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Digital Capability, Environmental Strategy Orientation, and Sustainable Organizational Performance: A Sequential Mediation Model of Environmental Management Accounting and Decision Quality

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Abstract

Despite increasing investments in digital transformation and sustainability initiatives, many organizations struggle to translate these efforts into measurable sustainable organizational performance, particularly in emerging economies, where resource constraints and institutional pressures persist. This study examines how digital capability and environmental strategy orientation contribute to sustainable organizational performance through the sequential mediating roles of environmental management accounting (EMA) integration and managerial decision quality. Drawing on dynamic capability theory and the natural resource-based view, this study proposes a moderated mediation model incorporating technology readiness and environmental regulatory pressure. Data were collected from 479 middle- and senior-level managers of ISO 14001-certified manufacturing firms in Pakistan and analyzed using partial least squares structural equation modeling (PLS-SEM). The results indicate that both digital capability and environmental strategy orientation significantly enhance EMA integration, which in turn improves managerial decision quality and ultimately drives sustainable organizational performance. The findings confirm the presence of sequential mediation through EMA integration and decision quality. Furthermore, technology readiness strengthens the relationship between digital capability and EMA integration, whereas environmental regulatory pressure does not significantly moderate the relationship between environmental strategy orientation and EMA integration. This study contributes to the sustainability literature by introducing a novel sequential mediation mechanism linking digital and strategic capabilities to sustainability outcomes through accounting-based processes. It also provides empirical evidence offering practical insights for managers and policymakers aiming to enhance sustainability performance. The findings provide context-specific insights from an emerging economy and contribute to advancing organizational sustainability in line with SDGs 8, 12, and 13.

Keywords: digital capability; environmental strategy orientation; environmental management accounting; managerial decision quality; sustainable organizational performance; SDGs



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1. Introduction

The rapid pace of digital transformation, coupled with increasing global sustainability pressures, has compelled organizations to rethink how they create value while address-

ing environmental and social challenges [1,2]. Advanced technologies such as artificial intelligence, cloud computing, and data analytics are reshaping strategic decision-making processes and enabling organizations to process complex information more efficiently [3,4]. Concurrently, stakeholders, including governing authorities, investors, and others, are constantly demanding that organizations report their environmental, social, and economic progress and their contribution towards the Sustainable Development Goals (SDGs) [5,6]. Therefore, Hristov et al. [7] highlight that it has become crucial for organizations to integrate sustainability into their system of planning as well as performance management. This challenge becomes more pertinent in the context of organizations in developing countries, where there are already limited resources and capabilities [4,8,9]. Therefore, organizations and policymakers seek effective mechanisms to support their sustainability efforts.

Stoian et al. [10] suggest that the process of sustainable development necessitates the effective acquisition, incorporation, and implementation of knowledge as supported by the Knowledge-Based View (KBV). In this regard, environmental management accounting (EMA) has been embraced as one of the key tools allowing the integration of social and environmental information into the decision-making process of an organization [11–13]. The integration of EMA facilitates organizations in acquiring, integrating, and applying sustainability-related data. This process enables them to make informed decisions regarding sustainability initiatives [2]. According to Asa'd et al. [14], EMA integration allows organizations to enhance the quality of their management decisions, which are crucial to their social, economic, and environmental progress. It means that organizations need to effectively implement and integrate EMA in order to enhance their managerial decision quality (MDQ) so that these decisions can positively contribute to their sustainable development. Effective implementation of EMA provides timely and relevant information that supports managers in making informed decisions [15,16]. This integration fosters a proactive approach to identifying opportunities and mitigating risks, thereby improving overall organizational performance. Consequently, organizations that leverage EMA effectively are better positioned to achieve long-term sustainability goals [17]. Alshahrani and Hakim [18] suggest that high-quality managerial decisions allow organizations to enhance their sustainable performance.

Despite intensifying investments in sustainability initiatives and technological solutions, several manufacturing organizations in Pakistan are still unable to translate these investments into sustainable organizational performance (SOP). This means that technology alone is not enough to attain SOP; rather, dynamic capabilities theory (DCT) suggests that the way an organization recognizes opportunities, acquires digital resources, and redesigns its internal processes plays a vital role in attaining sustainable competitive advantages and enhancing performance [19,20]. Therefore, scholars argue that organizations need to build a digital capability for successfully achieving sustainability, as this enables them to acquire, assess, and reorganize useful information in a more productive way [18,21]. In other words, it could be ascertained that this digital capability substantially enables organizations to integrate EMA into their decision-making systems. The current study provides insights into manufacturing organizations in Pakistan pursuing sustainability and examines how they can attain SOP by mobilizing their dynamic capabilities, i.e., digital capability. Alshahrani and Hakim [18] suggest that technology readiness is an influential factor in the relationship between digital capability and EMA integration. However, the past literature has rarely examined this moderating path between digital capability and EMA integration [22,23]. The current study evaluates how the technology readiness of Pakistani organizations amplifies the translation of their digital capabilities into EMA integration.

Another important primary factor in promoting the EMA integration of an organization is its environmental strategy orientation (ESO) [24]. The natural resource-based view

(NRBV) emphasizes the formulation and implementation of environmental strategies to lessen ecological impacts and make positive contributions towards the climate [25]. ESO becomes more pertinent when it comes to developing countries like Pakistan given their insufficient funds and high vulnerability to climate change effects [26–28]. According to Appannan and Mohd Said [24], when an organization integrates environmental concerns (such as pollution prevention, clean technology, and stewardship) into its core business strategy, it becomes more likely to integrate EMA into its system, which is an ultimate predictor of SOP. However, some scholars believe that organizations under high environmental regulatory pressure (ERP) are more likely to integrate EMA, e.g., refs. [24,29,30]. It means that organizations facing high ERP can possibly become more likely to translate their ESO into EMA integration. This research seeks to analyze the catalyzing role of ERP in the nexus between ESO and EMA integration in Pakistani manufacturing organizations.

Based on the above-mentioned views, a serial mediation model possibly emerges from digital capability and ESO to SOP, with the inclusion of EMA integration and MDQ as serial mediators. However, the existing empirical literature seems to lack discussion about this serial mediation, thus raising the need for empirical assessment of this process. The current study attempted to fill this gap in the literature by examining the paths from digital capability and ESO to SOP, with the inclusion of EMA integration and MDQ as serial mediators, in manufacturing organizations in Pakistan. Past studies have rarely investigated the constructs of digital capability, ESO, technology readiness, ERP, EMA integration, MDQ, and SOP simultaneously in a model [18,21,31], thus making the current study a comprehensive assessment of the process of determining SOP from digital capability and ESO. Although a few studies examined MDQ and EMA integration as mediators between digital capability or ESO and SOP [18,24], they did not attempt to evaluate their sequential mediating roles in the path, leaving an obvious gap in the literature. Furthermore, the existing literature indicates the rarity of a focus on moderated paths from digital capability or ESO to EMA integration, leaving unexplained the mechanism through which the presence of technology readiness or ERP can boost the process of translating these independent factors into EMA integration [30].

While the study integrates multiple organizational constructs, each variable captures a distinct dimension of the sustainability process. Digital capability reflects the organization's ability to leverage digital technologies, whereas ESO represents a strategic commitment toward environmental goals. EMA captures the integration of sustainability-related information into internal systems, and MDQ reflects the effectiveness of decision-making processes. Although these constructs are conceptually related, they represent different stages of capability, process, and outcome within the organizational sustainability framework. Therefore, the above-mentioned gaps in the literature cause organizations to lack a proper understanding of how they can direct their digital investments and environmental strategies to enhance EMA integration and the quality of their managerial decisions, which can contribute towards their SOP. The current study, by working on the following objectives, fills these gaps and enhances understanding of the phenomena through which organizations can attain SOP:

- (1) Examine the effect of digital capability on EMA integration of manufacturing organizations in Pakistan;
- (2) Evaluate the effect of ESO on EMA integration;
- (3) Evaluate the sequential mediation of EMA integration and MDQ in the path from digital capability to SOP;
- (4) Evaluate the sequential mediation of EMA integration and MDQ in the path from ESO to SOP;

- (5) Examine the moderating role of technology readiness in the nexus between digital capability and EMA integration;
- (6) Examine the moderating role of ERP in the nexus between ESO and EMA integration.

This study makes several important contributions to the sustainability literature. First, it introduces a novel sequential mediation mechanism that explains how digital capability and ESO influence SOP through EMA integration and MDQ. By doing so, the study shifts the focus from direct effects to underlying organizational processes that translate capabilities into sustainability outcomes. Second, it extends dynamic capability theory and the NRBV by integrating accounting-based mechanisms and decision-quality perspectives into sustainability research, thereby offering a more comprehensive theoretical explanation of how firms achieve sustainable performance. Third, the study incorporates important boundary conditions—technology readiness and ERP—to explain when and how these relationships are strengthened or constrained. Finally, by providing empirical evidence from Pakistan as an emerging economy, the study offers context-specific insights into sustainability challenges and contributes to advancing sustainable production and organizational performance in alignment with Sustainable Development Goals (SDGs) 8, 12, and 13.

2. Literature Review and Hypothesis Development

2.1. Digital Capability and EMA Integration

Digital capability refers to the organization's aptitude to apply and integrate advanced and complex digital technologies to improve the efficiency, accuracy, and strategic value of functions and operations. Drawing on DCT, scholars come with the view that organizations that have built their digital capability are more likely to identify opportunities, acquire knowledge, and redeploy information for the sake of the betterment of their operations and performance [18,19,21]. This dynamic capability leads them to adopt and integrate advanced accounting frameworks to support their sustainability-related decision-making and operations. Scholars emphasize that digital transformation allows organizations to integrate sustainability-relevant knowledge into their accounting and management reporting, thus supporting sustainability-oriented decision-making [32–34].

Pencle [35] suggests that utilizing digital technologies such as analytics and AI allows organizations to improve their operations and support routine tasks by automating them. This is embraced by scholars such as Chen and Zhao [36] and Purnamasari et al. [37], who suggest that strong information systems and digital tools enable a streamlined and efficient flow of information to management. Kusumawardhani et al. [38] also suggested that digitalization promotes the incorporation of accounting systems by improving the accuracy and timeliness of accounting data, which in turn strengthens the quality of managerial decisions. According to Alshahrani and Hakim [18], organizations with digital capability are better able to support EMA integration into their systems through their great ability to identify, capture, and reorganize relevant knowledge. However, past studies have mostly focused on particular digital tools (e.g., big data, AI) or general digitalization to examine their influence on EMA integration instead of focusing on digital capability specifically [18]. Drawing on DCT, digital capability enables organizations to reconfigure information systems and integrate sustainability-related knowledge into internal accounting processes, thereby facilitating EMA integration. Given the scarce empirical literature, the current study seeks to assess this nexus by hypothesizing the following:

H1. *Digital capability significantly positively affects EMA integration.*

2.2. Environmental Strategy Orientation and EMA Integration

Drawing from NRBV, Appannan, Mohd Said [24] suggest that a primary strategy integrating environmental concerns such as pollution prevention, clean technology, and stewardship enables an organization to achieve sustainable competitive advantages. For instance, an organization that has pollution prevention as its core strategic orientation is more likely to adopt such practices and tools, through which it can minimize or eliminate emissions instead of cleaning them [39]. According to Appannan, Mohd Said [24], ESO may not influence the environmental performance of an organization directly, but it can mobilize and promote different internal factors that can predict the SOP. This is because several studies in the past attempted to evaluate the role of ESO in shaping sustainable performance by integrating indirect factors between them [40,41].

EMA integration is a key outcome of environmental strategy, as many prior researchers have emphasized that ESOs such as pollution prevention lead organizations to adopt accounting systems that can facilitate their motives of waste reduction, cost minimization, emission control, and informed decision-making [24,40,42,43]. However, the existing literature mostly focuses on individual environmental strategies such as pollution prevention or clean technology to assess their influence on EMA, while clearly lacking an efficient explanation of the nexus existing between overall ESO and EMA integration. The current study aims to evaluate how the great ESO can facilitate EMA integration directly. From the perspective of the NRBV, ESO drives the adoption of internal systems such as EMA to support environmental objectives and sustainability performance, and it hypothesizes the following:

H2. *ESO significantly positively affects EMA integration.*

2.3. EMA Integration and Managerial Decision Quality

Successful EMA integration into an organizational system enables it to acquire and process sustainability-related knowledge in an efficient manner and come up with high-quality and informed decisions contributing towards SOP. Alshahrani and Hakim [18] emphasize that EMA plays a vital role in internal decision-making by prioritizing economic and environmental considerations. Pumiviset and Suttipun [44] suggest that strategic management accounting provides managers with ample sustainability-related knowledge and information. Based on such comprehensive information, they can develop better strategic decisions by incorporating environmental and social concerns to support SOP. Therefore, the current study argues that EMA integration acts as the predictor of managerial decision quality (MDQ). The strong EMA enables managers to have comprehensive information about costs, waste, emissions, and other environmental concerns, based on which they can develop more transparent and informed decisions to address those concerns.

Franke and Hiebl [45] highlighted the role of management accounting in determining the quality of management decisions by emphasizing that the day-to-day analytics skills of management accountants are crucial for determining decision quality. Asa'd, Ahmad [14] found that MDQ serves as a significant mediator between EMA and environmental performance, thus emphasizing the predictive role of EMA in deriving the quality of managerial decisions. However, they highlight that a possible EMA-MDQ nexus has rarely been examined in past studies. Although a number of researchers have attempted to identify and explain different predictors of MDQ, including management information systems [14,38,46,47], a particular focus on EMA integration as the antecedent of MDQ is still rare in the literature. Therefore, this study hypothesizes the following:

H3. *EMA integration significantly positively affects MDQ.*

2.4. Managerial Decision Quality and Sustainable Organizational Performance

Quality and informed decisions are considered to be crucial to enhancing the economic, operational, social, and environmental performance of an organization, as they are more likely to incorporate all-inclusive concerns and address them. SOP refers to the capability of an organization to attain long-standing economic, social, environmental, and operational gains [18]. MDQ is of considerable importance in the process of attaining SOP as it captures the behavioral as well as cognitive aspects of managerial actions and reflects the way in which accounting information is assessed and utilized in strategic decision-making. Yu, Wang [31] suggest that the quality of managerial decisions acts as a decisive factor in the process of determining sustainable performance. This is because high-quality management decisions are actually evidence-based sustainable decisions that facilitate sound forecasting and strategic planning. Alshahrani and Hakim [18] also suggest that managerial decisions derived from sustainability-based performance frameworks such as EMA enable organizations to enhance their performance with the consideration of eco-efficiency factors.

A number of researchers indicated that the quality of management and strategic decisions makes a significant difference to the sustainable outcomes. For example, Wang et al. [48] and Nisar et al. [49] described the positive contribution of high-quality decision-making towards sustainability and environmental performance, respectively. Malik [34] also emphasized that organizations with high-quality strategic decision-making align their decisions with real-time data, which improves the relevance and timeliness of their decisions and resulting actions, thus contributing towards sustainability [12,15]. Alshahrani and Hakim [18] point to the view that MDQ can be translated into SOP only when harmonized by supportive systems and data. Nonetheless, the literature provides no further explanation of the nexus, thus leading the current researchers to assess the nexus by hypothesizing the following:

H4. MDQ significantly positively affects SOP.

2.5. Mediating Roles of EMA Integration and Managerial Decision Quality

The discussion in Section 2.1 indicates that the digital capability of an organization increases EMA integration into the organizational system. Several researchers have attempted to explain how the digital capability and digitalization of an organization leads it to adopt and incorporate advanced accounting frameworks to support its sustainability-related decision-making and operations [18,32–34,38]. This is similar to the case of ESO, as it has also been embraced as a determinant of EMA integration by a number of prior studies. The discussion of the literature in Section 2.2 indicates that ESO tends to mobilize and promote internal accounting systems (i.e., EMA) in organizations to fulfill their strategic objectives, as various researchers emphasized the predictive role of different environmental strategies in EMA integration [24,40,42,43]. Furthermore, Agustia, Sawarjuwono [43] also emphasized that EMA integration plays a crucial intervening role in pollution prevention strategy (ESO) and firm value because this strategy needs substantial assistance from internal systems and the structure of an organization to achieve competitive advantages. Hence, EMA integration has been embraced as the outcome of both digital capability and ESO by past researchers.

EMA integration is able to predict MDQ because EMA allows organizations to acquire, analyze, and generate useful information, on which quality managerial decisions are made. The discussion of the literature in Section 2.3 leads the researchers to argue that EMA integration increases the quality of managerial decisions, as multiple researchers such as Alshahrani and Hakim [18], Pumiviset and Suttipun [44], Franke and Hiebl [45], and Asa'd, Ahmad [14] support the view that management accounting plays a central role in

improving the internal decision-making of an organization. Researchers such as Vasile and Man [50] emphasized that EMA plays a central role in providing enough knowledge of environmental costs to managers so that they can make high-quality decisions regarding pollution prevention and other environmental concerns. This suggests that EMA integration possibly serves as the mediating factor in both the path from digital capability to MDQ and that from ESO to MDQ.

The discussion of the literature in Section 2.4 reveals that high-quality managerial decisions enable organizations to improve their SOP by integrating all-inclusive concerns (ecological, social, operational, and economic) and addressing them. A number of researchers have attempted to highlight that quality and informed managerial decisions derived from advanced accounting frameworks (e.g., EMA) are likely to enhance sustainable performance [18,31,48,49]. Hence, the quality of managerial decisions tends to act as a decisive element in achieving SOP. It reveals that digital capability promotes EMA integration, which enhances MDQ in an organization. The resulting MDQ derives SOP, thus pointing towards the existence of serial mediation in the path from digital capability to SOP. A similar case is the path from ESO to SOP, as ESO promotes EMA integration, which enhances MDQ in the organization. The resulting MDQ derives SOP, thus pointing towards the presence of chain mediation in the path from ESO to SOP. However, the existence of these chains of mediation in these paths of attaining SOP has never been assessed empirically with data, thus leaving them unexplained. Furthermore, Alshahrani and Hakim [18] suggest that most prior studies have examined decision quality as the end result of using digital tools, while its intermediating role has been somehow ignored in the process of attaining SOP. The current study addresses these shortcomings in the literature by evaluating the intermediating roles of EMA integration as well as MDQ through the following hypotheses:

H5. *EMA integration and managerial decision quality significantly sequentially mediate the relationship between digital capability and SOP.*

H6. *EMA integration and managerial decision quality significantly sequentially mediate the relationship between ESO and SOP.*

2.6. Moderating Role of Technology Readiness Between Digital Capability and EMA Integration

Alshahrani and Hakim [18] suggest that, though the nexus between digital capability and EMA integration has been examined by some past researchers, their studies lack focus on intervening variables that can influence the relationship. For instance, it may be difficult to translate digital capability into EMA integration if an organization is not ready to adopt technology. Technology readiness is among the influential factors that can enhance the transformation of digital capability into EMA integration. Scholars such as Anh, Hoa [51] and Alshahrani and Hakim [18] revealed that the more technologically ready an organization is, the better able it is to integrate a certain technology or accounting system. This is because highly technologically ready organizations are better able to welcome new technologies such as EMA and embed them into their structure and culture. However, the existing literature seems to provide no further explanation of the catalyzing role of technology readiness in the nexus between digital capability and EMA. Therefore, the study seeks to evaluate the following hypothesis:

H7. *Technology readiness significantly positively moderates the relationship between digital capability and EMA integration.*

2.7. Moderating Role of ERP Between ESO and EMA Integration

ERP refers to the degree to which regulatory bodies force organizations to obey environmental standards, laws, and policies [52,53]. Scholars reveal that ERP has a significant impact on the environmental strategies of an organization and their successful implementation [54,55]. Qian, Burritt [56] suggested that organizations under high ERP are more likely to direct their strategic orientation towards environmental management. A number of researchers have emphasized that organizations under high regulatory pressure tend to translate their environmental strategies into the integration of accounting systems (i.e., EMA) that can help them enhance their environmental performance and ensure their compliance with environmental regulations [24,29,30]. This means that ERP can catalyze the influence of ESO on EMA integration; however, this moderation path remains unexplored in the existing literature. This study hypothesizes the following:

H8. *ERP significantly positively moderates the relationship between ESO and EMA integration.*

Figure 1 below presents the conceptual framework of the study.

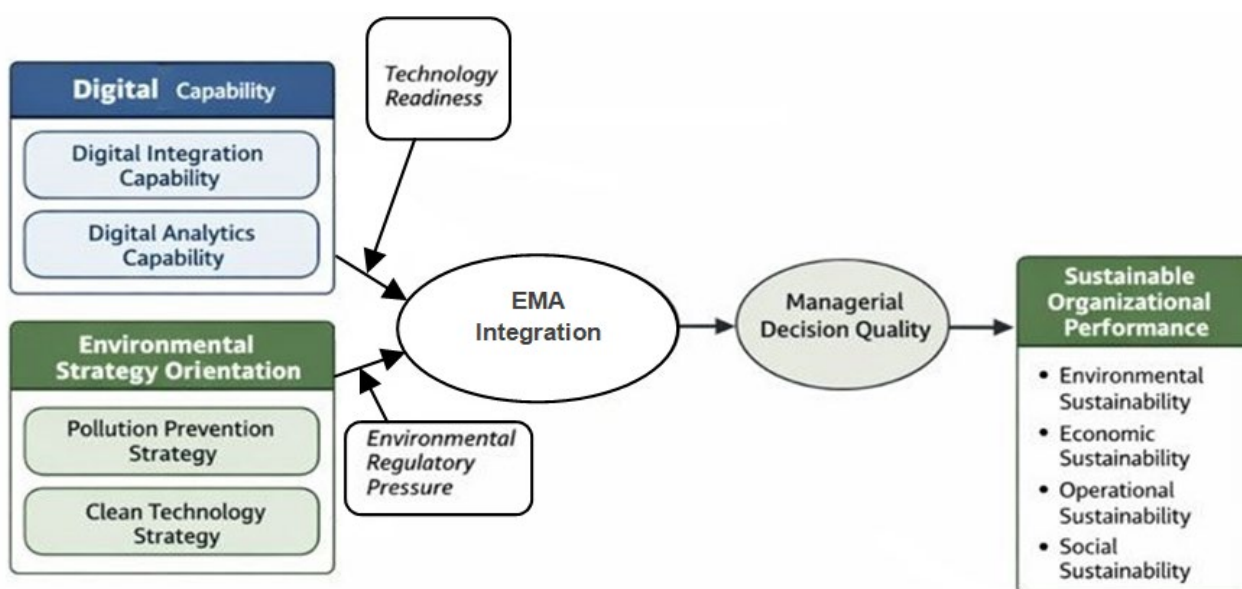


Figure 1. Conceptual framework.

3. Materials and Methods

3.1. Research Design

This study used a quantitative research approach to test the cause-and-effect relationships existing among the study constructs. As the study aimed to assess the serial mediation paths from digital capability and ESO to SOP, explanatory research was performed on the manufacturing sector of Pakistan. Data for the current study was collected during two time periods to eliminate the issue of common method bias (CMB). Data about independent factors (i.e., causes and organizational conditions), including digital capability, ESO, technology readiness, and ERP, was collected at Time 1, while data regarding processes and outcome variables, including EMA integration, MDQ, and SOP, was collected four weeks after the first stage of data collection, at Time 2. The primary structural nexuses of the study, being theory-driven, were investigated with the help of partial least squares structural equation modeling (PLS-SEM) as this approach is suitable for analyzing effect sizes, predictive relevance, and the explained variance of models, including moderation and mediation.

3.2. Population and Sampling

The current study targeted the manufacturing sector of Pakistan to assess the role of digital capability, ESO, EMA, and MDQ in deriving SOP of organization. This sector was selected being one of the most digitized sectors in Pakistan with the dominance of AI, integrated accounting systems, analytics, and great demand for sustainable development. Furthermore, manufacturing organizations in Pakistan are considered to be having considerable numbers of environmental impacts and they really need to pinpoint the major ways through which they can achieve sustainable development [2,28]. Manufacturing organizations rely heavily on EMA and other digital systems to control their environmental impacts, assess risks, and make sustainable efforts, which make them suitable for examining the relationships among digital capability, ESO, EMA integration, and MDQ, and SOP.

Given the manufacturing sector of Pakistan is the targeted sector of the study, the population of study comprised ISO 14001-certified manufacturing organizations in Pakistan [57]. Non-manufacturing organizations were not included in the population, so 846 manufacturing organizations (as per the ISO 2022 survey [58]) were evaluated in the study. The purposive sampling technique was applied to select the participants of the study, who included middle-level and senior-level managers in these organizations. This was because these managers fit well with the purpose of the current study and they could provide the most relevant data about their organization's EMA system, digital capability, ESO, MDQ, technology readiness, ERP, and SOP. Furthermore, lower-level or general managers may not have had adequate awareness about EMA and other studied factors. Therefore, the sample size was calculated based on the necessary number for any endogenous variable's structural paths. The minimum required sample size was determined using multiple approaches to ensure statistical adequacy and robustness. According to Krejcie and Morgan's sample table, a sample size of approximately 267 is sufficient for the study population. Additionally, using G*Power (version 3.1.9.7) analysis with six predictors, a medium effect size ($f^2 = 0.15$), a significance level of 0.05, and statistical power of 0.95, the minimum required sample size was approximately 146. Thus, a total of 500 responses were initially targeted, and after data screening for missing and invalid responses, 479 valid responses were retained for final analysis (see Appendix A for demographic details). This sample size exceeds the minimum requirements and ensures sufficient statistical power to test the proposed model.

3.3. Instrument Development

A structured questionnaire was used as the primary tool to collect data from participants. For this purpose, validated measurement scales were taken from prior studies. Each variable was measured as a latent construct on a five-point Likert scale. Digital capability was measured through a scale of eight items that were previously used by Alshahrani and Hakim [18]. ESO was measured through a 10-item scale previously used by Appannan, Mohd Said [24]. EMA was measured using six items from the study of Chaudhry and Amir [29]. Constructs of MDQ, SOP, and technology readiness were measured using five, five, and four items respectively, each taken from Alshahrani and Hakim [18], who previously used those items to measure the respective variables. The variable of ERP was measured through four items that were previously used by Zeng, Li [54].

3.4. Data Collection Procedure

The data was collected by sending online questionnaires to targeted managers through e-mail and LinkedIn business links. As mentioned above, the data was collected in two stages, as the data for some variables was collected at Time 1 and the data for other variables was collected at Time 2. Respondents were first given a short briefing along with

the questionnaire in which they were told the purpose of the study being conducted and were assured about their privacy.

3.5. Ethical Considerations

The research was performed in accordance with key ethical standards and research concerns. The informed consent of participants was taken to ensure that they were fully aware of the purpose of the study, and they voluntarily participated in the study. The data of the organizations was not disclosed to any third party and was presented only in the form of quantifiable results while keeping the identity of organizations and respondents confidential.

3.6. Data Analysis

PLS-SEM was performed to analyze the data using SmartPLS (version 4.1.1.6), in which reliability, convergent validity, discriminant validity, multicollinearity, and CMB assessments were performed. The measurement and structural models were estimated using the path weighting scheme. CMB was assessed using multiple complementary procedures (see Table 1). A comparison of structural models with and without the marker variable indicated negligible changes in path coefficients, thus revealing model stability. The marker variable showed no significant effects on endogenous constructs. Full collinearity tests also produced VIF values far below the recommended threshold of 3.3, indicating the absence of both vertical and lateral collinearity. Harman's single-factor test showed that the first factor accounted for only 21.52% of the total variance (see Appendix A, Table A1). Collectively, these findings confirm that CMB is unlikely to threaten the validity of the results. After validating the measurement model, PLS-SEM was applied to test the structural model and assess hypothesized relationships. Bootstrapping was performed with 10,000 resamples using a one-tailed significance test to evaluate the significance of direct, mediating, and moderating effects.

Table 1. Assessment of common method bias.

Test	Procedure	Criterion	Result	Conclusion
Measured latent marker variable	Workplace Social Interaction (WSI) regressed on endogenous constructs (EMA, MDQ, SOP) and structural paths compared with and without marker	Marker paths non-significant; structural coefficients remain stable	WSI → EMA ($p = 0.202$); WSI → MDQ ($p = 0.174$); WSI → SOP ($p = 0.176$); negligible changes in β ($\Delta\beta < 0.01$)	No evidence of CMB
Full collinearity assessment	All substantive constructs regressed on marker composite and VIF values examined	VIF < 3.30	VIF range = 1.345–1.696	No evidence of CMB
Harman single-factor test	Principal component analysis of all measurement items	First factor explains < 50% variance	First factor = 21.52% variance explained	No evidence of CMB

4. Results

To evaluate the normality of the collected data, descriptive statistics were produced as indicated in Table 2. The studied model encompassed seven latent constructs including digital capability, ESO, EMA, MDQ, SOP, technology readiness, and ERP. Descriptive statistics indicated that the data of each of the measured items gave a mean value ranging from 1 to 5, which was the standard range, and there were no extreme values in the data. To evaluate the normality of the data, both skewness and kurtosis values were examined (see Table 2). The skewness values ranged between -1 and $+1$, while kurtosis values were

also within the acceptable range of -3 to $+3$, indicating that the data did not significantly deviate from a normal distribution.

Table 2. Item-level descriptive statistics, outer loadings, and collinearity diagnostics.

Construct	Item	Mean	Skewness	Kurtosis	Loading	VIF
Digital Capability (DC)	DC1	3.589	−0.453	−0.776	0.841	2.731
	DC2	3.186	−0.143	−1.229	0.346 *	1.190
	DC3	3.576	−0.500	−0.590	0.801	2.519
	DC4	3.541	−0.404	−0.603	0.771	2.434
	DC5	3.545	−0.413	−0.636	0.842	2.780
	DC6	3.651	−0.517	−0.543	0.815	2.428
	DC7	3.656	−0.600	−0.447	0.807	2.436
	DC8	3.526	−0.510	−0.765	0.736	1.865
Environmental Management Accounting (EMA)	EMA1	3.378	−0.309	−0.932	0.700	1.713
	EMA2	3.470	−0.330	−0.701	0.733	1.818
	EMA3	3.392	−0.322	−0.733	0.810	2.517
	EMA4	3.397	−0.363	−0.807	0.812	2.667
	EMA5	3.363	−0.305	−0.894	0.834	2.573
	EMA6	3.438	−0.379	−1.014	0.704	1.550
Environmental Regulatory Pressure (ERP)	ERP1	3.094	−0.021	−1.223	0.832	2.543
	ERP2	3.075	−0.006	−1.159	0.859	2.881
	ERP3	3.065	0.014	−1.138	0.874	2.803
	ERP4	3.050	0.066	−1.209	0.780	1.906
	ERP5	3.223	−0.162	−1.159	0.890	2.914
Environmental Strategy Orientation (ESO)	ESO1	2.977	0.078	−1.017	0.807	2.324
	ESO2	2.931	0.037	−1.010	0.772	2.194
	ESO3	3.161	−0.058	−1.099	0.719	1.824
	ESO4	3.054	0.069	−0.979	0.773	2.382
	ESO5	2.981	0.132	−0.958	0.827	3.150
	ESO6	2.937	0.181	−0.831	0.816	2.910
	ESO7	2.975	0.151	−0.894	0.847	2.974
	ESO8	2.756	0.209	−1.031	0.556 *	3.073
	ESO9	2.987	0.117	−1.060	0.808	2.498
	ESO10	2.507	0.410	−0.807	0.470 *	2.833
Managerial Decision Quality (MDQ)	MDQ1	3.461	−0.323	−0.846	0.732	1.622
	MDQ2	3.472	−0.379	−0.829	0.827	2.155
	MDQ3	3.399	−0.212	−0.964	0.850	2.871
	MDQ4	3.495	−0.334	−0.865	0.824	2.401
	MDQ5	3.127	−0.121	−0.949	0.493 *	1.143
Sustainable Organizational Performance (SOP)	SOP1	3.695	−0.465	−0.561	0.816	1.853
	SOP2	3.401	−0.391	−0.721	0.613 *	1.427
	SOP3	3.620	−0.503	−0.334	0.800	1.846
	SOP4	3.357	−0.209	−0.930	0.734	1.397
	SOP5	3.582	−0.362	−0.842	0.732	1.518
Technology Readiness (TR)	TR1	2.555	0.523	−0.847	0.882	2.303
	TR2	2.645	0.402	−0.993	0.845	2.297
	TR3	2.689	0.265	−0.964	0.842	2.233
	TR4	2.802	0.215	−1.017	0.815	1.928

Note: Skewness values within ± 1 and kurtosis values within ± 1.5 indicate acceptable normality. Items marked with (*) indicate low factor loadings and were removed from the final measurement model.

To ensure the absence of multi-collinearity, outer loadings as well as the variance inflation factor (VIF) were calculated against all factors (see Table 2). Most factor loadings exceeded 0.5; items with lower loadings were removed [59]. For example, loading against DC7 was 0.807, which was definitely >0.5 , so it confirmed the intense connection digital capability with this factor. Collinearity was assessed at multiple levels. First, inner model VIF values were examined to detect multicollinearity among predictor constructs, with all values below the recommended thresholds. Second, a full collinearity test was conducted, in which each construct was regressed on all other constructs, capturing both vertical and lateral collinearity. All full collinearity VIF values were below 3.3, confirming the absence of collinearity issues and common method bias [59].

To analyze the reliability of each of the seven studied constructs, multiple indicators of internal consistency were considered, including Cronbach's alpha, rho_a, and composite reliability (rho_c). Among these, composite reliability (rho_c) is regarded as a more appropriate and less biased measure compared to Cronbach's alpha in PLS-SEM [60]. According to established guidelines, values exceeding 0.70 indicate satisfactory reliability. As shown in Table 3, all constructs demonstrate Cronbach's alpha, rho_a, and rho_c values above the recommended threshold, confirming the internal consistency and reliability of the measurement model. These results affirm that all constructs are adequately measured by their corresponding items [59].

Table 3. Measurement model assessment (Fornell–Larcker, reliability, and validity).

Constructs	DC	EMA	ERP	ESO	MDQ	SOP	TR
DC	0.803						
EMA	0.424	0.767					
ERP	0.294	0.420	0.848				
ESO	−0.156	0.237	−0.023	0.811			
MDQ	0.371	0.500	0.367	0.242	0.826		
SOP	0.392	0.399	0.335	0.192	0.423	0.779	
TR	−0.417	−0.383	−0.342	−0.062	−0.271	−0.397	0.846
HTMT < 0.85	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cronbach's alpha	0.908	0.859	0.902	0.926	0.856	0.787	0.884
CR (rho_a)	0.913	0.861	0.914	0.939	0.826	0.789	0.884
CR (rho_c)	0.927	0.895	0.927	0.939	0.895	0.861	0.910
AVE	0.645	0.589	0.719	0.657	0.683	0.607	0.716

Note: Diagonal elements (bold) represent the square root of average variance extracted (AVE), while off-diagonal elements represent inter-construct correlations. Discriminant validity is established when the square root of AVE for each construct exceeds its correlations with other constructs (Fornell–Larcker criterion).

To prove the convergent validity of constructs, the AVE was computed, which should be more than 0.5 against the construct as per the guidelines of PLS-SEM by Hair, Hollingsworth [59]. It is evident in Table 3 that the AVE against each of the seven studied constructs was >0.5 (e.g., 0.719 for ERP). Hence, items used to measure each of these constructs are actually associated with the corresponding variable in a perfect manner. To evaluate discriminant validity, both the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT) were applied (see Table 3). In the Fornell–Larcker matrix, the diagonal elements represent the square root of AVE, while the off-diagonal elements indicate correlations among constructs. Discriminant validity is confirmed when the square root of AVE for each construct is greater than its correlations with other constructs. For example, the square root of the AVE of EMA (i.e., 0.767) exceeded all its other correlations and a similar case occurred with the remaining six constructs. As shown in Table 3, this condition is satisfied for all constructs. Furthermore, HTMT values were below the recommended threshold of 0.85, providing additional evidence of discriminant validity [60].

To assess the hypotheses proposed in the study, PLS-SEM was run, the results of which are presented in Table 4. It was found that the impact of digital capability on EMA was significantly positive (p -value < 0.001). This revealed that a unitary increase in digital capability caused EMA integration to significantly increase by 30%. The effect of ESO on EMA was also found to be significantly positive (p < 0.001). EMA was in turn found to be significantly positively affecting MDQ, with an effect size of 0.50 (p -value < 0.001). Results further indicated that MDQ significantly positively affected SOP (p -value < 0.001).

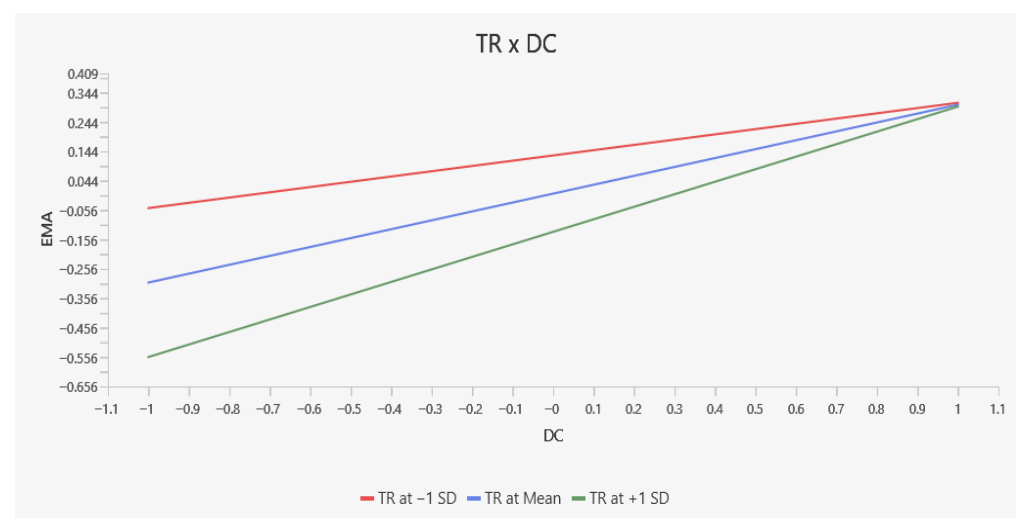
Results regarding sequential mediation indicated that digital capability significantly leads to EMA integration and EMA integration significantly enhances MDQ, which ultimately increases SOP significantly. This serial mediation of EMA integration and MDQ between digital capability and SOP was found to be significant (p -value < 0.001).

Table 4. Structural model results and hypothesis testing.

Hypothesis	Path	β	T	<i>p</i>	95% BC CI	Decision
Panel A. Antecedents and Organizational Mechanism (Direct Effects)						
H1	DC $\rightarrow$ EMA	0.303	6.771	<0.001	[0.227, 0.375]	Supported
H2	ESO $\rightarrow$ EMA	0.269	7.063	<0.001	[0.205, 0.329]	Supported
H3	EMA $\rightarrow$ MDQ	0.500	11.935	<0.001	[0.426, 0.565]	Supported
H4	MDQ $\rightarrow$ SOP	0.422	9.657	<0.001	[0.203, 0.385]	Supported
Panel B. Sequential Mediation						
H5	DC $\rightarrow$ EMA $\rightarrow$ MDQ $\rightarrow$ SOP	0.064	4.461	<0.001	[0.042, 0.080]	Supported
H6	ESO $\rightarrow$ EMA $\rightarrow$ MDQ $\rightarrow$ SOP	0.057	5.177	<0.001	[0.040, 0.075]	Supported
Panel C. Moderating Effects						
H7	TR $\times$ DC $\rightarrow$ EMA	0.123	3.510	<0.001	[0.067, 0.182]	Supported
H8	ERP $\times$ ESO $\rightarrow$ EMA	−0.007	0.170	0.433	[−0.068, 0.059]	Not Supported

Note. β = standardized path coefficient; BC CI = bias-corrected bootstrap confidence interval. Indirect effects represent sequential mediation through EMA and MDQ.

Results further indicated that ESO significantly improves EMA integration and EMA integration significantly increases MDQ, which ultimately increases SOP significantly. This sequential mediation of EMA integration and MDQ between ESO and SOP was also found to be significant (p -value < 0.001). The structural model tested in the study is presented in Appendix B. The results of the moderation analysis indicated that technology readiness significantly positively moderated the effect of digital capability on EMA integration (p -value < 0.001). This indicates that high technology readiness in an organization boosts the translation of digital capability into EMA integration (see Figure 2 for visual representation of intersection).

**Figure 2.** Moderating effect of TR.

Nonetheless, the moderating impact of ERP on ESO and EMA integration was not significantly supported by the results (p -value > 0.05). The structural model demonstrated a good fit, as the SRMR value (0.080) meets the recommended threshold of 0.08 for PLS-SEM [60]. Additionally, the NFI value (0.749) indicates a reasonable model fit. Furthermore, the predictive power of the endogenous constructs (EMA, MDQ, and SOP) was assessed using Q^2 predict (see Table 5), with values exceeding zero, confirming the model's predictive relevance [61].

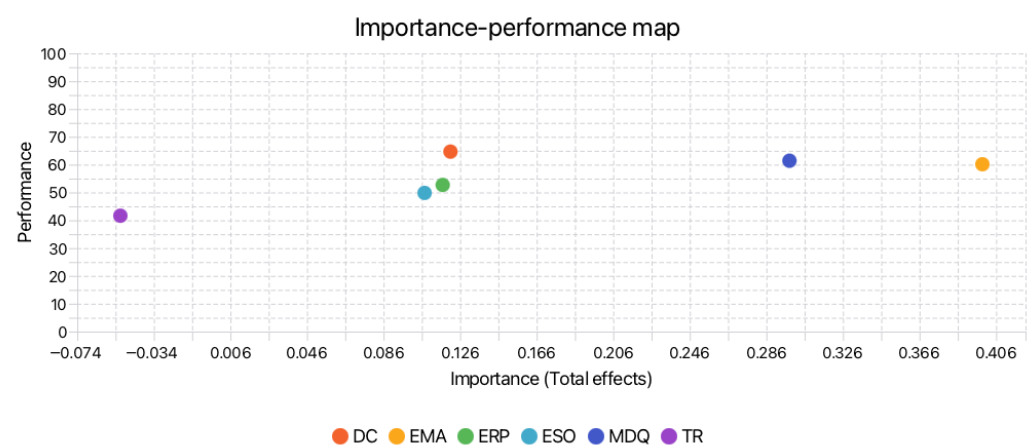
Table 5. Model fit and predictive assessment.

Category	Indicator	EMA	MDQ	SOP
Model Fit	SRMR (Estimated model)	-	-	0.080
	NFI (Estimated model)	-	-	0.749
Predictive Relevance	Q ² predict	0.367	0.235	0.195
Prediction Error	RMSE	0.799	0.878	0.901
	MAE	0.634	0.711	0.736

To evaluate the extent to which each variable was associated with SOP and how organizations are presently performing in that area, importance–performance map analysis (IPMA) was performed as indicated in Table 6. In IPMA, variables yielding the most significant impacts/importance receive moderate performance scores, while low-impact constructs receive slightly higher performance scores. For instance, EMA (impact = 0.399, performance 60.144) yields the highest impact on SOP, but its performance score is not very high. This means that a gap exists between the impact and actual performance of organizations in terms of MDQ. This indicates that although organizations identify the influential role of MDQ, this factor is underdeveloped and insufficiently implemented in organizations in Pakistan. They need to realize that improving MDQ will yield the greatest effect, so they should make a practical effort to enhance their MDQ and realize its benefits. After MDQ, EMA is the most significant yielding factor for SOP, but its performance score is, again, not extremely high, demonstrating the gap between impact and performance (see Table 6). Organizations should understand that EMA can greatly affect SOP, so they should make a practical effort to enhance EMA integration with the system and realize its benefits for SOP. Digital capability is the construct with the highest performance score, but its relative impact is low on SOP (refer to Figure 3).

Table 6. Importance–performance map analysis (target construct: SOP).

Construct	Importance (Total Effect)	Performance (Index Value)
DC	0.121	64.686
EMA	0.399	60.144
ERP	0.117	52.703
ESO	0.107	49.843
MDQ	0.298	61.411
TR	−0.052	64.031

**Figure 3.** Importance–performance map analysis (target construct: SOP).

5. Discussion of Results

The findings of this study provide important theoretical insights into the mechanisms through which digital and strategic capabilities influence sustainability outcomes. By confirming the sequential role of EMA integration and managerial decision quality, the study moves beyond direct-effect explanations and highlights the importance of internal organizational processes in translating capabilities into performance. The study found that the digital capability of Pakistani manufacturing organizations acts as a significant determinant of EMA integration. It confirmed H1, showing alignment with multiple past studies, e.g., refs. [18,32–34,38]. Therefore, this study suggests that mobilizing digital capability can lead organizations to enhance EMA integration in the organization. The results of the study revealed that ESOs such as pollution prevention strategies and clean technology strategies are another significant predictor of EMA integration. This finding confirmed H2 and suggests that a high ESO pushes Pakistani manufacturing organizations to integrate EMA into their systems in order to fulfill their strategic objectives related to sustainability. This finding also showed consistency with previous studies, e.g., refs. [24,40,42,43]. However, those studies mostly focused on one or two types of ESOs instead of considering the impact of overall ESO on EMA.

Results further indicate that EMA integration significantly improved the quality of managerial decisions, thus confirming H3. Based on these findings, it is clear that when manufacturing organizations integrate EMA effectively, they become better positioned to come up with quality managerial decisions. This finding is in line with the viewpoints of a number of past studies, such as Alshahrani and Hakim [18], Pumiviset and Suttipun [44], Franke and Hiebl [45], and Asa'd, Ahmad [14], who supported the direct or indirect role of EMA in the enhancement of management decisions. However, the direct effect of EMA on MDQ in particular was among the rare findings of the current study. High MDQ, in turn, was found to significantly improve SOP, which led the researchers to accept H4. This suggests that manufacturing organizations in Pakistan with high-quality managerial decisions are better able to enhance their SOP by improving their performance in all-inclusive aspects such as economic, operational, social, and environmental matters. This finding also complements findings of previous studies, e.g., refs. [18,31,48,49], as they also emphasized the crucial role of quality of management decisions in shaping organizational performance.

The above discussion points towards the existence of sequential mediation by EMA integration and MDQ between digital capability and SOP and between ESO and SOP. The results of serial mediation also confirmed that EMA integration and MDQ serve as sequential mediators in the paths from digital capability to SOP and from ESO to SOP. These results confirm H5 and H6. These results are in line with the viewpoints of Alshahrani and Hakim [18] and Agustia, Sawarjuwono [43] who emphasized the intervening role of EMA integration in such paths. However, they did not attempt to evaluate the possible serial mediation of EMA integration and MDQ in relevant relationships. Therefore, the serial mediation found in the current study is a new finding which may have little support from the past literature but has been justified in a theoretical and practical context. Based on these findings, it is suggested that manufacturing organizations in Pakistan should focus on building digital capability and enhancing ESO as they both promote EMA integration, which contributes to the quality of managerial decisions. This will help them enhance their SOP through better and higher-quality managerial decisions.

Results regarding the moderating factors revealed that the technology readiness of an organization amplifies the effect of digital capability on EMA integration. This confirms H7 and led the researchers to emphasize that highly technologically ready organizations are better able to translate their digital capability into EMA, as they are better able to adopt and integrate new technologies and digitalization. These suggestions are consistent

with Alshahrani and Hakim [18] and Anh, Hoa [51], who supported the boosting role of technology readiness in the implementation of EMA. The results of the moderation analysis further revealed that ERP does not cause any significant difference in or amplifying effect on the relationship between ESO and EMA. This means that H8 was rejected, as the moderating effect of ERP did not get significant support from the current data. This finding may contradict some previous researchers' views, such as Qian, Burritt [56] and Chaudhry and Amir [29], who regarded ERP as an important factor in the process of EMA integration. However, those researchers did not examine the actual moderating role of ERP on ESO and EMA integration. Furthermore, ERP might not be very significant in boosting their relationships in the context of manufacturing organizations in Pakistan.

6. Conclusions

This study examined the roles of digital capability and ESO in determining EMA integration in Pakistani manufacturing organizations and the sequential mediation by EMA integration and MDQ of the relationship between digital capability and SOP and between ESO and SOP. This study found that both digital capability and ESO independently affect EMA integration in an organization. EMA integration improves the quality of managerial decisions, which in turn boosts SOP. The results proved sequential mediation by EMA integration and MDQ in these paths. Furthermore, the findings explained that technology readiness is a significant catalyst in the nexus between digital capability and EMA integration. This study makes considerable contributions to theory and practice in the following ways:

6.1. Implications

The study assessed rarely examined paths from digital capability and ESO to SOP. The currently moderated–mediated paths have been empirically examined to enhance understanding of the process of attaining SOP. Past studies lack a focus on intervening variables in such relationships. Furthermore, this study is among the first to evaluate the sequential mediation by EMA integration and MDQ of the relationship between digital capability and SOP, as well as between ESO and SOP, thereby offering important theoretical contributions. Specifically, the sequential mediation mechanism provides deeper insight into the underlying processes through which organizational capabilities are translated into sustainable performance, moving beyond direct-effect explanations. It enhances the literature on DCT and NRBV by adding empirical evidence of relationships that were previously unexplained. In addition, the inclusion of moderating variables contributes by identifying the boundary conditions under which these relationships are strengthened or constrained. The findings regarding technology readiness and ERP offer important contextual insights, particularly in emerging economies. They open new avenues for future research to further explore the process of achieving SOP through digital capability and ESO with the integration of various intervening and conditional factors.

This study guides managers and decision-makers in manufacturing organizations in Pakistan on how they can achieve SOP by mobilizing various factors such as digitalization, ESO, EMA, and technology readiness. The study encourages them to integrate EMA effectively in order to better transform their digital capability and ESO into SOP. It provides evidence-based findings to help them realize the great importance of EMA integration and MDQ in determining their sustainable performance. The IPMA also highlights the high-impact factors of SOP, such as EMA and MDQ, as well as the performance gaps of organizations in these areas, indicating that they need to devise better strategies to enhance practices in these areas so that they can achieve sustainability. Hence, the current study offers considerable contributions towards the sustainable development of the manufac-

turing sector of Pakistan and enables it to effectively work on the economic, social, and environmental agendas of the SDGs.

The study can help policymakers in Pakistan realize the central role of digital capability, ESO, EMA, and MDQ in shaping the SOP of organizations. They can learn how they can push organizations to implement sustainable practices such as EMA. In this regard, they can better design policies to promote EMA application in the sector in order to monitor the sustainable development of the sector. For example, they can revisit the existing procedures in sustainability reports and make EMA implementation necessary for organizations. In this way, they can make sure that the sector is positively contributing towards attainment of the SDGs. Specifically, integration of EMA and improvement in managerial decision quality support SDG 12 (responsible consumption and production) by enabling organizations to optimize resource utilization and reduce environmental impacts. The enhancement of sustainable organizational performance contributes to SDG 8 (decent work and economic growth) by promoting long-term economic and operational efficiency. Furthermore, the alignment of environmental strategies with digital capabilities supports SDG 13 (climate action) by facilitating informed decisions related to emissions reductions and environmental management. Thus, the study provides actionable insights for organizations and policymakers to align internal capabilities with global sustainability agendas.

6.2. Limitations and Future Research Areas

Despite its contributions, this study has several limitations that offer avenues for future research. First, the sample was limited to ISO 14001-certified manufacturing firms in Pakistan, which may introduce selection bias toward organizations with relatively advanced EMS and limit generalizability across sectors and regions. Future studies are encouraged to include non-certified firms, as well as conduct comparative analyses across small- and medium-sized enterprises (SMEs) and large organizations, where differences in digital capability, environmental practices, and decision-making processes may be more pronounced. Cross-country studies across diverse institutional settings would further strengthen the external validity of this model. Moreover, study variables exhibit heterogeneous dynamics across sectors due to variations in technological intensity, regulatory pressure, and environmental exposure. For instance, in service sectors such as finance or logistics, where environmental impacts are less direct but digitalization is more intensive, the role of data analytics and managerial decision quality may become more prominent. In contrast, in the energy and extractive industries, characterized by high environmental externalities and strict regulations, environmental regulatory pressure may exert a stronger moderating effect.

Second, although a time-lagged design was employed, causal inferences remain limited. Future research may adopt longitudinal panel designs or quasi-experimental approaches to better capture temporal dynamics and causal relationships. In addition, mixed-method approaches, such as combining survey data with case studies, could provide deeper insights into the internal processes of EMA implementation. Third, the non-significant moderating effect of ERP suggests that additional contextual factors may influence these relationships. Future research could incorporate variables such as organizational culture, environmental proactivity, or advanced digitalization capabilities to better capture organizational complexity. Finally, future studies may enhance methodological robustness by incorporating objective performance indicators (e.g., environmental or financial data), applying multi-group or comparative analyses, and validating measurement scales across different cultural and organizational contexts. Such extensions would improve the generalizability and robustness of findings and provide a more comprehensive understanding of how digital capability and environmental strategies drive sustainable performance.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Departmental Ethical Review Committee, Department of Commerce, University of the Punjab (Gujranwala Campus), (under ORIC, D/PUGC/COM/0254 and date 14 October 2025).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request due to privacy considerations.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Respondent demographic profile.

Variable	Category	Frequency	Percent (%)
Gender	Male	282	58.9
	Female	197	41.1
Age	Less than 25 years	86	18.0
	26–30 years	128	26.7
	31–35 years	164	34.2
	More than 35 years	101	21.1
Education	Graduation	88	18.4
	Post-graduation	167	34.9
	Master's	188	39.2
	Other	36	7.5
Professional Experience	2–5 years	111	23.2
	5–8 years	201	42.0
	More than 8 years	167	34.9
Ownership Structure	Government	105	21.9
	Private	363	75.8
	Semi-government	11	2.3
ISO Environmental Certification	Yes	462	96.5
	No	4	0.8
	Not sure	13	2.7

Table A2. Comprehensive assessment of common method bias.

Panel A. Structural Paths with and Without Marker Variable				
Structural Path	Without Marker β	With Marker β	$\Delta\beta$	Interpretation
DC $\rightarrow$ EMA	0.303	0.304	+0.001	Stable
ESO $\rightarrow$ EMA	0.269	0.270	+0.001	Stable
ERP $\rightarrow$ EMA	0.293	0.293	+0.000	Stable
TR $\rightarrow$ EMA	−0.130	−0.131	−0.001	Stable
EMA $\rightarrow$ MDQ	0.500	0.505	+0.005	Stable
MDQ $\rightarrow$ SOP	0.422	0.413	−0.009	Stable
TR $\times$ DC $\rightarrow$ EMA	0.123	0.122	−0.001	Stable
ERP $\times$ ESO $\rightarrow$ EMA	−0.007	−0.008	−0.001	Stable
Panel B. Marker Variable Effects				
Path	β	<i>p</i> -value	Result	
WSI $\rightarrow$ EMA	−0.058	0.218	Not significant	
WSI $\rightarrow$ MDQ	0.096	0.171	Not significant	
WSI $\rightarrow$ SOP	0.104	0.175	Not significant	
Panel C. Full Collinearity Assessment				
Constructs			VIF	
DC			1.673	
ESO			1.388	
EMA			1.674	
MDQ			1.696	
TR			1.381	
ERP			1.345	
SOP			1.439	
Panel D. Harman Single-Factor Test				
Statistic			Value	
Variance explained by first factor			21.52%	
Threshold			<50%	
Conclusion			No dominant single factor	

Note. β = standardized path coefficient; $\Delta\beta$ = coefficient change after inclusion of marker variable; VIF = variance inflation factor; WSI = Workplace Social Interaction (marker variable).

Table A3. Measurement items.

Construct	Code	Measurement Item
Digital Capability (DC)	DC1	Digital Technologies (e.g., AI and Analytics) are effectively leveraged to enhance accounting and financial processes.
	DC2	Advanced data analytics are widely used to support managerial decision-making.
	DC3	High-quality and timely digital data are available for forecasting and risk analysis.
	DC4	IT infrastructure efficiently supports large-scale digital applications.
	DC5	Cloud-based systems enable real-time integration of accounting and operational information.
	DC6	Digital systems enhance the transparency and reliability of financial and sustainability reporting.
	DC7	Employees possess the digital skills required to use advanced accounting and reporting systems.
	DC8	Continuous investment is made in upgrading digital technologies.
Environmental Management Accounting (EMA)	EMA1	Environmental management accounting practices are formally implemented.
	EMA2	Sustainability-related KPIs are integrated into budgeting and performance planning.
	EMA3	Triple Bottom Line considerations guide internal accounting and reporting practices.
	EMA4	Sustainability-related information is systematically incorporated into managerial decision-making.
	EMA5	Accounting systems support integrated financial and sustainability reporting.
	EMA6	Sustainability indicators are regularly used to guide operational decisions.

Table A3. Cont.

Construct	Code	Measurement Item
Environmental Regulatory Pressure (ERP)	ERP1	Environmental regulations drive the adoption of environmental management accounting practices.
	ERP2	Environmental regulations are a key factor in implementing environmental management accounting.
	ERP3	Compliance with strict environmental regulations imposed by authorities is required.
	ERP4	Leading firms in the industry influence the adoption of environmental management accounting practices.
	ERP5	To break environmental standard and regulations face a number of penalties.
Environmental Strategy Orientation (ESO)	ESO1	Pollution prevention is prioritized in strategic policies and practices.
	ESO2	Structured waste management and environmental monitoring are emphasized.
	ESO3	Employees are encouraged and empowered to support environmental initiatives.
	ESO4	Compliance with environmental regulations and standards is strongly emphasized.
	ESO5	Environmental expertise and financial objectives are integrated into strategic planning.
	ESO6	A clear environmental vision and willingness to take sustainability-related risks are demonstrated.
	ESO7	Environmental risks are carefully assessed and appropriate safeguards are implemented.
	ESO8	Eco-friendly products are developed to gain market advantages.
	ESO9	Environmental considerations are integrated into product design, compliance, and innovation practices.
	ESO10	Investment is made in environmental technologies and in-house capabilities.
Managerial Decision Quality (MDQ)	MDQ1	Managerial decisions are based on reliable sustainability-related information.
	MDQ2	Forecasting tools enhance the accuracy of sustainability-oriented decisions.
	MDQ3	Real-time digital and sustainability data support strategic planning.
	MDQ4	Financial and environmental considerations are effectively balanced in decision-making.
	MDQ5	Digital analytics improve the overall quality of managerial judgments.
Sustainable Organizational Performance (SOP)	SOP1	Environmental performance has improved over time.
	SOP2	Strong social responsibility is demonstrated in operations.
	SOP3	Sustainability initiatives contribute positively to financial performance.
	SOP4	Sustainability reputation has improved significantly.
	SOP5	Stakeholder trust in sustainability commitments is high.
Technology Readiness (TR)	TR1	Digital systems effectively support sustainability-related decision-making.
	TR2	Real-time digital tools and dashboards are available for decision support.
	TR3	Digital decision-support systems are reliable and easy to use.
	TR4	Technology enhances the speed and effectiveness of sustainability-related decisions.

Appendix B

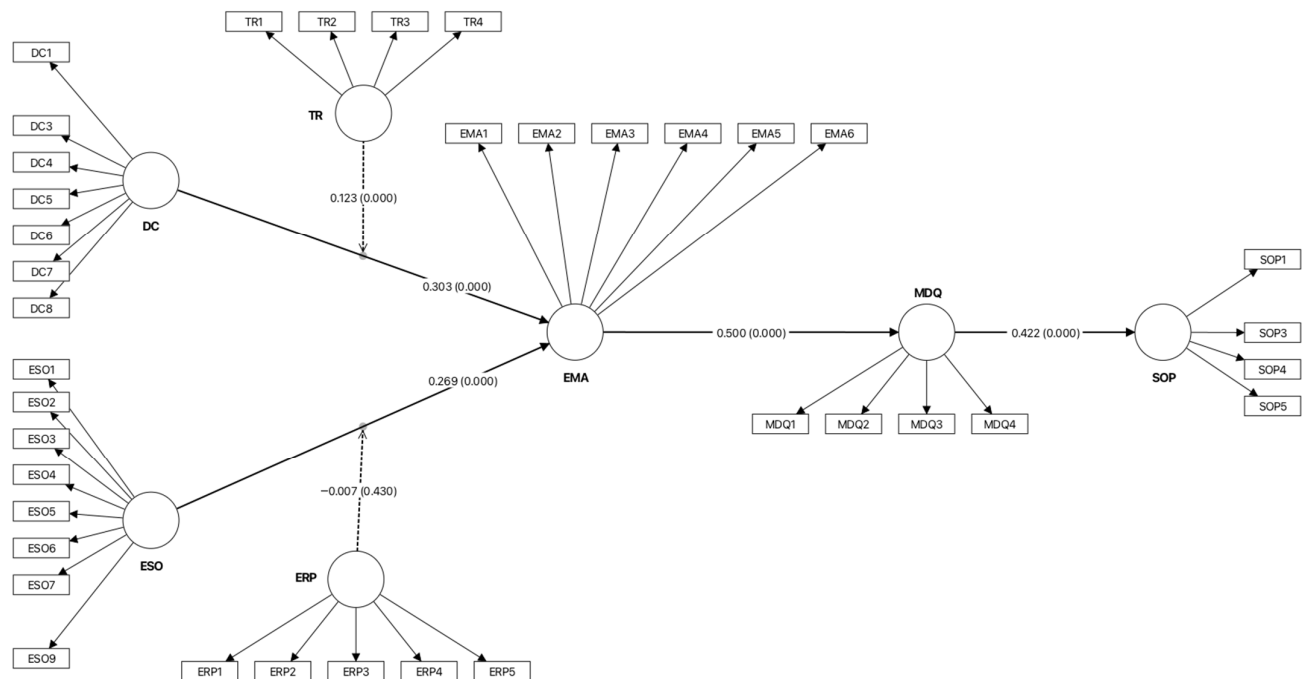


Figure A1. Structural equation modeling.

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