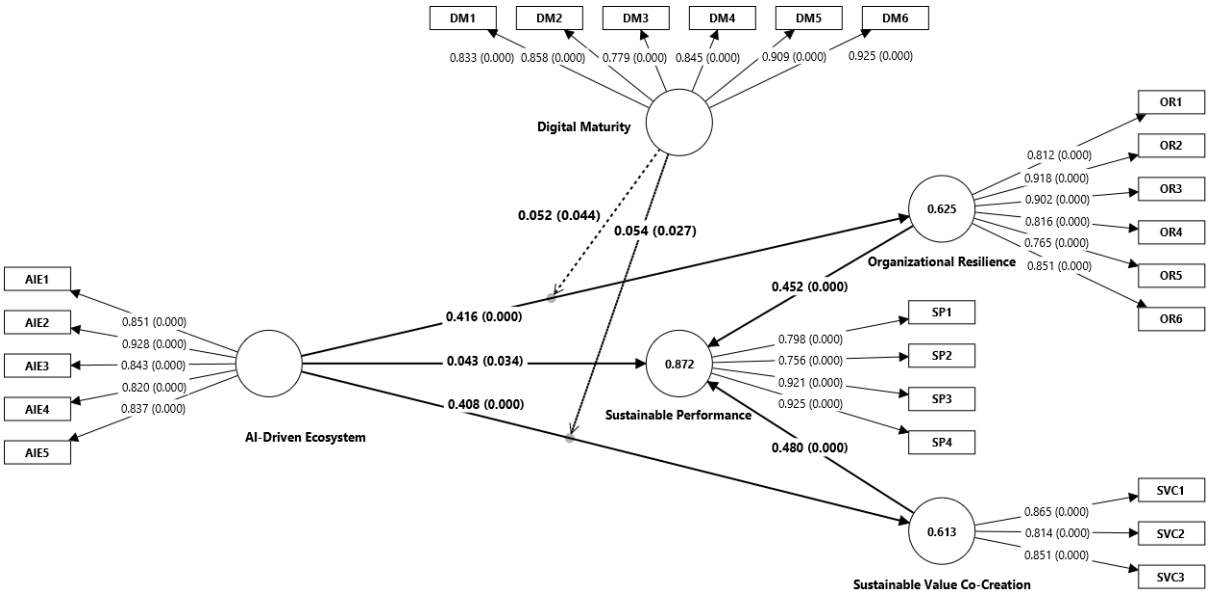


*Figure 1: Structural Model (Source: Authors' own work)*

*Table.5: Inner Model VIF and f-Square (Source: Authors' own work)*

| Inner model VIF | | | |
|---|---|---|---|
| | OR | SP | SVC |
| AI-Driven Ecosystem | 1.383 | 1.866 | 1.3830 |
| Digital Maturity | 1.392 | | 1.3921 |
| Organizational Resilience | | 4.801 | |
| Sustainable Value Co-Creation | | 4.702 | |
| f-square | | | |
| | OR | SP | SVC |
| AI-Driven Ecosystem | 0.334 | 0.008 | 0.3111 |
| Digital Maturity | 0.450 | | 0.4362 |
| Organizational Resilience | | 0.332 | |
| Sustainable Value Co-Creation | | 0.384 | |

*4.4 Model Fit, Predictive Validity, and R-Square*

The standardized root mean square residual (SRMR) for both the saturated model (0.063) and the estimated model (0.083) is below the threshold of 0.10, suggesting acceptable approximate fit. The normed fit index (NFI) for the saturated model (0.755) and the estimated model (0.730) is below the recommended threshold of 0.90; therefore, global fit should be interpreted cautiously in this complex, prediction-oriented model. In PLS-SEM, global fit indices are supplementary diagnostics; substantive evaluation relies primarily on predictive

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relevance ($Q^2$predict) and explained variance ($R^2$), which we report below. In line with current PLS-SEM reporting practice, we treat global fit indices as supplementary rather than decisive criteria, particularly in prediction-oriented models with multiple mediators/moderators. While SRMR suggests acceptable approximate fit, indices such as NFI can be conservative in complex PLS models; therefore, we interpret them cautiously and place greater emphasis on predictive relevance ($Q^2$predict) and explained variance ($R^2$) when evaluating model usefulness. $Q^2$predict values confirm strong predictive validity with $Q^2$ (0.607) and RMSE (0.629), demonstrating good predictive power and consistent prediction accuracy for Sustainable Performance (SP).

R-Square (explained variance) values indicate the variance in dependent variables explained by the independent variables. Adjusted R-square accounts for model complexity (Kumar & K Sukumaran, 2017). For OR, $R^2$ (0.625) and Adjusted $R^2$ (0.622) reveal that 62.5% of the variance in OR is explained by predictors, reflecting strong explanatory power (see

Figure 1). Additionally, SVC $R^2$ (0.613) and Adjusted $R^2$ (0.610) indicate that the model explains 61.3% of the variance. For further information, please refer to Table 6.

*Table 6: Model Fit, Predictive Validity, and R-Square (Source: Authors' own work)*

| Model Fit summary | | |
|---|---|---|
| | Saturated model | Estimated model |
| SRMR | 0.063 | 0.083 |
| NFI | 0.755 | 0.730 |
| PLS $Q^2$predict | | |
| | $Q^2$predict | RMSE |
| Organizational Resilience | 0.617 | 0.621 |
| Sustainable Performance | 0.607 | 0.629 |
| Sustainable Value Co-Creation | 0.606 | 0.630 |
| R-square | | |
| | R-square | R-square adjusted |
| Organizational Resilience | 0.625 | 0.622 |
| Sustainable Performance | 0.872 | 0.871 |
| Sustainable Value Co-Creation | 0.613 | 0.610 |

*4.5 Path Analysis*

Table 7 summarizes the hypothesis tests. AI-driven digital ecosystems positively predict organizational resilience and SVC, while the direct AIE → SP effect is statistically significant but negligible in magnitude. Digital maturity shows strong effects on both OR and SVC, and

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the interaction term (DM×AIE → OR) is significant but small, indicating a modest boundary-condition effect. Indirect effects are substantial, confirming that AIE influences SP primarily through OR and SVC rather than through a large direct pathway.

*Table.7: Hypotheses Testing*

Direct Path Analysis

| | Path | Confidence Intervals at 2.5% | Confidence Intervals at 97.5% | STDV | P values |
|---|---|---|---|---|---|
| AI-Driven Ecosystem -> Organizational Resilience | 0.416 | 0.351 | 0.480 | 12.649 | 0.000 |
| AI-Driven Ecosystem -> Sustainable Performance | 0.043 | 0.003 | 0.083 | 2.119 | 0.034 |
| AI-Driven Ecosystem -> Sustainable Value Co-Creation | 0.408 | 0.340 | 0.475 | 11.781 | 0.000 |
| Digital Maturity -> Organizational Resilience | 0.486 | 0.418 | 0.551 | 14.449 | 0.000 |
| Digital Maturity -> Sustainable Value Co-Creation | 0.485 | 0.417 | 0.551 | 14.247 | 0.000 |
| Organizational Resilience -> Sustainable Performance | 0.452 | 0.380 | 0.526 | 12.058 | 0.000 |
| Sustainable Value Co-Creation -> Sustainable Performance | 0.480 | 0.402 | 0.553 | 12.612 | 0.000 |
| Digital Maturity x AI-Driven Ecosystem -> Organizational Resilience | 0.052 | 0.002 | 0.104 | 2.010 | 0.044 |

Specific indirect effects

| | Path | Confidence Intervals at 2.5% | Confidence Intervals at 97.5% | STDV | P values |
|---|---|---|---|---|---|
| AI-Driven Ecosystem -> Organizational Resilience -> Sustainable Performance | 0.188 | 0.149 | 0.231 | 9.063 | 0.000 |
| Digital Maturity -> Organizational Resilience -> Sustainable Performance | 0.219 | 0.174 | 0.270 | 8.906 | 0.000 |
| AI-Driven Ecosystem -> Sustainable Value Co-Creation -> Sustainable Performance | 0.196 | 0.156 | 0.237 | 9.338 | 0.000 |
| Digital Maturity -> Sustainable Value Co-Creation -> Sustainable Performance | 0.233 | 0.183 | 0.286 | 8.829 | 0.000 |

## 5. Discussion

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Our findings indicate that digital maturity is the strongest enabler of organizational resilience and sustainable value co-creation, which together explain most of the pathway to sustainable performance in manufacturing SMEs (Hortovanyi et al., 2023). This supports the view that digitally mature firms are better able to reconfigure resources, collaborate across their ecosystem, and translate technology investments into sustainability outcomes (Schöggl et al., 2024).

Organizational resilience was also found to be a significant driver of SP, confirming its role as a critical capability for SMEs navigating volatile and resource-constrained environments. This corroborates (Wang et al., 2022), but the current study extends the literature by showing resilience as a mediator linking DM to performance outcomes—an underexplored relationship. Although the direct effect of AI-driven digital ecosystems on sustainable performance is statistically significant, its magnitude is small. This suggests that the primary value of AI ecosystems for sustainability is realized indirectly, through stronger resilience routines and stakeholder-oriented value co-creation practices.

The moderating role of DM further indicates that digitally advanced SMEs can amplify the benefits of AIE, consistent with (Jacobides et al., 2021). However, the modest effect size suggests that complementary factors such as leadership, culture, or governance structures are needed to maximize these benefits. Unlike earlier studies that emphasized single constructs by (Manser Payne et al., 2021) which focused on individual constructs like resilience or sustainability, our integrated model emphasizes the interdependencies among AIE, digital maturity, and value co-creation. Additionally, (Wamba-Taguimdje et al., 2020) established a direct influence of AI technologies on performance, but our findings show a more complex relationship, where AIE's impact on performance is mediated through organizational resilience and co-creation. This contrast highlights the importance of contextual factors specifically, the resource constraints faced by SMEs in emerging markets such as Pakistan.

*5.1 Practical Implications*

The findings of this study offer significant implications for SMEs, particularly in developing economies like Pakistan, where digital transformation is no longer optional but a strategic imperative. Our results provide a clear prioritization for resource-constrained SMEs; digital maturity is the most reliable enabler because it strengthens organizational resilience and sustainable value co-creation, while sustainable value co-creation is the strongest pathway to sustainable performance. Therefore, SMEs should avoid expecting instant sustainability gains

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from AI tool adoption alone and instead implement AI ecosystems through a phased capability-building approach that first strengthens digital maturity routines, then resilience practices, and finally stakeholder co-creation. SMEs must consider digital maturity as a cornerstone for resilience and sustainability. Digital maturity emerges as the key enabler of both organizational resilience and sustainable value co-creation; therefore, manufacturing SMEs should prioritize strengthening digital maturity before scaling AI investments. A practical approach is to begin with low-cost, high-impact technologies (e.g., cloud services, basic analytics, mobile solutions) that can scale as capabilities and resources grow. For resource-constrained SMEs in Pakistan, the findings support a phased roadmap. Phase 1 (Weeks 1–6) establishes digital foundations through a rapid audit of processes, data, and skills, the appointment of a single accountable "digital owner," and the selection of three to five KPIs (e.g., share of processes digitized, decision-ready data availability, staff training hours). Phase 2 (Months 2–4) focuses on one high-ROI AI ecosystem use case (e.g., demand forecasting, inventory optimization, predictive maintenance, or service automation) embedded into a single workflow, preferably through partnerships with vendors or platform providers; progress can be tracked via forecast error, stockouts, downtime, and response time. Phase 3 (Months 4–8) institutionalizes resilience routines by implementing early-warning dashboards, simple scenario planning, and disruption recovery playbooks, monitored through recovery time objectives, lead-time variance, and fulfillment stability. Phase 4 (Months 6–12) scales sustainable value co-creation through one to two stakeholder initiatives (e.g., supplier waste reduction, eco-design, circular pilots), evaluated using co-creation project counts and outcome metrics such as waste/energy intensity, defect returns, and ESG-aligned target achievement. From a policy perspective, adoption can be accelerated through targeted digital vouchers, subsidized training/consulting, cluster-based shared platforms, and incentives for circular/green initiatives tied to measurable KPIs.

AI-driven ecosystems (AIE) offer capabilities for real-time adaptability, risk mitigation, and enhanced decision-making, all critical for improving organizational resilience. SMEs should collaborate with AI solution providers to implement predictive analytics tools that forecast changes in market conditions, ensuring business resilience in the face of economic volatility and supply chain disruptions.

Considering the resource constraints SMEs often face, a lean managerial approach, focusing on high-ROI technologies, is recommended for successful digital adoption. Additionally, embedding resilience and sustainability into the organizational culture is crucial

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for fostering continuous learning, adaptability, and long-term growth in a rapidly evolving digital economy.

### *5.2 Theoretical Implications*

Our findings extend RBV by showing that in SMEs, advantage-relevant resources in the digital era are not only physical assets but also ecosystem-enabled informational resources (data access, analytics, partner connectivity) and digitally mature routines that allow SMEs to mobilize those resources. This explains why digital maturity reliably strengthens capability development and sustainability outcomes in resource-constrained environments.

Extending DCT (routines/capabilities and boundary condition): We extend DCT by positioning digital maturity as a boundary condition that strengthens how AI ecosystem engagement translates into organizational resilience (i.e., digitally mature SMEs can sense–seize–reconfigure more effectively). Importantly, we interpret the modest moderation magnitude as theoretical nuance: digital maturity strengthens the pathway but does not replace other complementary capabilities (leadership/culture/governance). We extend Stakeholder Theory by demonstrating that sustainability performance is best explained through a stakeholder-engagement mechanism, where sustainable value co-creation operationalizes "value for stakeholders" as a measurable process that translates digital and resilience capabilities into triple-bottom-line outcomes. Together, these results provide a mechanism-based (OR and SVC) and boundary-conditioned (DM) explanation of how AI-enabled ecosystems contribute to sustainable performance in emerging-market SMEs.

### *5.3 Limitations and Future Research*

This study makes useful contributions; however, some limitations should be noted. Future research can improve these limitations by exploring the industry-specific applications of digital transformation in SMEs. Longitudinal studies examining causal relationships are needed, while comparisons across different regions would help understand the cultural and economy-related factors shaping the resilience-performance dynamic in SMEs. Furthermore, the integration of emerging constructs, such as digital ethics and algorithmic transparency, would enrich the model and provide more holistic insights into the transformational impact of AI ecosystems.

## 6. Conclusion

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This research investigated the interconnected roles of AI-driven digital ecosystems, digital maturity, organizational resilience, and sustainable value co-creation in driving sustainable performance among SMEs in Pakistan's manufacturing sector. Using SEM, the study demonstrates that digital maturity is a pivotal enabler of resilience and co-creation, both of which act as key pathways to sustainable performance.

The findings emphasize that successful digital transformation in SMEs requires not only technological adoption but also strategic alignment with adaptive and collaborative practices. By extending RBV, DCT, and Stakeholder Theory, the study offers a comprehensive framework for understanding how SMEs can align digital strategies with sustainability objectives.

From a practical perspective, the study highlights the importance of phased digital transformation, stakeholder co-creation, and lean innovation strategies for SMEs facing resource constraints. For policymakers, it underscores the need for targeted programs that build SMEs' digital readiness, resilience, and sustainability capabilities.

By addressing critical gaps in the literature and linking findings to global sustainability goals, this research provides actionable guidance for scholars, practitioners, and policymakers seeking to navigate the challenges of SME digitization in volatile environments. Future research should broaden the scope to larger industries and cross-country comparisons, ensuring the global applicability of insights on how digital ecosystems can enhance resilience and sustainability.

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**Appendix A.**

| |
|---|
| **AI Driven Ecosystem** (He et al., 2022) |
| AIE1 We are using digital technologies (such as analytics and AI tools) across our business network to support key ecosystem partners. |
| AIE2 Technology allows us to support customers and partners in new ways through AI-enabled and digital channels. |
| AIE3 We use digital technologies to increase the performance or added value of our products and services for customers and partners. |
| AIE4 We have launched new business models based on digital technologies that connect us more closely with ecosystem partners. |
| AIE5 The company is promoting the culture and skills needed to participate in AI-enabled digital ecosystems. |
| **Digital Maturity** (He et al., 2022) |
| DM1 We are using digital technologies (such as analytics, social media, mobile and embedded devices) to understand our customers better. |
| DM2 We use digital channels (such as online, social media and mobile) to market and distribute our products and services. |
| DM3 Digital technologies allow us to support customers and improve internal operational processes in new ways. |
| DM4 We use digital technologies to increase the performance or added value of our existing products and services. |
| DM5 We have launched new business models based on digital technologies. |
| DM6 The company is promoting the cultural changes needed for digital transformation. |
| **Sustainable Value Co-Creation** (Cossío-Silva et al., 2016b; Lacoste, 2016b) |
| SVC1 Our collaboration with partners integrates environmental, social and economic goals to create long-term sustainable value. |
| SVC2 Co-creation efforts with partners lead to innovative and resource-efficient solutions that enhance sustainability and business performance. |
| SVC3 Partnerships focused on sustainability strengthen trust, loyalty and competitive advantage for our organization. |
| **Organizational Resilience** – (He et al., 2022) |
| OR1 During an average day, people in our company interact often enough to know what is going on. |
| OR2 Managers actively listen for problems in our company because it helps them prepare a better response. |
| OR3 Our company proactively monitors what is happening in its industry to obtain early warning of emerging issues. |
| OR4 Our company has sufficient internal resources to operate successfully during business-as-usual. |
| OR5 In our company, if something out of the ordinary happens, people know who has the expertise to respond. |
| OR6 Our company is able to shift rapidly from business-as-usual mode to respond to crises. |
| **Sustainable Performance – 7 item scale -** (Ishaq et al., 2023a) |
| SP1 Growth in the firm's profits, in general, is due to reductions in energy consumption and material use. |
| SP2 Our firm contributes to developing economic activities in the community and providing more job opportunities. |
| SP3 Our firm has increased the volume of recycled materials and reduced waste. |
| SP4 Our firm has improved the quality of services provided and strengthened its commitment to professional codes of ethics. |

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