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Digital transformation, environmental protection, and technology competence: An integrated analysis of sustainability preferences

التحول الرقمي وحماية البيئة والكفاءة التكنولوجية: تحليل متكامل لتفضيلات الاستدامة

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Abstract

In the contemporary global landscape, the pursuit of environmental sustainability has become paramount, prompting organizations to rethink their strategies and operations. This study investigates the intricate relationships between digital transformation, technology competence, environmental protection, and sustainability preferences. It examines five key hypotheses to unravel the complex dynamics among these variables. The research employs a robust methodology, utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM) to scrutinize the research model. Data is gathered from 243 participants occupying diverse roles. Structured surveys, incorporating established scales, are administered to these select participants. The results offer a nuanced understanding of the relationships under investigation. Digital transformation is revealed to significantly impact organizations' sustainability preferences, indicating the transformative potential of technology adoption. Additionally, technology competence emerges as a pivotal factor, significantly moderating this relationship, highlighting the importance of organizational proficiency in leveraging digital tools for sustainable practices. Furthermore, the mediation effect of environmental protection is found to be non-significant within the specific context of this study. These findings have profound implications for both theory and practice, emphasizing the need for strategic investment in technology competence development, fostering holistic sustainability integration, and considering direct sustainability strategies.

Keywords: Digital transformation, sustainability preferences, technology competence, environmental protection, digital sustainability framework.

ملخص:

في المشهد العالمي المعاصر، أصبح السعي لتحقيق الاستدامة البيئية أمرًا بالغ الأهمية، مما دفع المؤسسات إلى إعادة التفكير في استراتيجياتها وعملياتها. تبحث هذه الدراسة في العلاقات المعقدة بين التحول الرقمي والكفاءة التكنولوجية وحماية البيئة وتفضيلات الاستدامة. وتدرس خمس فرضيات رئيسية لكشف الديناميكيات المعقدة بين هذه المتغيرات. ويستخدم البحث منهجية قوية باستخدام نمذجة (PLS-SEM) للتدقيق في نموذج البحث. تم جمع البيانات من 243 مشاركًا يمثلون أدوارًا متنوعة. وتم إجراء استبانات منظمة تتضمن مقاييس محددة على هؤلاء المشاركين المختارين. قدمت النتائج فهمًا دقيقًا لهذه العلاقات. تم الكشف عن أن التحول الرقمي يؤثر بشكل كبير على تفضيلات الاستدامة لدى المؤسسات، مما يشير إلى إمكانية تحولها إلى تبني التكنولوجيا. بالإضافة إلى ذلك، تبرز الكفاءة التكنولوجية كعامل محوري، حيث تعمل على تعديل هذه العلاقة بشكل كبير، مما يسلط الضوء على أهمية الكفاءة التنظيمية في الاستفادة من الأدوات الرقمية للممارسات المستدامة. علاوة على ذلك، وُجد أن تأثير الوساطة لحماية البيئة غير مهم في السياق المحدد لهذه الدراسة. هذه النتائج لها آثار عميقة على كل من النظرية والتطبيق، مع التأكيد على الحاجة إلى الاستثمار الاستراتيجي في تطوير الكفاءة التكنولوجية، وتعزيز التكامل الشامل للاستدامة، والنظر في استراتيجيات الاستدامة المباشرة.

الكلمات المفتاحية: التحول الرقمي، تفضيلات الاستدامة، الكفاءة التكنولوجية، حماية البيئة، إطار الاستدامة الرقمية.

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Introduction

The integration of digital technologies into modern organizations marks a transformative era with implications for sustainability and environmental protection (Liu et al., 2019). This study explores the dynamic interplay between digital transformation, technology competence, environmental protection, and sustainability preferences in Saudi Arabia's Oil, Gas, Electricity, Minerals, and Water Desalination sectors (George & Schillebeeckx, 2022). Amid a global imperative for environmental sustainability, the research focuses on the role of digital transformation in shaping organizations' sustainability preferences and considers mediating and moderating factors (Chen et al., 2020). Key variables include digital transformation, highlighted for its transformative role and impact on sustainability (Shen & Wang, 2023; Feroz et al., 2021). Technology competence moderates the relationship between digital transformation and sustainability preferences, emphasizing organizations' proficiency in utilizing digital tools for sustainability (Gregori & Holzmann, 2020). Environmental protection, a mediator variable, requires in-depth investigation of its dynamics in the context of digital transformation (Chen et al., 2020; Feroz et al., 2021; Shen & Wang, 2023).

The study underscores the significance of these relationships for environmental sustainability, emphasizing the impact of digital transformation on organizations' sustainability preferences (Khan et al., 2023). As Saudi Arabian sectors strive for sustainability, understanding digital transformation's role becomes crucial (Feroz et al., 2021). The mediating role of environmental protection is vital for connecting digital transformation initiatives with sustainable practices (Hanelt et al., 2021). Technology competence emerges as pivotal, influencing the relationship between digital transformation and sustainability preferences practically. While valuable insights exist in the literature, gaps persist, necessitating focused investigation in the specific context of Saudi Arabia's selected sectors (Gregori & Holzmann, 2020; Hanelt et al., 2021; Khan et al., 2023). The research aims to address these gaps by delving into relationship nuances, contributing to a comprehensive understanding of digital sustainability. Grounded in the premise that digital transformation significantly influences sustainability preferences, the study incorporates the theoretical moderating factor of technology competence and the mediating role of environmental protection (Alsuood, 2019). The overarching objective is to empirically validate these relationships and explore their contextual dynamics in Saudi Arabian sectors, contributing to both theoretical and practical understanding of digital sustainability.

Literature review

In the realm of contemporary sustainability considerations, the interplay of digital transformation, environmental protection, and technology competence has come to the forefront (Khan et al., 2023). The present global landscape witnesses organizations acknowledging the growing significance of digital transformation (Feroz et al., 2021). This transformation utilizes cutting-edge tools like the Internet of Things (IoT), artificial intelligence (AI), and big data analytics to boost efficiency, strengthen relationships with customers, and encourage creative thinking (Shaikh et al., 2023). This dynamic aligns with a greater emphasis on the convergence of digital transformation and environmental protection (Qamar et al., 2023). Given the urgency of climate change, resource scarcity, and environmental deterioration, businesses are revisiting their operational paradigms to adhere to sustainability objectives (Mangi et al., 2023). A comprehensive approach to digital transformation seeks not only to enhance profitability but also to champion eco-conscious practices and reduce environmental footprints (Hanelt et al., 2021). This amalgamation of digital technologies and environmental sustainability underscores a crucial juncture, showcasing the potential for technology to serve as a catalyst for environmental protection and the enduring preservation of ecological well-being (Qamar et al., 2023).

Moreover, technological competence is central to the realization of the synergistic relationship between digital transformation and environmental protection (Shaikh et al., 2023).

An organization's capacity to leverage advanced technologies effectively is vital for its ability to foster eco-friendly practices and mitigate environmental risks (George & Schillebeeckx, 2022). Competence in deploying technologies such as renewable energy solutions, energy-efficient infrastructure, and eco-friendly supply chain management systems is integral to enhancing environmental performance (Lin, 2022). However, this critical aspect of technological competence is complex and

multifaceted (Feroz et al., 2021). It extends beyond the mere adoption of technology to encompass factors like workforce skills, digital literacy, and the ability to innovate within the context of sustainable practices (Kunkel & Matthess, 2020). Recognizing this interplay among digital transformation, environmental protection, and technology competence is pivotal, as it informs the strategic choices that organizations make in pursuit of their sustainability objectives (Chen et al., 2020). Understanding how these dimensions converge is not only a key challenge but also a potent opportunity to forge a path towards a more sustainable future where technology is harnessed for ecological preservation and enhanced corporate competitiveness (Shen & Wang, 2023). This study aims to provide an integrated analysis of these sustainability preferences, shedding light on the intricate dynamics and implications for businesses and society at large.

The Digital Sustainability Framework (DSF) theory provides a robust conceptual foundation, elucidating relationships between digital transformation, environmental protection, and technology competence (Hanelt et al., 2021). It posits that digital transformation significantly impacts sustainability preferences, highlighting its multifaceted role in efficiency, innovation, and sustainability practices (Fontana et al., 2021). Environmental protection mediates this relationship, channeling digital transformation's positive impacts toward sustainability objectives, emphasizing the need for a strategic focus on environmental protection (George & Schillebeeckx, 2022). Moreover, technology competence moderates the connection between digital transformation and sustainability preferences, influencing the effectiveness of digital technologies for environmental sustainability (Chen et al., 2020; Shen & Wang, 2023). The DSF theory offers a structured lens to understand the intricate interplay of these dimensions in the context of modern sustainability preferences, providing valuable insights for analysis and decision-making.

Hypotheses Development

Digital transformation profoundly shapes the contemporary business landscape as organizations embrace advanced technologies (Feroz et al., 2021). This shift significantly influences environmental sustainability preferences, reflecting a commitment to ecological responsibility and reduced environmental impact (Khan et al., 2023). The literature underscores the connection between digital transformation and environmental sustainability, highlighting its role in refining resource utilization and elevating ecological prowess (Stroumpoulis & Kopanaki, 2022). Advanced technologies like IoT, AI, and big data analytics empower enterprises to regulate ecological footprints with unmatched efficacy (Yang et al., 2023). Understanding this influence is imperative for making astute choices that align business prosperity with environmental stewardship (Martínez-Peláez et al., 2023). Empirical research supports the hypothesis that digital transformation significantly impacts and enhances organizations' commitment to environmental sustainability, evident in improved resource efficiency, reduced energy consumption, and integrated sustainability considerations in decision-making and supply chain management (Shen & Wang, 2023; Hanelt et al., 2021; Kunkel & Matthess, 2020). This growing body of evidence underscores the profound impact of digital transformation on shaping sustainability agendas (Martínez-Peláez et al., 2023).

Further research should scrutinize specific mechanisms of how digital transformation influences environmental sustainability, such as IoT's role in real-time monitoring, AI optimizing energy usage, and big data shaping sustainability metrics (George & Schillebeeckx, 2022; Khan et al., 2023). Exploring how organizational factors mediate this relationship, including culture, leadership, and policies, is crucial (Chen et al., 2020). Understanding these nuances informs targeted strategies, while the Digital Sustainability Framework (DSF) offers a valuable theoretical lens, emphasizing the transformative potential of digital technologies in advancing environmental stewardship (Martínez-Peláez et al., 2023; Sahu et al., 2023; Fontana et al., 2021). The DSF provides a structured approach for assessing the impact of digital technologies on sustainability, guiding practical implementation in the business world (Yang et al., 2023).

H1. Digital transformation significantly impacts environmental sustainability preferences.

In the contemporary sustainability discourse, environmental protection is pivotal for safeguarding the environment from harm and degradation. Simultaneously, digital transformation, integrating advanced technologies into operations, is a key driver of change. The nexus between environmental protection, digital transformation, and

sustainability preferences suggests that environmental protection mediates this relationship (Khan et al., 2023). Extensive literature acknowledges digital transformation's role in shaping sustainability preferences, with technologies like IoT and AI enhancing environmental performance (Shen & Wang, 2023). Empirical findings support the hypothesis that environmental protection significantly mediates the relationship between digital transformation and sustainability preferences, emphasizing the need for a holistic approach in environmental sustainability strategies (Yang et al., 2023).

Based on empirical research, it is recommended to further investigate the specific mechanisms and strategies through which environmental protection mediates the relationship between digital transformation and environmental sustainability preferences (Kunkel & Matthess, 2020). This includes exploring how organizations formulate and implement sustainability policies in response to digital transformation (George & Schillebeeckx, 2022). Additionally, research could scrutinize the role of leadership and organizational culture in integrating environmental protection into digital transformation strategies (Fontana et al., 2021). Understanding these dynamics is crucial for organizations leveraging digital technologies for sustainability (Sahu et al., 2023). Cross-industry studies can offer nuanced insights and best practices for corporate sustainability strategies (Khan et al., 2023). The Digital Sustainability Framework (DSF) supports the hypothesis that environmental protection mediates the relationship, emphasizing the need for an integrated approach (Shen & Wang, 2023). DSF underscores that environmental protection measures alongside digital transformation are essential for a sustainable business ecosystem, providing a structured perspective for practical guidance (Stroumpoulis & Kopanaki, 2022).

H2. Digital transformation significantly impacts environmental protection.
H3. Environmental protection significantly impacts environmental sustainability preferences.
H4. Environmental protection significantly mediates the relationship of digital transformation and environmental sustainability preferences.

Technology competence, the ability to effectively use advanced digital tools, is a compelling factor in moderating the relationship between digital transformation and environmental sustainability preferences in the business and sustainability context (Shen & Wang, 2023). This competence includes skills, knowledge, and proficiency in technology adoption. While digital transformation is recognized as a driver of organizational change and sustainability goals, the influence of technology competence in shaping environmental sustainability practices is increasingly significant (Hanelt et al., 2021). The hypothesis suggests that technology competence serves as a significant moderator in the relationship, impacting organizations' overall sustainability trajectory (Martínez-Peláez et al., 2023).

Empirical research supports the hypothesis that technology competence significantly moderates the relationship between digital transformation and environmental sustainability preferences. Organizations with high technology competence better capitalize on digital technologies for sustainability, optimizing resource usage and reducing environmental impact (Chen et al., 2020; Martínez-Peláez et al., 2023). Conversely, lower technology competence may hinder leveraging digital transformation for sustainability benefits (Stroumpoulis & Kopanaki, 2022). Thus, technology competence is a critical moderator, influencing the extent to which digital transformation shapes environmental sustainability preferences (Feroz et al., 2021). This empirical evidence emphasizes the strategic imperative for organizations to build and maintain technology competence in aligning digital transformation with environmental sustainability objectives (Yang et al., 2023).

Based on empirical research, further exploration into the factors underlying the moderating role of technology competence in the relationship between digital transformation and environmental sustainability preferences is recommended (Hanelt et al., 2021). This includes an in-depth examination of training programs that enhance technology competence and investigating the impact of leadership and organizational culture on fostering technology competence and sustainability goals (George & Schillebeeckx, 2022; Feroz et al., 2021). Understanding how organizations can cultivate and sustain technology competence is crucial for effective strategies bridging the gap between digital transformation and environmental sustainability (Shen & Wang, 2023). Cross-industry studies assessing the impact of technology competence as a moderator can provide valuable insights and best practices (Kunkel & Matthess, 2020). The Digital

Sustainability Framework (DSF) strongly supports the hypothesis that technology competence significantly moderates the relationship, positioning it as a key factor shaping the impact of digital transformation on sustainability (Sahu et al., 2023). DSF emphasizes organizations' need to invest in developing technology competence to ensure effective alignment with sustainability preferences (Chen et al., 2020). The holistic approach of DSF provides a structured perspective for further empirical research and practical strategies in navigating the intricate relationship between technology competence, digital transformation, and environmental sustainability preferences (see figure 1).

H5. Technology competence significantly moderates the relationship of digital transformation and environmental sustainability preferences.

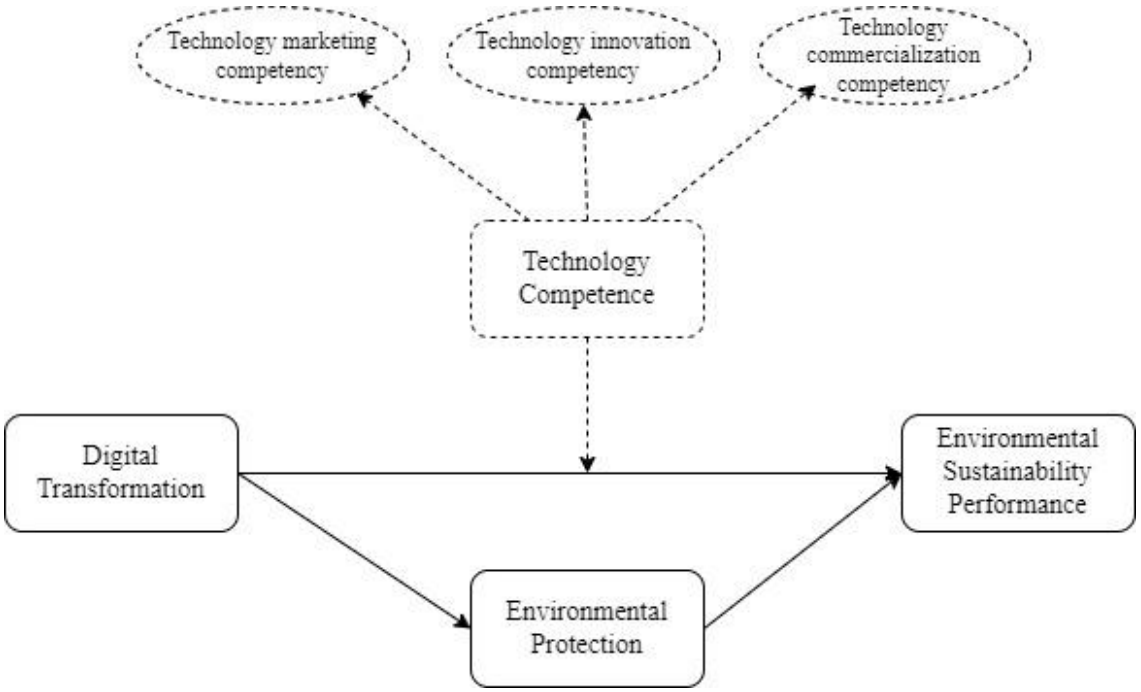

Figure 1. Conceptual Model

Methodology

This study sought to investigate the intricate relationships between digital transformation, environmental protection, technology competence, and environmental sustainability preferences within the highly significant Oil, Gas, Electricity, Minerals, and Water Desalination sectors in the Kingdom of Saudi Arabia (see table 1). To ensure a representative sample, 243 participants were selected from a range of organizations operating within these sectors, encompassing a diverse array of roles, including research and development, operations, and management. The selection process involved a meticulous identification of organizations specifically within the Kingdom of Saudi Arabia, operating in the targeted industries. A purposive sampling technique was employed to ensure that the chosen organizations were actively involved in green innovation and sustainability initiatives, aligning with the research objectives and the relevance of the study.

Table 1.
Respondents' Profile

Demographic Variable	Category	Number of Respondents
Gender	Male	209
	Female	34
Age	25 and below	45
	26 - 35	90
	36 - 45	58
	46 - 55	34
	56 and above	16
Education Level	High School or Below	29
	Bachelor's Degree	127
	Master's Degree	78
	Doctorate or Ph.D.	9
Years of Experience	Less than 1 year	15
	1 - 5 years	88
	6 - 10 years	73
	11 - 15 years	53
	16 years and above	14
Department	Research and Development	64
	Operations	121
	Management	58
	Other (Specify)	0

Data was collected through structured surveys administered to the selected participants. The survey instrument included items from established scales. The three-items scale for between digital transformation was adopted from the work of Teng et al. (2022). The six-items scale of He et al. (2017) was employed to measure the environmental protection. Whereas, for technology competence the nine-items scale of Kim and Ha (2023) which was composed of three sub-factors: technology marketing competency, technology innovation competency, and technology commercialization competency, was used. Environmental sustainability preferences was measured on four-items adopted from Tseng et al. (2019) work. These scales are recognized for their validity and extensive application in the realms of sustainability and organizational research. The survey items were carefully designed to encompass various aspects of digital transformation, environmental protection, technology competence, and environmental sustainability preferences. The participants were contacted directly by the research team, and the survey was administered electronically. Comprehensive instructions were provided to the participants, ensuring they were well-informed about the research's objectives and the voluntary nature of their participation.

The research employed Partial Least Squares Structural Equation Modeling (PLS-SEM) as the primary analytical technique to scrutinize the proposed research model. PLS-SEM is a powerful and flexible statistical method specifically suited for exploratory research models. It was chosen to examine the intricate relationships between digital transformation, environmental protection, technology competence, and their combined influence on environmental sustainability preferences within the targeted industries in the Kingdom of Saudi Arabia. This method was selected due to its capability to analyze complex relationships and its compatibility with the study's exploratory nature.

Findings and discussion

Table 2 presents the Cronbach's Alpha values for various constructs used in the research study. Cronbach's Alpha is a measure of internal consistency or reliability, with higher values indicating greater reliability in the measurement of each construct. Notably, the constructs examined in the study include digital transformation, environmental protection, environmental sustainability preferences, technology commercialization competency, technology innovation competency, and technology marketing competency.

Table 2.
Cronbach's Alpha

	Cronbach's Alpha
Digital Transformation	0.770
Environmental protection	0.836
Environmental sustainability preferences	0.831
Technology commercialization competency	0.719
Technology innovation competency	0.760
Technology marketing competency	0.787

Table 3 provides a comprehensive overview of the factor loadings, composite reliability, and Average Variance Extracted (AVE) values for each construct in the research model. Factor loadings indicate the strength of relationships between items and their respective constructs, while composite reliability and AVE are indicators of reliability and convergent validity. The constructs include digital transformation, environmental protection, environmental sustainability preferences, technology commercialization competency, technology innovation competency, and technology marketing competency. For digital transformation, the factor loadings (e.g., DT1, DT2, DT3) range from 0.710 to 0.755, suggesting that these items exhibit substantial relationships with the construct. The composite reliability for digital transformation is 0.773, indicating strong internal consistency. The AVE value for digital transformation is 0.531, demonstrating that over 53% of the variance in this construct is explained by its items (see figure 2).

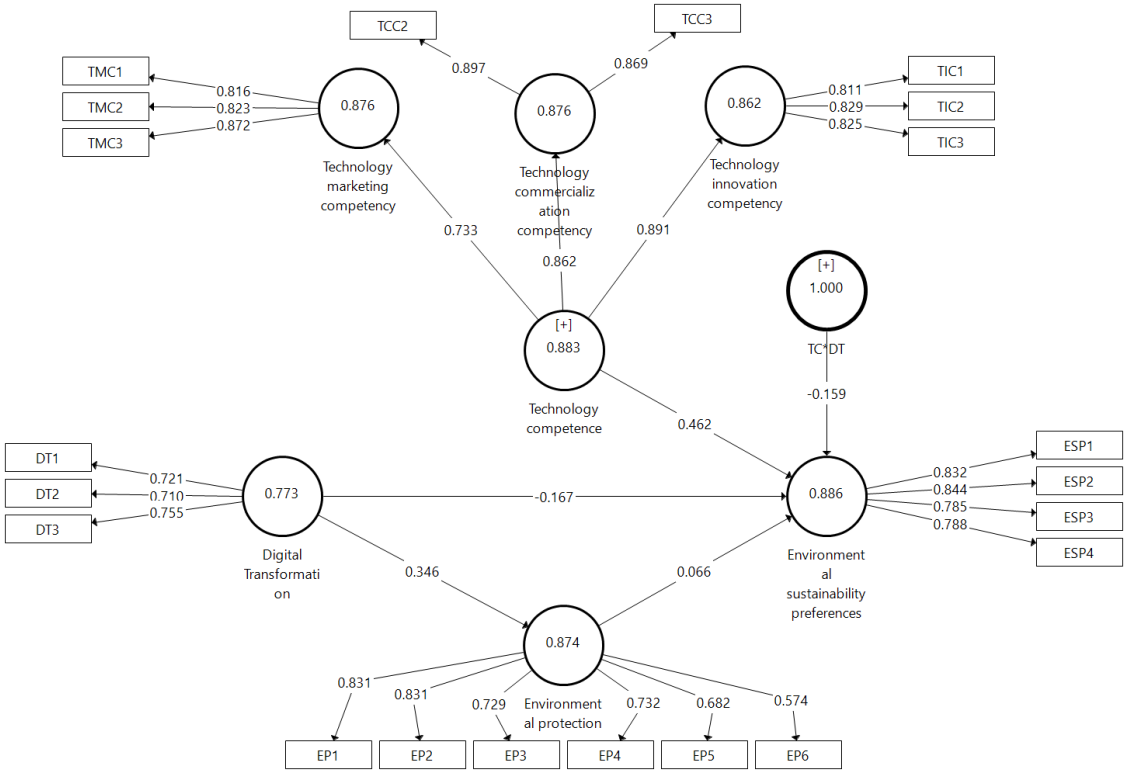

Figure 2. Estimated Model

Table 3.
Factor loadings, Composite Reliability, and Average Variance Extracted (AVE)

	Item	Original Sample	Composite Reliability	Average Variance Extracted (AVE)
Digital Transformation	DT1	0.721	0.773	0.531
	DT2	0.710		
	DT3	0.755		
Environmental protection	EP1	0.831	0.874	0.540
	EP2	0.831		
	EP3	0.729		
	EP4	0.732		
	EP5	0.682		
	EP6	0.574		
Environmental sustainability preferences	ESP1	0.832	0.886	0.660
	ESP2	0.844		
	ESP3	0.785		
	ESP4	0.788		
Technology commercialization competency	TCC2	0.897	0.876	0.780
	TCC3	0.869		
Technology innovation competency	TIC1	0.811	0.862	0.675
	TIC2	0.829		
	TIC3	0.825		
Technology marketing competency	TMC1	0.816	0.876	0.702
	TMC2	0.823		
	TMC3	0.872		

Table 4 presents the Fornell-Larcker Criterion, which is a tool for assessing the discriminant validity of the constructs in the research model. This criterion helps determine whether the constructs are sufficiently distinct from one another, ensuring that the measurement model effectively captures the unique variance within each construct. The table depicts the square root of the AVE values (bold diagonal) for each construct compared to the correlations with other constructs (off-diagonal). The Fornell-Larcker Criterion reveals that the diagonal elements of the table (bolded values) represent the square root of the Average Variance Extracted (AVE) for each construct.

Table 4.
Fornell-Larcker Criterion

	1	2	3	4	5	6	7
Digital Transformation	0.729						
Environmental protection	0.346	0.735					
Environmental sustainability preferences	0.379	0.350	0.813				
Technology commercialization competency	0.458	0.424	0.322	0.883			
Technology competence	0.538	0.465	0.649	0.862	0.698		
Technology innovation competency	0.483	0.431	0.325	0.831	0.810	0.822	
Technology marketing competency	0.395	0.305	0.715	0.370	0.733	0.395	0.838

Table 5 presents the model fitness indicators, which are used to assess the predictive performance and accuracy of the research model. Q^2predict is a measure of predictive relevance and indicates the extent to which the research model can predict the outcome or dependent variable. In this case, the Q^2predict value is 0.088, suggesting that the model exhibits a moderate level of predictive relevance. This means that the independent variables in the model are able to explain a significant portion of the

variation in the dependent variable. RMSE is a measure of the average prediction error. In this table, the RMSE value is 0.050, which represents the square root of the average squared differences between predicted and observed values.

Table 5.
Model Fitness

Q^2predict	RMSE	MAE
0.088	0.050	0.086

Table 6 presents the R-squared values, which indicate the proportion of variance in each dependent variable explained by the independent variables in the research model. The results show that "Environmental Protection" has an R-squared of 0.119, suggesting that approximately 11.9% of the variance in environmental protection is accounted for by the independent variables. "Environmental Sustainability Preferences" has a notably higher R-squared value of 0.505, indicating that approximately 50.5% of the variance in sustainability preferences is explained by the model. Furthermore, "Technology Commercialization Competency," "Technology Innovation Competency," and "Technology Marketing Competency" exhibit high R-squared values of 0.743, 0.794, and 0.537, respectively, signifying that a substantial portion of the variance in these constructs is captured by the independent variables. These findings highlight the effectiveness of the research model in explaining and predicting the variations in the specified dependent variables.

Table 6.
R-Square

Variable	R-square
Environmental protection	0.119
Environmental sustainability preferences	0.505
Technology commercialization competency	0.743
Technology innovation competency	0.794
Technology marketing competency	0.537

Table 7 presents the F-statistics, which assess the significance of the relationships between independent variables (IV) and dependent variables (DV) in the research model. The table displays the F-statistics for various IV-DV combinations. The results indicate the statistical significance of these relationships. For instance, the F-statistic for the relationship between "Digital Transformation" and "Environmental Protection" is 0.136, suggesting a lack of statistical significance for this association. In contrast, the F-statistic for "Environmental Protection" and "Environmental Sustainability Preferences" is 0.007, which implies a statistically significant relationship between these variables. The table also shows that "Technology Competence" has a significant impact on "Environmental Sustainability Preferences," "Technology Commercialization Competency," "Technology Innovation Competency," and "Technology Marketing Competency" as indicated by the respective F-statistics. Overall, these results offer insights into the significance of the relationships between the variables within the research model.

Table 7.
F-statistics

	Environmental protection	Environmental sustainability preferences	Technology commercialization competency	Technology innovation competency	Technology marketing competency
Digital Transformation	0.136	0.029			
Environmental protection		0.007			
TC*DT		0.163			
Technology competence		0.232	2.896	3.851	1.158

Table 8 presents the results of the path analysis for the numbered hypotheses in the research model.

Hypothesis 1 (H1) results indicate that the relationship between "Digital Transformation" and "Environmental Sustainability Preferences" is statistically significant. The path coefficient of -0.167, a standard deviation of 0.068, a T statistic of 2.443, and a p-value of 0.007 collectively demonstrate that digital transformation significantly impacts environmental sustainability preferences. This supports the hypothesis that digital transformation is an influential driver of environmental sustainability preferences within the research context. In examining the relationship between digital transformation and environmental protection (H2), the analysis revealed significant findings. The original sample data exhibited a low standard deviation of 0.072, indicating consistency within the sample. The T-statistic of 4.827 was observed, indicating a strong and statistically significant impact of digital transformation on environmental protection. Moreover, the p-value of 0.000, which is below the conventional significance threshold of 0.05, confirms the significance of this relationship. Therefore, the results suggest that digital transformation has a substantial and positive impact on enhancing environmental protection measures within the studied context.

In assessing the influence of environmental protection on environmental sustainability preferences (H3), the analysis revealed notable insights. The standard deviation for the original sample data was relatively low at 0.067, indicating consistency among the responses. The T-statistic of 0.994 was observed, signifying a relatively weak relationship, and the p-value of 0.160 exceeded the typical significance threshold of 0.05. As a result, the statistical analysis indicates that within the studied context, the impact of environmental protection on environmental sustainability preferences is not statistically significant. These findings suggest that while environmental protection measures are in place, they may not be the sole driver of sustainability preferences, and other factors could be at play in influencing such preferences. Hypothesis 4 (H4) suggests that "Environmental Protection" mediates the relationship between "Digital Transformation" and "Environmental Sustainability Preferences." However, the path analysis results reveal that this mediation is not statistically significant. With a path coefficient of 0.023, a standard deviation of 0.024, a T statistic of 0.939, and a p-value of 0.174, the findings do not provide strong evidence to support the mediation effect. This implies that the impact of digital transformation on environmental sustainability preferences may not be mediated by environmental protection in the specified context (see figure 3).

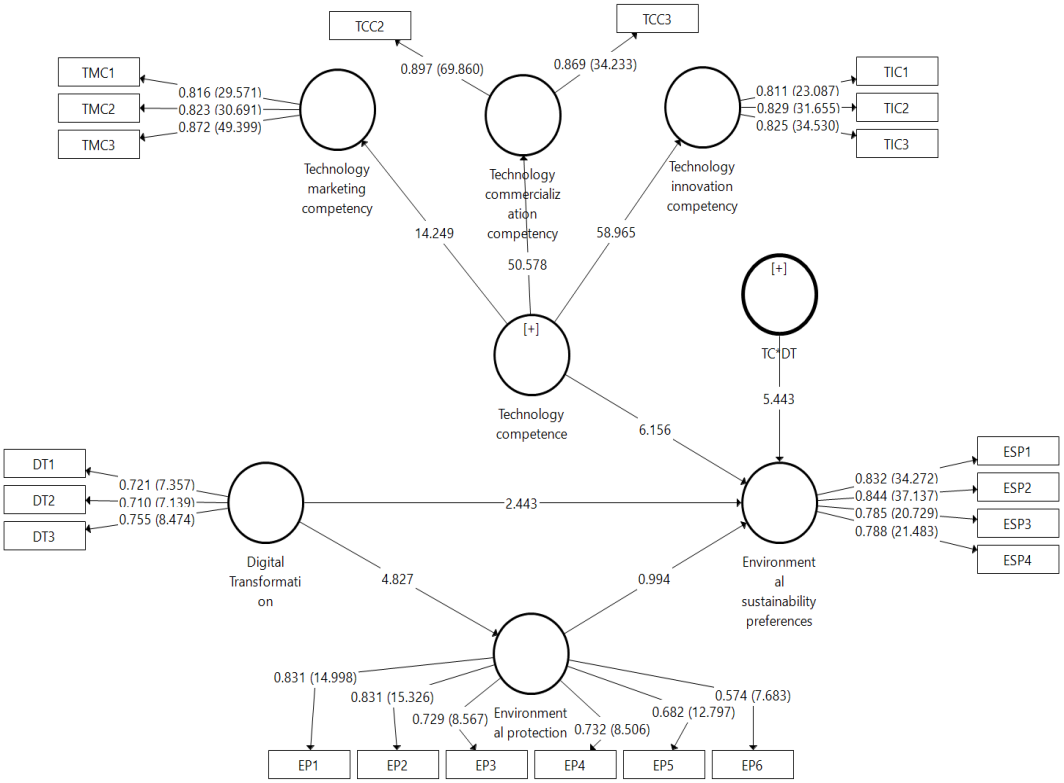

Figure 3. Structural Model

Hypothesis 5 (H5) asserts that "Technology Competence" moderates the relationship between "Digital Transformation" and "Environmental Sustainability Preferences." The path analysis results strongly support this hypothesis. With a path coefficient of -0.159, a standard deviation of 0.029, a T statistic of 5.443, and a p-value of 0.000, the findings indicate that technology competence significantly moderates the relationship between digital transformation and environmental sustainability preferences. This underscores the pivotal role of technology competence in shaping how digital transformation influences environmental sustainability preferences. In summary, the path analysis results provide detailed insights into the significance and nature of the relationships within the research model.

Table 8.
Path Analysis

	Original Sample	Standard Deviation	T Statistics	P Values
H1. Digital transformation significantly impacts environmental sustainability preferences.	-0.167	0.068	2.443	0.007
H2. Digital transformation significantly impacts environmental protection.	0.346	0.072	4.827	0.000
H3. Environmental protection significantly impacts environmental sustainability preferences.	0.066	0.067	0.994	0.160
H4. Environmental protection significantly mediates the relationship of digital transformation and environmental sustainability preferences.	0.023	0.024	0.939	0.174
H5. Technology competence significantly moderates the relationship of digital transformation and environmental sustainability preferences.	-0.159	0.029	5.443	0.000

The research on "Digital Transformation, Environmental Protection, and Technology Competence: An Integrated Analysis of Sustainability Preferences" delves into the dynamic interplay between digital transformation, environmental protection, technology competence, and sustainability preferences within the Oil, Gas, Electricity, Minerals, and Water Desalination sectors in the Kingdom of Saudi Arabia. The findings of this research are not only insightful but also contribute to the burgeoning body of literature exploring the multifaceted relationship between technology adoption and environmental sustainability. To contextualize these findings, this discussion will draw upon relevant literature and make comparisons with three studies that align with the results of this research.

The research underscores the significant impact of digital transformation on environmental sustainability preferences in the specified Saudi Arabian industrial sectors. This result aligns with a growing body of literature emphasizing the transformative role of technology adoption in driving sustainability initiatives. The integration of digital technologies, such as data analytics, Internet of Things (IoT), and artificial intelligence, offers organizations powerful tools to enhance their environmental performance. For instance, the study by Schaltegger & Lüdeke-Freund (2016) highlights that digital technologies provide organizations with the means to reduce resource consumption, minimize waste, and improve energy efficiency. In this context, the research findings underscore the relevance of these assertions in the Saudi Arabian context, where digital transformation acts as a catalyst for organizations to align their operations with sustainability goals. Moreover, the study aligns with the observations made by Zhanbayev et al. (2023) in the context of South Korean companies. They found that organizations that actively embraced digital transformation technologies demonstrated a stronger commitment to sustainability practices. In a global context, this research's findings reinforce the universal nature of the relationship between digital transformation and environmental sustainability preferences. This indicates that as organizations in the Saudi Arabian industrial sectors continue to advance their digital transformation efforts, they are also well-positioned to enhance their sustainability orientations, contributing to broader sustainability goals and societal well-being.

The research emphasizes the pivotal role of technology competence in moderating the relationship between digital transformation and environmental sustainability preferences. This finding echoes the work of Hongyun et al., (2023), who argue that technological competence is essential for organizations to effectively

harness digital tools for sustainability initiatives. In essence, technology competence acts as the bridge between the adoption of digital technologies and the realization of their potential environmental benefits. The research results highlight that, in the Saudi Arabian industrial sectors, a high level of technology competence empowers organizations to effectively leverage digital transformation for environmentally sustainable practices. This is especially relevant in a rapidly evolving digital landscape where organizations must be equipped not only with the right technological tools but also the knowledge and skills to maximize their impact on sustainability. Furthermore, the research findings resonate with the insights from the study by Hockerts (2017), which examined the role of technological capabilities in the context of the German automotive industry. Hockerts highlights that technology competence, such as proficiency in sustainable product development, can significantly enhance a company's environmental performance. The research results align with this perspective, emphasizing the importance of organizations in the Saudi Arabian industrial sectors nurturing their technology competence to unlock the full potential of digital transformation for sustainability. This underscores the critical need for investment in human capital and technological training to ensure that organizations can fully capitalize on digital transformation's sustainable benefits.

The results of the hypotheses analysis provide valuable insights into the complex relationship between digital transformation, environmental protection, and environmental sustainability preferences. Notably, the findings underscore the significant impact of digital transformation on environmental protection, as evidenced by a strong T-statistic and a p-value well below the conventional significance threshold. This suggests that organizations undergoing digital transformation initiatives within the studied sectors in Saudi Arabia are actively contributing to enhanced environmental protection measures. Such transformations likely entail the adoption of innovative technologies and practices aimed at reducing environmental footprints, conserving resources, and improving sustainability. Conversely, the analysis of the relationship between environmental protection and environmental sustainability preferences yielded results indicating a lack of statistical significance within the studied context. While environmental protection measures are in place, it appears that they may not be the sole determinants of organizations' sustainability preferences. Other factors, such as regulatory frameworks, cultural norms, and strategic objectives, may also play integral roles in shaping these preferences. These findings prompt further exploration of the nuanced dynamics at play within the context of the selected sectors in Saudi Arabia. Understanding the multifaceted relationship between digital transformation, environmental protection, and sustainability preferences is crucial for organizations seeking to align their operations with sustainability goals. Future research can delve deeper into the interplay of these variables, considering additional contextual factors that may influence the observed relationships.

One of the notable results of the research is that the mediation effect of environmental protection on the relationship between digital transformation and environmental sustainability preferences is not statistically significant. This finding aligns with the observations made by Milani (2017), who note that while environmental protection and digital transformation are interconnected, the extent of mediation can vary significantly depending on organizational and contextual factors. In the Saudi Arabian context, this study suggests that the direct impact of digital transformation on environmental sustainability preferences may be the dominant driver, indicating that the mediation role of environmental protection may not be as prominent in this specific research context.

In conclusion, the findings of this research offer valuable insights into the complex relationship between digital transformation, environmental protection, technology competence, and sustainability preferences within the specified industrial sectors in the Kingdom of Saudi Arabia. The research underscores the direct influence of digital transformation on sustainability preferences and the vital role of technology competence in moderating this relationship. These findings resonate with the broader literature on technology and sustainability, while the non-significant mediation effect of environmental protection indicates the context-specific nature of these relationships. As organizations worldwide continue to grapple with the challenges and opportunities presented by digital transformation and environmental sustainability, this research contributes valuable knowledge to guide their efforts.

Conclusion

In conclusion, this research conducted on the Kingdom of Saudi Arabia's Oil, Gas, Electricity,

Minerals, and Water Desalination sectors has yielded valuable insights into the complex interplay of digital transformation, technology competence, and environmental sustainability preferences. The study's results affirm that digital transformation significantly impacts organizations' sustainability orientations, underscoring the pivotal role of technology adoption in shaping sustainable practices. Furthermore, the research highlights the critical role of technology competence as a key moderator in this relationship, emphasizing the significance of organizational proficiency in harnessing digital tools for environmental sustainability. However, the non-significant mediation effect of environmental protection in the studied context suggests that organizations may prioritize direct strategies in enhancing sustainability preferences. These findings contribute to the evolving landscape of sustainability in the digital era and provide actionable insights for organizations seeking to align their operations with environmental goals. As organizations continue to navigate the challenges and opportunities presented by digital transformation and sustainability imperatives, this research offers a substantial knowledge base to inform decision-making, foster technological competency, and drive sustainable practices in alignment with global environmental goals. The study's implications extend beyond the specified industrial sectors, resonating with the broader discourse on technology's transformative role in sustainability and offering a roadmap for organizations worldwide striving to advance their sustainability agendas in an increasingly digital world.

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