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EMA and Sustainable Development: Role of Digital Transformation and Business Intelligence System

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Abstract
Environmental management accounting (EMA) is an evolving in the recent decade and EMA approach integrates environmental and financial information within organizations to support effective environmental management decisions. With growing attention towards EMA, the concerns about sustainable development is still unclear in the academic literature. Underpinned by the dynamic capability theory, the current study aimed to fill this research gap by addressing the role of EMA on addressing sustainable performance through digital transformation and business intelligence system. Methodologically, the sample of 202 collected from manufacturing eEnterprise in Pakistan. Based on the result, the findings revealed that EMA need to mitigate the impacts of business activities on the environment and provides a valuable framework for organizations to identify, measure, and manage their sustainable performance. In addition, the role of digital transformation and business intelligence system create an avenue for the manufacturing firms to reinforce the direction towards digitalization.

Keywords: EMA, Digital Transformation, Business Intelligence System, Sustainable Performance

Introduction

In 21st century, the adoption of environmental management accounting (EMA) has gained recognition as a valuable tool for integrating environmental and financial information within organizations, several challenges persist in its implementation and widespread adoption. However, organization nowadays aims to identify the key issues hindering the effective implementation for sustainable development and the barriers preventing organizations from fully harnessing its potential. Organization facing challenge in the identification and quantification of environmental costs, which often involve complex and subjective assessments. The lack of standardized methodologies and guidelines for measuring environmental impacts and assigning monetary values to them hinders accurate cost analysis and reporting. In this regard, EMA emerged as a valuable tool to achieve sustainable development. Integrating of EMA reinforce environmental and financial information which overcoming organizational barriers. The strong EMA system fostering to inadequate data collection systems, and limited collaboration between environmental and accounting departments and provide the integration of environmental reporting into existing management systems.

In previous research, the EMA focused mainly on developed countries, which often have well-established infrastructure for data collection, reporting, and analysis, which facilitates the implementation of EMA systems. The developed countries have robust environmental monitoring networks and well-defined regulatory frameworks that enable accurate measurement and reporting of environmental costs and impacts. However, the examination of EMA in developing country such as Pakistan paid unclear attention in academic literature. Developing countries such as Pakistan often face resource constraints, both in terms of financial capacity and technical expertise. This can hinder the implementation of comprehensive EMA systems. In addition, limited of financial resources may limit the investment in advanced technologies required for data collection and analysis, while a shortage of skilled professionals can pose challenges in implementing and maintaining EMA systems. In this regard, the present study aimed to fill this research gap by addressing the role of EMA on developing country (e.g., Pakistan). In addition, the previous research paid limited attention on moderating role in EMA research. However, the current study employed digital transformation and business intelligence system between EMA and sustainable performance. Based on the aforementioned gaps, the current study addresses three important research questions:

- Does EMA influence sustainable performance?
- Does digital transformation moderate between EMA and sustainable performance?
- Does BI system moderate between EMA and sustainable performance?

The current study aiming to contribute several contribution to academic literature. First, the study examining EMA and sustainable performance relationship. EMA promotes a culture of continuous improvement by providing feedback loops and performance tracking mechanisms. By regularly measuring and evaluating environmental performance, organizations can identify inefficiencies, implement corrective actions, and monitor the effectiveness of sustainability initiatives. EMA enables organizations to set targets, track progress, and adapt strategies to improve sustainable performance over time. Second, the current study applied dynamic capability theory on EMA and sustainable performance relationship. Dynamic capability theory enables organizations to adapt to changing environmental requirements, technological advancements, and stakeholder expectations. By developing these dynamic capabilities, organizations can enhance their EMA practices and improve their sustainable performance over time. Third, the current study employed digital transformation and BI system as moderator between EMA and sustainable performance. Digital technologies provide platforms for enhanced collaboration and engagement with stakeholders, both internal and external. Through online platforms, social media, and digital communication channels, organizations can involve employees, customers, suppliers, and other stakeholders in sustainability initiatives. In addition, BI system can help identify opportunities for environmental performance improvement by analyzing large datasets. By uncovering hidden inefficiencies, waste generation patterns, or energy consumption trends, organizations can identify areas where sustainable performance can be enhanced.

Literature Review and Hypothesis Development

Dynamic Capability Theory

Dynamic capability theory is a strategic management framework that focuses on an organization's ability to adapt, innovate, and learn in response to changing environmental conditions and market dynamics (Teece et al., 1997). When applied to environmental management accounting (EMA), dynamic capability theory highlights the importance of developing and leveraging organizational capabilities to effectively integrate environmental considerations into accounting practices and decision-making processes. According to dynamic capability theory, organization's ability to identify and understand environmental issues, risks, and opportunities. It involves actively monitoring and analyzing environmental trends, regulations, stakeholder expectations, and emerging technologies that impact the organization's environmental performance (Laine & Korhonen, 2015). Sensing capability helps organizations proactively identify areas for improvement and develop strategies to address environmental challenges. Dynamic capability focuses on an organization's ability to continuously innovate and transform its EMA practices and systems. It involves developing new tools, techniques, and processes to better measure, manage, and report environmental performance. Transforming capability enables organizations to adapt to changing environmental requirements, technological advancements, and stakeholder expectations. By developing these dynamic capabilities, organizations can enhance their EMA practices and improve their environmental performance over time. The integration of dynamic capability theory with EMA provides a framework for organizations to align their accounting systems, decision-making processes, and strategic initiatives with environmental sustainability goals.

Environmental Management Accounting

Environmental management accounting (EMA) is an approach that integrates environmental and economic information to support decision-making and improve environmental performance within an organization. It involves the identification, collection, analysis, and use of environmental data to guide strategic and operational decisions (Bennett & James, 2011). EMA recognizes that environmental issues have significant financial implications for businesses and that effective management of these issues can contribute to long-term sustainability and competitive advantage. By integrating environmental considerations into traditional accounting practices, EMA provides a more comprehensive view of the costs and benefits associated with environmental impacts and helps organizations make informed decisions that align with their environmental goals (Burritt & Schaltegger, 2010). It involves assessing the total costs associated with a product or service throughout its entire life cycle, including raw material extraction, production, use, and disposal. This approach helps identify areas where environmental improvements can lead to cost savings. It focuses on identifying and quantifying the environmental costs incurred by an organization, including costs related to pollution control, waste management, and compliance with environmental regulations (Unerman et al., 2007). By tracking and analyzing these costs, organizations can identify opportunities for efficiency gains and cost reductions.

Sustainable Performance

Sustainable performance described as the ability of an organization to achieve its objectives while simultaneously considering and minimizing its impact on the environment, society, and long-term economic viability (Epstein & Roy, 2001). It involves integrating sustainability principles into the core operations, strategies, and decision-making processes of an organization to create value in a holistic and responsible manner. To achieve sustainable performance, organizations need to adopt a comprehensive approach that encompasses environmental, social, and economic dimensions. This approach is often referred to as the triple bottom line, which emphasizes the need to balance environmental, social, and economic outcomes (Schaltegger & Wagner, 2011). Sustainable performance goes beyond short-term financial gains and takes into account the long-term implications of business activities. Organizations strive to minimize their ecological footprint by reducing resource consumption, optimizing energy efficiency, adopting clean technologies, and implementing waste management and recycling initiatives (San et al., 2022). This includes adopting environmentally friendly practices throughout the supply chain. Organizations recognize the importance of considering the interests and well-being of their employees, communities, and other stakeholders. This involves promoting workplace safety, fair labor practices, diversity and inclusion, community engagement, and supporting social initiatives.

Hypothesis Development

EMA and Sustainable Performance

The relationship between environmental management accounting (EMA) and sustainable performance is closely intertwined. EMA provides organizations with the tools and information needed to measure, manage, and improve their environmental performance, which in turn contributes to overall sustainable performance (Bennett & James, 2011). EMA helps organizations identify and analyze environmental costs, track environmental performance indicators, and make informed decisions that align with their sustainability goals. Based on DC theory, EMA emerged as a dynamic capability which allows organizations to identify and analyze environmental costs throughout their operations (Burritt & Schaltegger, 2010). By understanding the environmental impacts associated with different activities, processes, and products, organizations can identify areas for improvement and implement measures to reduce resource consumption, waste generation, and associated costs. This focus on efficiency and cost savings contributes to overall financial sustainability. In manufacturing sector of Pakistan, EMA helps organizations identify and assess environmental risks and their financial implications. By understanding and managing these risks, organizations can mitigate potential liabilities, regulatory non-compliance, and reputational damage. Proactive management of environmental risks enhances overall sustainability and resilience (Schaltegger & Burritt, 2017). EMA encourages organizations to explore innovative practices, technologies, and products that reduce environmental impacts. This emphasis on sustainability and eco-efficiency can drive product and process innovation, leading to the development of new market opportunities and a competitive advantage. By integrating EMA into their operations, organizations can position themselves as leaders in sustainability and attract environmentally conscious customers and investors.

Hypothesis H1: EMA positively influence sustainable performance

Moderating role of Business Intelligence System

The current study employed the moderating role of business intelligence system between environmental management accounting and sustainable performance (Xu & Dey, 2018). The significance of BI system can enhance the effectiveness and impact of EMA initiatives, leading to improved sustainable performance. BI system enables organizations to process and analyze large volumes of environmental data from various sources, such as sensors, monitoring systems, and external databases. By leveraging advanced analytics techniques, including machine learning and data mining, organizations can uncover patterns, correlations, and insights that were previously difficult to identify. This enhanced data processing and analysis capability provides organizations with a deeper understanding of their environmental performance and supports more informed decision-making for sustainable performance improvement (Hashem et al., 2015). BI system allows for real-time monitoring and feedback on environmental performance. Through the continuous collection and analysis of environmental data, organizations can identify deviations from desired sustainability targets and take prompt corrective actions. Real-time monitoring enhances the agility and responsiveness of organizations in addressing environmental issues, leading to improved sustainable performance outcomes. In addition, BI system facilitates the application of predictive analytics and forecasting models to assess the potential impact of different environmental strategies and interventions. By analyzing historical data and identifying relevant patterns and trends, organizations can develop predictive models that help anticipate future environmental outcomes (Latif et al., 2022). This enables organizations to proactively plan and implement sustainable practices, optimize resource allocation, and mitigate environmental risks.

BI system can help identify opportunities for environmental performance improvement by analyzing large datasets. By uncovering hidden inefficiencies, waste generation patterns, or energy consumption trends, organizations can identify areas where sustainable performance can be enhanced. This allows for targeted interventions and optimization of resource utilization, contributing to improved sustainability outcomes (Vo & Nguyen, 2020). BI system provides organizations with insights that support strategic decision-making for sustainable performance improvement. By analyzing large and diverse datasets, organizations can identify emerging trends, assess market dynamics, and make data-driven decisions that align with sustainability goals. This enables organizations to develop proactive strategies that leverage environmental opportunities and navigate sustainability challenges. The use of BI system in conjunction with EMA practices enhances organizations' ability to leverage environmental data for sustainable performance improvement, ultimately contributing to long-term environmental and economic viability.

Hypothesis H2: BI System moderate between EMA and sustainable performance

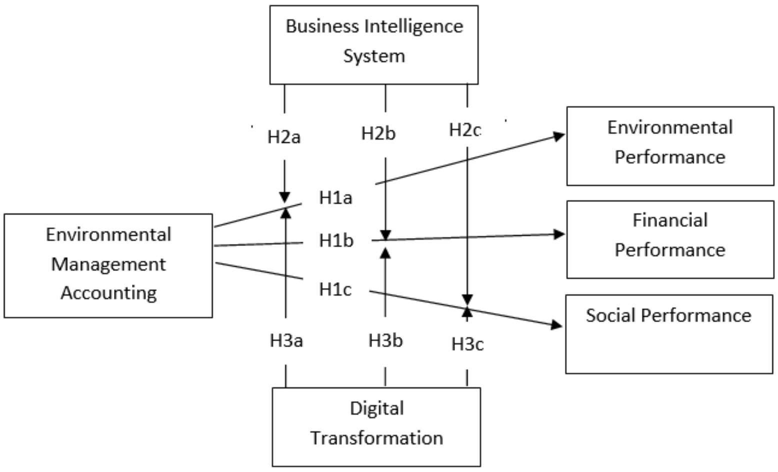
Moderating Role of Digital Transformation

The current study employed moderating role of digital transformation between environmental management accounting and sustainable performance. Digital transformation is referred to how the adoption and integration of digital technologies influence the relationship between EMA practices and overall sustainability initiatives (Linnenluecke & Griffiths, 2013). Digital transformation can enhance the effectiveness and impact of EMA initiatives, thereby contributing to improved sustainable performance. Digital technologies enable organizations to collect, store, and analyze vast amounts of environmental data more efficiently and accurately. Through real-time monitoring, sensor networks, and data analytics, organizations can obtain more detailed and timely information on their environmental performance. This enhanced data collection and analysis enable better decision-making, target setting, and performance tracking, ultimately leading to improved sustainable performance (Ismail & Yusuf, 2020). Digital transformation allows for the seamless integration of EMA systems with other organizational processes and data sources. By integrating EMA with financial and operational systems, organizations can capture and analyze environmental information within a broader organizational context. This integration facilitates a more comprehensive understanding of the environmental impact and cost implications, leading to more effective decision-making for sustainable performance.

Digital technologies provide platforms for enhanced collaboration and engagement with stakeholders, both internal and external (Di Vaio et al., 2023). Through online platforms, social media, and digital communication channels, organizations can involve employees, customers, suppliers, and other stakeholders in sustainability initiatives. Digital platforms enable greater transparency, participation, and feedback, fostering a sense of shared responsibility and driving sustainable performance improvements (Abreu & Alves, 2021). Digital transformation enables the use of advanced analytics techniques, such as predictive modeling and scenario planning, to assess the potential impact of different environmental strategies and interventions. By simulating various scenarios, organizations can evaluate the likely outcomes of different sustainability initiatives and optimize their decision-making accordingly. This predictive capability enhances the effectiveness of EMA practices and supports sustainable performance improvements. Digital transformation acts as a facilitator and enhancer of the relationship between EMA and sustainable performance. By leveraging digital technologies, organizations can overcome traditional barriers and limitations in EMA implementation, leading to more robust and impactful sustainability outcomes.

Hypothesis H3: Digital transformation moderate between EMA and sustainable performance

Research Framework



Methodology and Sampling

This section describes a comprehensive description of the research methodology applied and the data obtained through the questionnaire through survey method. The results presented in this section were obtained through descriptive analysis in SPSS. Although, the total response that participated in this study was 202 responses out of 455 distributed questionnaire, which represents a response rate of 44.89%. Table 1 presents the respondents profiles to check frequency distribution. Therefore, the majority of the respondents are male (n=147, 73%), while the remaining respondents are female (n=55, 27 %). Regarding the sample size of companies, the respondent are found that the highest proportion of the postgraduate degree holders (n=104, 51.5%). This was also followed by respondents with a Ph.D. qualification (n=31, 15.3%), and undergraduate degree holders (n=67, 33.2%) within the companies. Additionally, the sample of the company's results indicate that the respondents have a significant work experience. Specifically, a considerable section of the respondents reported working for less than 1 year (n=47, 23.3%), while the major portion had a working duration ranging from 1 to 5 years (n=93, 46%), and a significant number of respondents reported working for more than 5 years (n=62, 30.7%).

The age factor was also analyzed to understand the frequency distribution of employees' profiles. The findings reveal that the majority of the sample employees fall within the age range of 30-39 years (n=43, 21.3%), which is considered beneficial for the long-term stability of companies. This is followed by employees aged between 40-49 (n=79, 39.1%) or 20-29 (n=27, 13.4%). So on, the proportion of employees fall within the age range of 50-59 (n=53, 26.2%). Although the sample companies are from various industry sectors, the majority of respondents reported working in the accounting department (n=77, 39.1%). Other sectors were also represented (n=32, 15.8%), including departments related to environmental protection. The production department was the next group (n=24, 11.9%), followed by the finance department (n=69, 34.2%).

Table 1

Description of N=202	Frequency	%
Gender		
Male	147	73
Female	55	27
Age		
20-29	27	13.4
30-39	43	21.3
40-49	79	39.1
50-59	53	26.2
Education Level		
Undergraduate	67	33.2
Postgraduate	104	51.5
Ph.D.	31	15.3
Service Tenure		
Less than 1 year	47	23.3
1-5 year	93	46
More than 5 year	62	30.7
Engaged Department		
Accounting Department	77	38.1
Finance Department	69	34.2
Environmental Protection Department	32	15.8
Production Department	24	11.9

Measurement of Scale

This research adopts the scales from previous research, which provides greater insights into the validity and reliability of the research findings. Eight-item of digital transformation were measured by Ifenthaler and Egloffstein (2020), five-item of EMA by Henri (2006), Five-items of environmental performance were adopted from Zailani et al (2019); Sassen et al (2016); Cheng et al (2014), five-items of social performance were adopted from Zailani et al (2019) Sassen et al (2016); Cheng et al (2014) and Six-item of Financial performance were measured from pevious studies by Zailani et al (2019); Sassen et al (2016); Cheng et al (2014) and four-items of business intelligence system were measured through ().

Results and Findings

The analysis was categorized into two different parts, the first part is analyzed through measurement model analysis while the second part is dealing with the structural equation model.

Measurement Model Assessment

The results of reliability was measured through error-free nature of constructs to ensure the consistency. While, the internal and stability concepts of consistency was captured. Therefore, the internal consistency was related to the ability of items scale to link with other items of the same scale to measure the same concept of constructs. In this research, the Composite Reliability (CR) serves the upper bond for true reliability (Hair et al., 2011), while the Cronbach's Alpha (CA) is used as the lower bound for the internal consistency of reliability. As shown in Table 2, the range value of CA from 0.808 to 0.915 from all the constructs are higher from recommended threshold 0.7 suggested by (Hair et al., 2013). Additionally, the CR Values of the constructs range from 0.868 to 0.933, indicating adequate convergence or internal consistency (Hair et al., 2016).

Subsequently, the Average Variance Extracted (AVE) represents the average amount of variance that a latent variable explains in its associated indicators. While the value of 0.5 or higher indicated that the latent variables indicates on average which is considered sufficient (Hair et al., 2013; Henseler et al., 2009). Therefore, the AVE scores of each variables are found above the minimum threshold of 0.5, as suggested by (Hair et al., 2013). Hence, the AVE values was ranged from 0.593 to 0.774. Based on the results, convergent validity was achieved and by adequately pointing to the constructs to adequately conclude the measurements of the underlying concepts.

Table 2

Construct	Items	Factor loading	Cronbach's alpha (α)	Composite reliability	Average Variance extracted
Environmental Management Accounting	EM1	0.765	0.808	0.868	0.568
	EM2	0.773			
	EM3	0.682			
	EM4	0.752			
	EM5	0.792			
Business Intelligence System	BIS1	0.899	0.894	0.932	0.774
	BIS2	0.848			
	BIS3	0.860			
	BIS4	0.910			
Digital Transformation	DT1	0.823	0.915	0.933	0.636
	DT2	0.813			
	DT3	0.820			
	DT4	0.863			
	DT5	0.863			
	DT6	0.689			
	DT7	0.767			
	DT8	0.723			
Environmental Performance	EP1	0.848	0.869	0.904	0.611
	EP2	0.809			
	EP3	0.818			
	EP4	0.693			
	EP5	0.703			
	EP5	0.807			
Financial Performance	FP1	0.843	0.840	0.896	0.593
	FP2	0.842			
	FP3	0.820			
	FP4	0.783			
	FP5	0.696			
	FP6	0.609			
Social Performance	SP1	0.845	0.892	0.923	0.708
	SP2	0.738			
	SP3	0.795			
	SP4	0.903			
	SP5	0.912			

Fornell and Larcker Criterion for Discriminant Validity

The Fornell and Larcker Criterion, also known as the Fornell-Larcker criterion, is a statistical method used to assess the discriminant validity of constructs in a research study. Discriminant validity refers to the extent to which two constructs or variables are distinct from each other and measure different underlying concepts (Hair et al., 2013). It is assessed using cross-loading Chin (1998) and the Fornell-Larcker criterion (Fornell & Larcker, 1981). According to the Fornell and Larcker Criterion, researchers typically perform confirmatory factor analysis

(CFA) or SEM and examine the estimated factor loadings and correlation matrix of the latent variables. The criterion suggests comparing the square roots of the average variance extracted (AVE) for each construct with the correlations between constructs (Chin, 1998; Fornell & Larcker, 1981). In Table 3, the calculated square root of AVE ranges from 0.754 to 0.879, indicating that the values exceeded the inter-correlations of the construct with the other constructs in the model. This suggests adequate discriminant validity.

Table 3

Constructs	Mean	SD	1	2	3	4	5	6
EMA	5.190	0.765	**0.754**					
BIS	5.147	0.899	0.548***	**0.879**				
DT	4.728	0.898	0.503***	0.533***	**0.797**			
EP	5.208	1.000	0.529***	0.525***	0.489***	**0.782**		
FP	5.098	0.892	0.376***	0.485***	0.588***	0.578***	**0.770**	
SP	5.024	0.916	0.451***	0.518***	0.539***	0.479***	0.351***	**0.841**

*Note(s): *p < 0.05; **p < 0.01; ***p < 0.001, Standard errors in parentheses*

Structural Model Assessment

Hierarchical Regression Analysis

Hierarchical regression analysis is a statistical technique used to examine the relationship between predictor variables and a dependent variable while controlling for the influence of other variables. It allows researchers to assess the incremental contribution of each predictor variable to the explained variance in the dependent variable. In hierarchical regression, predictor variables are entered into the regression equation in a stepwise manner based on a specified order or theoretical rationale. The goal is to investigate whether the addition of each predictor significantly improves the predictive power of the model. This analysis is particularly useful when there is a theoretical reason to believe that certain variables have different levels of importance or influence on the dependent variable (Cohen et al., 2003; Tabachnick et al., 2019; Field, 2018).

As Shown in Table 4, the EMA was found a positive influence social performance (β= 0.204, $p < 0.01$, Model 2), environmental performance (β=0.280. $p < 0.001$, Model 5), and financial performance (β =0.159, $p < 0.01$, Model 8) in Pakistan. Therefore, H1a, H1b, and H1c were all supported. Nevertheless, BIS moderate the effect of EMA on social performance, as the interaction coefficient was significant and positive (β = 0.062, $p < 0.01$, Model 3). Thus H2a was supported. On the other hand, H2b was accepted as the interaction coefficient of EMA and BIS was significant and positively moderate with environmental performance (β= 0.135, $p < 0.05$, Model 6) H2b was supported. Therefore, in table 7, also illustrates that the interaction terms of coefficient of EMA and BIS had a significant and positive effect on financial performance (β = 0.011, $p < 0.05$, Model 9), which accept H2c. Likewise, the moderating effect of Digital transformation between EMA and social performance was significant and positive (β = 0.021, P < 0.01, Model 3). Thus, H3a accepted. In contrast H3b was supported as digital transformation was found to significantly and positively moderate the relationship between EMA and environmental performance (β 5 0.124, p < 0.05, Model 6). Similarly, the interaction coefficient of EMA and Digital transformation for financial performance was significant and positive (β = 0.132, p < 0.05, Model 9) thereby confirming H3c. therefore, in table 4, the hierarchical regression analysis was utilized to analyze whether Business Intelligence System and digital transformation moderate the relationship between EMA and sustainable performance, following Preacher and Hayes (2008) approach.

Table 4

	Social Performance			**Environmental Performance**			**Financial Performance**		
Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Gender	0.062	0.051	0.044	0.012	-0.008	-0.010	-0.047	-0.058	-0.057
Age	-0.091	-0.030	-0.025	-0.125	-0.046	-0.044	-0.034	0.041	0.041
Educational level	-0.159*	0.048	0.047	-0.194	0.035	0.034	-0.172*	0.060	0.058
Service Tenure	0.333***	0.073	0.067	0.314***	0.026	0.024	0.284***	-0.005	-0.004
Engaged Department	0.141**	0.109	0.117	-0.073	-0.032	-0.021	0.027	0.069	0.071
EMA		0.204**	0.178**		0.280***	0.272***		0.159**	0.156**
BIS		-0.004	-0.002		0.195**	0.205***		0.125**	0.135
DT		0.664***	0.676***		0.498***	0.502***		0.677***	0.676***
EMA X BIS			0.062**			0.135*			0.011*
EMA X DT			0.021**			0.124*			0.132*
R2	0.152	0.331	0.037	0.154	0.344	0.511		0.210	0.428
ΔR2	0.120	0.179	0.016	0.134	0.189	0.112		0.074	0.110
F value	5.865***	10.93***	1.322	5.984***	14.23***	3.897*		8.767***	4.120***

Abbreviation: - EMA: - Environmental Management Accounting, BIS: - Business Intelligence System, DT: - Digital Transformation. *Note(s): *p < 0.05; **p < 0.01; ***p < 0.001, Standard errors in parentheses*

Discussion

Underpinned by the dynamic capability theory, the current research has addressed three important research questions: RQ1: Does EMA influences sustainable performance? RQ2: Does digital transformation moderate the nexus between EMA and sustainable performance? RQ3: Does BI system moderate the nexus between EMA and sustainable performance. First research question covers H1a, H1b, and H1c which demonstrated the positive impact of EMA on sustainable performance. This result is consistent with the past literature (Latif et al., 2020). Based on the results of H1, EMA proved as a key identify element which assessed environmental risks and their financial implications. By understanding and managing these risks, organizations can mitigate potential liabilities, regulatory non-compliance, and reputational damage. Proactive management of environmental risks enhances overall sustainability and resilience (Schaltegger & Burritt, 2017).

Second research question covers H2a, H2b and H2c, which demonstrated the moderating role of digital transformation between EMA and sustainable performance. The results are in line with the past literature (Cuganesan et al., 2019). Based on the results, digital technologies enable organizations to collect, store, and analyze vast amounts of environmental data more efficiently and accurately. Through real-time monitoring, sensor networks, and data analytics, organizations can obtain more detailed and timely information on their environmental performance. This enhanced data collection and analysis enable better decision-making, target setting, and performance tracking, ultimately leading to improved sustainable performance (Ismail & Yusuf, 2020).
Third research question covers H2a, H2b and H2c, which demonstrated the moderating role of BI system between EMA and sustainable performance. The results are in line with the past literature (Cuganesan et al., 2019). Based on the results, BI system allows for real-time monitoring and feedback on environmental performance. Through the continuous collection and analysis of environmental data, organizations can identify deviations from desired sustainability targets and take prompt corrective actions. Real-time monitoring enhances the agility and responsiveness of organizations in addressing environmental issues, leading to improved sustainable performance outcomes. In addition, BI system facilitates the application of predictive analytics and forecasting models to assess the potential impact of different environmental strategies and interventions

Managerial and Policy Implications
The managerial implications of EMA encompass various aspects of organizational decision-making, performance measurement, and strategic planning. By implementing EMA practices, organizations can improve their environmental performance, enhance resource efficiency, and achieve sustainable outcomes. EMA provides organizations with relevant and reliable environmental information that supports decision-making processes. By integrating environmental considerations into decision frameworks, managers can make informed choices that align with sustainability goals. EMA enables the evaluation of different alternatives based on their environmental impact, cost implications, and long-term sustainability benefits. EMA helps organizations identify and manage environmental costs, thereby promoting cost control and resource efficiency. By analyzing the environmental impact of various activities, processes, and products, organizations can identify areas for improvement and implement measures to reduce waste, energy consumption, and associated costs. EMA facilitates the identification of cost-saving opportunities through eco-efficiency initiatives.
Policy-level implications of environmental management accounting (EMA) refer to the broader considerations and actions that policymakers can take to promote the adoption and integration of EMA practices at a systemic level. These implications focus on creating an enabling environment for EMA implementation, fostering sustainability, and driving environmental performance improvements. Policymakers can establish and enforce regulatory frameworks that require organizations to adopt EMA practices and report on their environmental performance. This includes setting standards for environmental accounting, disclosure requirements, and reporting formats. Clear and consistent regulatory frameworks provide organizations with guidance and incentives to integrate environmental considerations into their accounting practices. Policymakers can provide financial incentives, such as tax breaks, subsidies, and grants, to encourage organizations to invest in EMA implementation. Financial support can help offset the costs associated with adopting EMA

practices and provide organizations with the resources needed to develop and maintain robust environmental accounting systems. These incentives can accelerate the adoption of EMA and foster sustainability-oriented decision-making. Policymakers can support capacity building initiatives and training programs to enhance the knowledge and skills of accounting professionals in EMA practices. By providing educational resources, workshops, and certification programs, policymakers can ensure that accountants and financial professionals are equipped with the necessary tools and expertise to effectively implement EMA. This helps organizations integrate EMA practices seamlessly into their accounting systems.

Conclusion

Investigating the relationship between EMA and the circular economy can provide valuable insights into how EMA can support the transition to a more circular and sustainable economy. This research can explore the role of EMA in measuring and managing the environmental impacts and resource efficiency of circular economy practices, as well as the financial implications and performance outcomes of circular business models. Examining the integration of EMA with non-financial reporting frameworks and the impact of EMA on the quality and transparency of sustainability reporting can be an interesting research direction. This includes investigating the linkages between EMA practices and the disclosure of environmental information, assessing the credibility and comparability of EMA data in non-financial reports, and examining the role of EMA in enhancing stakeholder engagement and decision-making.

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