Evaluating Digital Transformation as Mediator and Organizational Culture as Moderator in UAE Agile Project Management

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ABSTRACT

The United Arab Emirates (UAE) has invested heavily in digital construction technologies to improve project efficiency, responsiveness, and sustainability. Digital transformation is increasingly viewed as a key enabler for Agile Project Management (APM) and sustainability-oriented project delivery within the construction sector. Despite this investment, digital transformation adoption among UAE contractors remains inconsistent, which limits the achievement of sustainability and efficiency targets in agile construction projects. This study the evaluating digital transformation as mediator and organizational culture as moderator in UAE agile project management. This study employed a quantitative, hypothesis-driven survey design under a positivist paradigm and deductive approach, guided by the Technology–Organization–Environment (TOE) framework. The population comprised contractors involved in sustainable construction projects in the UAE, based on licensed and classified construction firms listed by the UAE Ministry of Infrastructure Development. The sample size determination based on a population of 11,676 contractors, the required sample size was 371 respondents. Data were collected through a structured questionnaire survey, distributed electronically to targeted contractor managers, supported by official access to company lists and facilitated through the licensing sector to enhance reach and participation. The study analyzed data using Partial Least Squares Structural Equation Modelling (PLS-SEM) via SmartPLS, including mediation and moderation testing to assess a moderated mediation model linking TOE determinants to sustainability outcomes through digital transformation. Findings indicate that technological, organizational, and environmental factors significantly influence contractors' digital transformation adoption. Digital transformation also shows a strong mediating role in improving sustainability outcomes. Moreover, organizational culture significantly moderates the relationships between TOE factors and digital transformation, strengthening the effects of these drivers on adoption. This study contributes by offering an integrated empirical model that positions digital transformation as a mediator and organizational culture as a moderator in explaining sustainability-oriented APM within the UAE construction industry.

Keywords: Digital Transformation, Online Agile Project Management, Contractors, UAE,

INTRODUCTION

In the context of the UAE construction industry, digital transformation (DT) has introduced innovative tools and processes that enhance project management efficiency, reduce costs, and improve overall project outcomes (Dabash, 2023). The adoption of Building Information Modeling (BIM), for example, has revolutionized how construction projects are planned, designed, and executed, offering a collaborative platform that integrates various stakeholders throughout the project lifecycle. Agile project management (APM) has become a dominant approach in managing complex and rapidly changing projects. In the UAE, driven by national digitalization strategies and economic diversification initiatives, organizations are actively embracing agile frameworks to remain competitive.

Furthermore, the cost of digital transformation is a critical obstacle for many contractors. Implementing advanced technologies requires substantial initial investment, covering software licenses, hardware upgrades, and workforce training. For companies operating on thin profit margins, these costs can be prohibitive (Ahmad & Alammary, 2022). Unlike in other sectors where digital transformation has been supported by targeted

subsidies and incentives, sectors such as healthcare and energy in the UAE have benefited from strategic government initiatives like the National Health IT Strategy and Energy Efficiency Funding Programs that provide financial and technical support for technology adoption (Khansaheb, 2024). The UAE construction sector lacks sufficient financial mechanisms to offset these high upfront costs.

Digital transformation (DT) is no longer optional but a strategic necessity. It involves integrating digital technologies into all business areas, fundamentally changing how organizations operate and deliver value (Dabash, 2023). Meanwhile, organizational culture (OC) plays a crucial role in shaping how agile practices and digital initiatives are adopted and sustained.

To conceptualize these relationships, the study adopts the Technology–Organization–Environment (TOE) framework (Tornatzky & Fleischer, 1990), a widely used model for analysing the multi-dimensional drivers of technology adoption in complex industries. This framework is particularly suitable for the construction sector, where adoption decisions are shaped not only by the perceived usefulness of technology but also by organizational capabilities and external institutional pressures.

This study is particularly relevant in the context of the UAE's broader sustainability and innovation agenda. As the nation continues to invest in sustainable infrastructure and smart cities, the construction sector must evolve to meet these expectations. Digital transformation plays a crucial role in achieving these goals, enabling contractors to reduce waste, optimize resource use, and enhance project performance. For instance, IoT-enabled smart sensors can monitor energy consumption in real-time, allowing for better resource management and reducing a building's carbon footprint (Alassafi et al., 2024). One of the key targets under the UAE Energy Strategy 2050 includes achieving 40% improvement in building energy efficiency by 2050, a goal that is contingent on digital-enabled monitoring and operational control technologies (Khansaheb, 2024). However, without widespread adoption of these technologies, the industry will struggle to meet the ambitious targets set by the UAE government.

This study aimed to develop a conceptual framework that evaluating digital transformation as mediator and organizational culture as moderator in UAE agile project management.

THEORETICAL LITERATURE AND HYPOTHESIS DEVELOPMENT

The Technology–Organization–Environment (TOE) framework offers a robust theoretical foundation for examining the adoption of digital transformation within the construction sector, particularly as it relates to agile project management and sustainability. Originally developed by Tornatzky and Fleischer (1990), the TOE framework proposes that the adoption of technological innovations within an organization is shaped by three contextual dimensions: technological factors, organizational characteristics, and environmental conditions. Each of these dimensions aligns closely with the research questions guiding this study and provides a multidimensional lens through which to understand how contractors in the UAE construction industry adopt digital transformation initiatives for managing sustainable facilities. The literature review approach was used in this study since its objective is to acceptance of digital transformation for agile project management among contractors of sustainable facilities in UAE.

The factors influencing

This study investigates the key factors influencing digital transformation adoption and its mediating effect on sustainability outcomes in construction projects. The conceptual framework guiding this study is grounded in the Technology–Organization–Environment (TOE).

1) Technology factors

Technology factors refer to the range of digital tools, platforms, systems, and infrastructures that enable organizations to integrate digital processes and capabilities across their operations. In the context of digital transformation, these factors serve as the core drivers of change, allowing industries to transition from traditional methods of operation to more modern, data-driven, and automated approaches. The term "technology factors" encompasses not only hardware and software but also includes the technological infrastructures and digital

innovations that organizations adopt to optimize efficiency, productivity, and competitiveness (Alizadehsalehi & Yitmen, 2023).

2) Organization factors

Information Organizational factors refer to the internal dynamics, structures, and management practices that influence an organization's ability to adopt and implement digital transformation. These factors include leadership styles, corporate culture, resource allocation, decision-making processes, and organizational hierarchy. Successful digital transformation requires the alignment of various internal elements to ensure that new technologies and innovative practices are fully integrated into the organization's operations (Ahmad, 2024; Alieva & Powell, 2023). Effective leadership, clear communication, and a culture that embraces change are critical components for driving transformation and ensuring long-term success..

3) Environment factors

External environmental factors play a significant role in shaping the direction and implementation of digital transformation in the construction industry. These factors encompass the broader socio-economic, regulatory, technological, and market-related conditions outside of an organization's direct control but heavily influence its decision-making and operational strategies. In the context of construction, external environmental factors relate to elements such as government regulations, industry standards, technological advancements, economic conditions, and sustainability imperatives that drive or hinder digital adoption (Abdou & Zaazou, 2019). Understanding these external forces is critical, as they set the stage for how organizations within the construction sector approach innovation and adapt to the evolving digital landscape.

Organizational culture

Organizational culture is broadly defined as the collective set of shared values, beliefs, and norms that guide behavior within an organization. In construction firms, this culture influences the way employees interact, make decisions, and solve problems, especially in complex project environments. Abdou and Zaazou (2019) argue that organizational culture is critical in shaping how a company responds to external and internal challenges, particularly in industries like construction, where collaboration and coordination across multiple stakeholders are necessary. Culture in construction firms typically emphasizes values such as safety, quality, cost-efficiency, and teamwork, which are foundational for the successful execution of construction projects. These cultural norms often become deeply embedded within the organization, influencing not only operational decisions but also how technology is perceived and adopted.

Digital transformation

Digital transformation in the construction sector refers to the fundamental reshaping of traditional construction processes through the integration of modern digital technologies. This transformation is aimed at improving project execution, enhancing productivity, and boosting collaboration across the lifecycle of construction projects. As industries across the globe embrace digital tools and systems, the construction sector has gradually begun to recognize the potential for integrating solutions such as Building Information Modeling (BIM), Internet of Things (IoT), Artificial Intelligence (AI), and big data analytics to drive efficiencies and improve outcomes (Adebowale & Agumba, 2023). Digital transformation is not limited to the adoption of isolated technological tools but requires a holistic approach where technologies are integrated to support the seamless flow of information across various phases of a project, from design and planning to construction and facility management.

Sustainability of construction projects

Sustainability of construction projects serves as the dependent variable, capturing the ultimate outcomes associated with digital transformation adoption and its antecedents. Sustainability in construction projects refers to the practice of developing buildings and infrastructure that meet current needs without compromising the ability of future generations to do the same. This involves minimizing the environmental impact of construction activities by optimizing resource use, reducing waste, and enhancing the well-being of both the environment and building occupants (Alassafi et al., 2024; Ahmad, 2024).

Hypotheses development

4) Influence of technological factors on digital transformation adoption

Technological factors represent the foundation upon which digital transformation initiatives are built. In the TOE framework, these factors encompass an organization's access to modern IT infrastructure, compatibility of systems, scalability, and perceived relative advantage of the technology being adopted (Tornatzky & Fleischer, 1990). In the context of the UAE construction industry, this includes the availability of technologies such as Building Information Modeling (BIM), Internet of Things (IoT), Artificial Intelligence (AI), and cloud computing, all of which are essential for managing complex construction projects more efficiently and sustainably (Alizadehsalehi & Yitmen, 2023). The success of digital transformation heavily depends on the degree to which these technologies are perceived as useful, reliable, and aligned with organizational needs. According to the Technology Acceptance Model (TAM), perceived usefulness and ease of use are primary determinants of adoption behavior (Davis, 1989). If contractors believe that technologies like BIM will streamline communication, enhance real-time data sharing, and reduce errors, they are more likely to adopt them. Likewise, compatibility with existing systems and interoperability among digital platforms also enhances adoption likelihood (Alami & El Idrissi, 2022).

H1*: Technological factors significantly influence the adoption of digital transformation among contractors in the UAE construction industry.*

5) Influence of organizational factors on digital transformation adoption

Organizational factors refer to internal structures, processes, and resources that shape a firm's readiness to engage in digital transformation. These factors include leadership commitment, human resource capability, financial resources, organizational strategy, and communication structures (Tornatzky & Fleischer, 1990). In the UAE construction context, the organizational climate is a critical success factor for driving change, especially in firms transitioning from traditional project management systems to agile and digitalized frameworks. Leadership plays a pivotal role in articulating digital visions, setting clear goals, and motivating employees to adopt new technologies (Ali Mohamad et al., 2023). Top management support ensures that the necessary investments in infrastructure, training, and change management are made. Without executive buy-in, digital initiatives often lack the momentum or funding needed to scale effectively. Moreover, employees' digital literacy and openness to learning also influence the pace and success of technology adoption (Abiodun et al., 2023).

In addition, the organizational structure, whether hierarchical or agile, affects how quickly digital tools are tested, implemented, and refined. Agile organizations with decentralized decision-making and responsive feedback loops are better positioned to adopt and adapt digital technologies (Adeosun et al., 2022). Conversely, rigid structures with bureaucratic inertia may delay or reject innovative solutions, even when the technical infrastructure exists. As such, the organizational ecosystem must be conducive to innovation for digital transformation to take root.

H2: *Organizational factors significantly influence the adoption of digital transformation among contractors in the UAE construction industry.*

6) Influence of Environmental factors on digital transformation adoption

The Environmental factors encompass external conditions that shape an organization's strategic and operational behavior. Within the TOE framework, the environment includes government regulations, industry competition, client expectations, supplier dynamics, and market uncertainty (Tornatzky & Fleischer, 1990). In the UAE construction sector, environmental pressures are notably strong due to national strategies like the UAE Vision 2021 and the UAE Green Agenda 2030, which emphasize digital innovation and sustainable infrastructure development. Government regulations and policies often mandate or incentivize the use of digital technologies to enhance project transparency, safety, and sustainability. For example, BIM is increasingly required in public construction tenders, making it a competitive necessity for contractors (Alizadehsalehi & Yitmen, 2023). Similarly, clients, particularly international or government-backed organizations, expect project partners to use advanced project management tools that provide real-time updates and integrated communication channels

(Abiodun et al., 2023). These expectations exert external pressure that pushes firms toward digital adoption, even if internal readiness is limited.

H3: *Environmental factors significantly influence the adoption of digital transformation among contractors in the UAE construction industry.*

7) Influence of digital transformation on sustainability outcomes

Digital transformation is not just a technological upgrade, it is a strategic shift that alters how construction projects are designed, managed, and delivered. In this study, digital transformation refers to the integration of digital technologies into core project operations, including planning, resource management, monitoring, and stakeholder communication. The adoption of such technologies has a direct and measurable impact on project sustainability, encompassing environmental, economic, and social dimensions (Mohamed Hashim et al., 2022). Technologies like BIM enhance project visualization and coordination, reducing rework and material waste. IoT devices allow real-time monitoring of energy use and environmental impact, while AI and data analytics enable smarter scheduling and resource optimization. Collectively, these tools contribute to the three pillars of sustainability: reducing the environmental footprint, improving economic efficiency, and enhancing worker safety and well-being (Alassafi et al., 2024). In this context, digital transformation becomes an enabler of sustainability by embedding performance monitoring and continuous improvement into everyday operations.

Furthermore, empirical studies have confirmed that firms undergoing digital transformation report higher levels of project sustainability, especially when supported by organizational alignment and policy frameworks (Ali Mohamad et al., 2023). Therefore, digital transformation is not only a technological outcome but a strategic means to achieve sustainable project goals. Its influence on sustainability is both direct and amplified by the firm's capacity to integrate digital tools into every stage of the construction lifecycle.

H4: *The adoption of digital transformation significantly influences sustainability outcomes in construction projects in the UAE.*

8) Digital transformation as a mediator

In this study, digital transformation is posited not only as a variable influenced by external and internal factors but also as a mediating variable that transmits the effects of technological, organizational, and environmental factors (TOE) to sustainability outcomes. Mediation occurs when an intermediate variable explains the mechanism through which an independent variable influences a dependent variable (Baron & Kenny, 1986). Applying this to the construction context, the hypothesis asserts that TOE factors influence sustainability performance through their effect on digital transformation adoption. The rationale for this hypothesis lies in the growing empirical evidence that supports the enabling role of digital transformation in sustainability. While the availability of technology, organizational support, and regulatory frameworks are essential, their impact on sustainability is not automatic. Instead, these factors must lead to the adoption and integration of digital technologies such as BIM, IoT, and AI to produce measurable sustainability outcomes (Alizadehsalehi & Yitmen, 2023; Mohamed Hashim et al., 2022).

For instance, an organization with strong technological infrastructure may only achieve sustainable performance if that infrastructure supports digital processes like automated energy tracking or lifecycle cost analysis. Similarly, external environmental pressure to reduce carbon emissions will only yield results if firms translate these pressures into digital practices. Therefore, digital transformation functions as a critical bridge, connecting enabling conditions with project-level sustainability impacts.

H5: *The adoption of digital transformation mediates the relationship between technological, organizational, and environmental factors and sustainability outcomes in construction projects.*

9) Organizational culture as moderator between technological factors and digital transformation

Organizational culture is proposed as a moderator that influences the strength or direction of the relationship between technological factors and digital transformation adoption. As a moderator, organizational culture does

not directly affect digital transformation but alters how much technological readiness contributes to its successful adoption. In firms where the culture promotes innovation, risk-taking, and continuous learning, even moderate levels of technology infrastructure can lead to effective digital implementation (Abiodun et al., 2023; Alami & El Idrissi, 2022). By contrast, in organizations with rigid, hierarchical, or change-resistant cultures, advanced technologies may be underutilized or rejected altogether. This misalignment can severely hinder digital transformation, regardless of how sophisticated the technological tools are. Thus, the presence of a supportive culture amplifies the positive effects of technological factors, whereas a resistant culture weakens the relationship.

This moderating role is supported by the Diffusion of Innovation theory, which emphasizes that organizational norms and values significantly impact how innovations spread within an entity (Rogers, 2003). In construction firms, especially those undergoing agile transitions, cultural openness to experimentation and feedback accelerates technology adoption. The UAE's construction industry, characterized by a mix of traditional practices and rapid modernization, makes this moderating effect especially pertinent.

H6: *Organizational culture moderates the relationship between technological factors and the adoption of digital transformation.*

10) Organizational culture as moderator between organizational factors and digital transformation

Organizational culture also plays a moderating role in the relationship between organizational factors and the adoption of digital transformation. While organizational factors such as leadership commitment, employee readiness, and resource availability are essential for driving innovation, their effectiveness depends on the broader cultural context of the organization. A culture that encourages collaboration, transparency, adaptability, and innovation enhances the influence of these organizational enablers on digital transformation adoption (Ali Mohamad et al., 2023; Adeosun et al., 2022). For instance, even in firms with highly competent leadership and well-funded IT departments, digital transformation efforts may stall if employees are risk-averse or reluctant to deviate from established routines. Conversely, in firms where culture supports open communication and learning, even modest organizational capabilities can result in successful digital adoption. Thus, organizational culture acts as a contextual force that determines whether leadership initiatives and internal resources are translated into transformative digital action.

This dynamic aligns with findings from the technology adoption literature, where supportive organizational culture has been identified as a facilitator of innovation diffusion, particularly in change-intensive sectors like construction (Abiodun et al., 2023). In agile project environments, the ability to iterate, adapt, and respond quickly to feedback is culturally driven. Therefore, assessing the moderating effect of culture provides a deeper understanding of why some firms outperform others in digital adoption, despite having similar structural resources.

H7: *Organizational culture moderates the relationship between organizational factors and the adoption of digital transformation.*

11) Organizational culture as moderator between environmental factors and digital transformation

Finally, organizational culture is proposed to moderate the relationship between environmental factors and the adoption of digital transformation. Environmental factors, such as regulatory mandates, client demands, and competitive pressures, often act as external motivators for adopting innovation. However, the extent to which these external stimuli lead to internal action depends largely on the firm's cultural disposition toward change and responsiveness (Tornatzky & Fleischer, 1990; Rogers, 2003). A firm with a culture that values compliance, innovation, and agility is more likely to respond positively to external digitalization pressures. In such environments, mandates for digital integration, like BIM adoption in public tenders, are embraced proactively. Conversely, in firms with traditionalist or reactive cultures, these pressures may be met with resistance or superficial compliance, undermining the transformative potential of digital tools (Alami & El Idrissi, 2022).In the UAE's dynamic construction market, where policy shifts and competitive dynamics are accelerating, cultural responsiveness becomes a key differentiator. Firms that embed agility and openness into their culture can better align with external change, thereby enhancing the impact of environmental factors on digital adoption.

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H8: *Organizational culture moderates the relationship between environmental factors and the adoption of digital transformation.*

B. The research framework

This framework illustrates the relationships between key factors influencing digital transformation adoption in sustainable construction projects in the UAE. The framework focuses on technology factors, organizational factors, and environmental factors, with organizational culture as a moderating variable affecting the relationship between these factors and digital transformation adoption. This approach recognizes that while technology, organizational resources, and external pressures drive digital transformation, the extent to which they influence adoption depends significantly on the prevailing organizational culture. Finally, there are four hypotheses identified in Fig. 1.

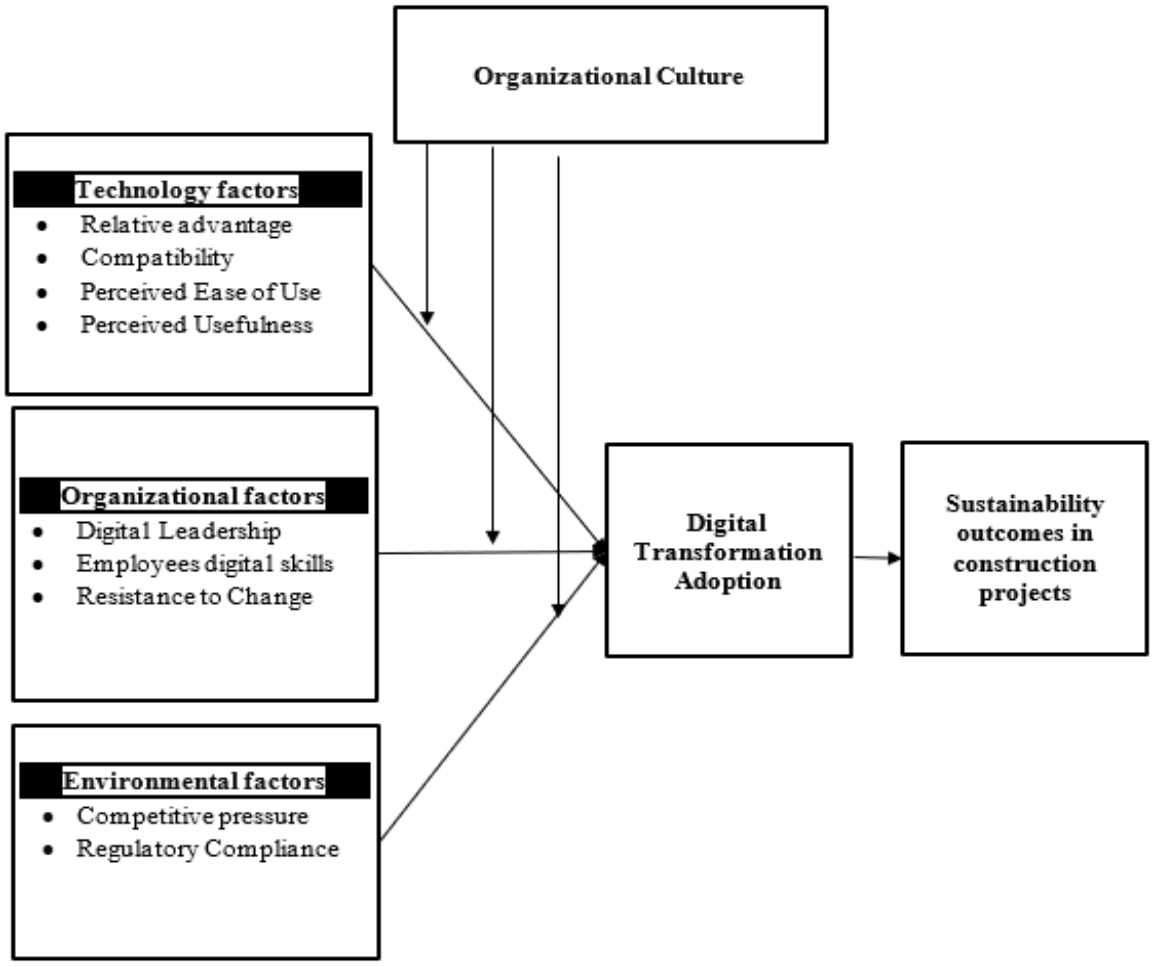

Fig. 1. Research framework

METHODOLOGY

In this research, A total of 500 questionnaires were distributed to contractors operating within the UAE construction industry, representing a cross-section of small, medium, and large enterprises. Out of these, 402 questionnaires were returned, yielding an overall response rate of 80.4%. However, after data screening, 31 questionnaires were identified as incomplete and were therefore excluded from further analysis. Consequently, 371 questionnaires were deemed valid and usable for statistical analysis, representing a usable response rate of 74.2%. The minimum sample size required for generalization was satisfied. Data collection was conducted over a six-week period. The completed responses were downloaded from the online data collection platform and analyzed using Smart PLS for structural equation modeling. The data were initially recorded and organized within the online platform according to the response structure before being exported for statistical analysis.

C. Demographic analysis

Table 1 shows the respondents profile for those who participated in the research. The results in Table 1 indicate that male respondents formed the majority at 60.9%, while female respondents accounted for 39.1%. This reflects the typical gender distribution within the construction industry, where male professionals tend to dominate operational and technical roles. In terms of age distribution, the majority of respondents (48.5%) were between 36 and 40 years old, followed by 31% aged above 40 years. This suggests that most participants are experienced professionals with substantial exposure to construction management practices and digital technologies. Regarding educational qualifications, a significant portion of the respondents held Master's degrees (60.6%), followed by PhDs (22.4%), Bachelor's degrees (13.7%), and Diplomas (3.2%). This indicates a well-educated workforce that is capable of understanding and implementing digital transformation initiatives within the construction sector. In terms of work experience, nearly half of the respondents (49.1%) had 4–6 years of experience, while 29.1% had more than 6 years. This distribution suggests that most participants possessed considerable practical experience, which enhances the reliability of their responses regarding digital transformation practices and sustainability implementation.

Table 1. Profile of Respondents (N = 371)

Demographic Variable	Category	Frequency	Percent (%)
Gender	Male	226	60.9
	Female	145	39.1
	Total	371	100
Age	20–25 years	9	2.4
	26–35 years	67	18.1
	36–40 years	180	48.5
	> 40 years	115	31
	Total	371	100
Education	Diploma	12	3.2
	Bachelor's	51	13.7
	Master's	225	60.6
	PhD	83	22.4
	Total	371	100
Experience	1–3 years	81	21.8
	4–6 years	182	49.1
	> 6 years	108	29.1
	Total	371	100

D. Measurement Model Evaluation

The research model analysis includes a detailed evaluation of the measurement model to ensure the constructs meet the criteria for reliability and validity. The process incorporates assessments of factor loadings, Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) to confirm that the measurement indicators adequately represent their respective constructs. The Cronbach's alpha values for all constructs exceed 0.70, ranging from 0.771 (EF) to 0.967 (TF), confirming excellent internal consistency (Nunnally & Bernstein, 1994). Similarly, the Composite Reliability (CR) values fall between 0.779 and 0.976, well above the 0.70 benchmark, suggesting that the items consistently measure their underlying constructs with minimal error variance (Hair et al., 2019; Sarstedt et al., 2022).. The Average Variance Extracted (AVE) values provide further evidence of convergent validity. All constructs Technology Factors (TF = 0.654), Organizational Factors (OF = 0.607), Environmental Factors (EF = 0.813), Digital Transformation (DT = 0.759), Organizational Culture (OC = 0.739), and Sustainability Outcomes (SO = 0.596) exceed the 0.50 threshold (Fornell & Larcker, 1981), indicating that more than 50% of the variance in their indicators is explained by the latent construct, again exceeding the threshold for acceptable convergent validity. All retained items demonstrated solid loading values, further supporting the unidimensionality and internal reliability of the construct. These improvements are further summarized in Table 2, which displays the loadings, Cronbach's alpha, CR, and AVE values for each construct in the final model.

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Table 2. Construct Reliability and Validity - Final Model measurements

	Loading	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
DT1	0.882	0.894	0.894	0.759
DT2	0.880			
DT3	0.879			
DT4	0.842			
EF7	0.914	0.771	0.779	0.813
EF8	0.889			
OC1	0.855	0.883	0.894	0.739
OC2	0.893			
OC3	0.859			
OC4	0.829			
OF1	0.801	0.944	0.976	0.607
OF10	0.792			
OF11	0.790			
OF12	0.762			
OF2	0.741			
OF3	0.782			
OF4	0.797			
OF5	0.796			
OF6	0.799			
OF7	0.785			
OF8	0.777			
OF9	0.720			
SO1	0.744	0.864	0.866	0.596
SO2	0.800			
SO3	0.790			
SO4	0.807			
SO5	0.773			
SO6	0.714			
TF1	0.828	0.967	0.963	0.654
TF10	0.800			
TF11	0.768			
TF12	0.735			
TF13	0.799			
TF14	0.875			
TF15	0.811			
TF16	0.749			
TF2	0.794			
TF3	0.860			
TF4	0.752			
TF5	0.800			
TF6	0.736			
TF7	0.874			
TF8	0.845			
TF9	0.886			

CR= Composite Reliability; AVE= Average Variance Extracted

E. Discriminate Validity

As displayed in Table 3, all HTMT values are below the conservative threshold of 0.85, confirming satisfactory discriminant validity across the constructs. The highest HTMT value is observed between Organizational

Factors (OF) and Technology Factors (TF) at 0.836, which is within the acceptable limit, indicating that while these two constructs are conceptually related as posited in the Technology–Organization–Environment (TOE) framework they remain empirically distinct (Tornatzky & Fleischer, 1990).

Moderate HTMT correlations are found between Environmental Factors (EF) and Organizational Culture (OC) (0.745), and between Environmental Factors (EF) and Digital Transformation (DT) (0.647), suggesting that external pressures and organizational readiness jointly influence digital adoption consistent with the theoretical model. Meanwhile, weaker correlations such as between Technology Factors (TF) and Digital Transformation (DT) (0.172), and between Organizational Factors (OF) and Environmental Factors (EF) (0.110), demonstrate adequate construct differentiation, ensuring that each latent variable captures a unique conceptual dimension.

These results confirm that the constructs do not exhibit multicollinearity or conceptual redundancy, thus fulfilling the discriminant validity requirement. The measurement model therefore satisfies the conditions of both convergent and discriminant validity, providing a solid foundation for subsequent structural model testing and hypothesis evaluation.

Table 3.The heterotrait-monotrait ratio of correlations (HTMT)

	DT	***EF***	***OC***	***OF***	***SO***	***TF***
DT						
EF	*0.647*					
OC	*0.605*	*0.745*				
OF	*0.213*	*0.110*	*0.268*			
SO	*0.424*	*0.462*	*0.323*	*0.267*		
TF	*0.172*	*0.136*	*0.202*	*0.836*	*0.320*	

TF: Technology Factors; OF: Organizational Factors; EF: Environmental Factors; DT: Digital Transformation; OC: Organizational Culture; SO: Sustainability Outcomes

F. Hypotheses Testing

Testing hypotheses is the most important test in the current research since it shows whether or not the goals of the research were met. Since there is a mediation in the current research, the direct effect test, and the indirect effect test will be used to examine the hypotheses. The following Fig. 2 shows the results of the direct effect test followed by some explanations.

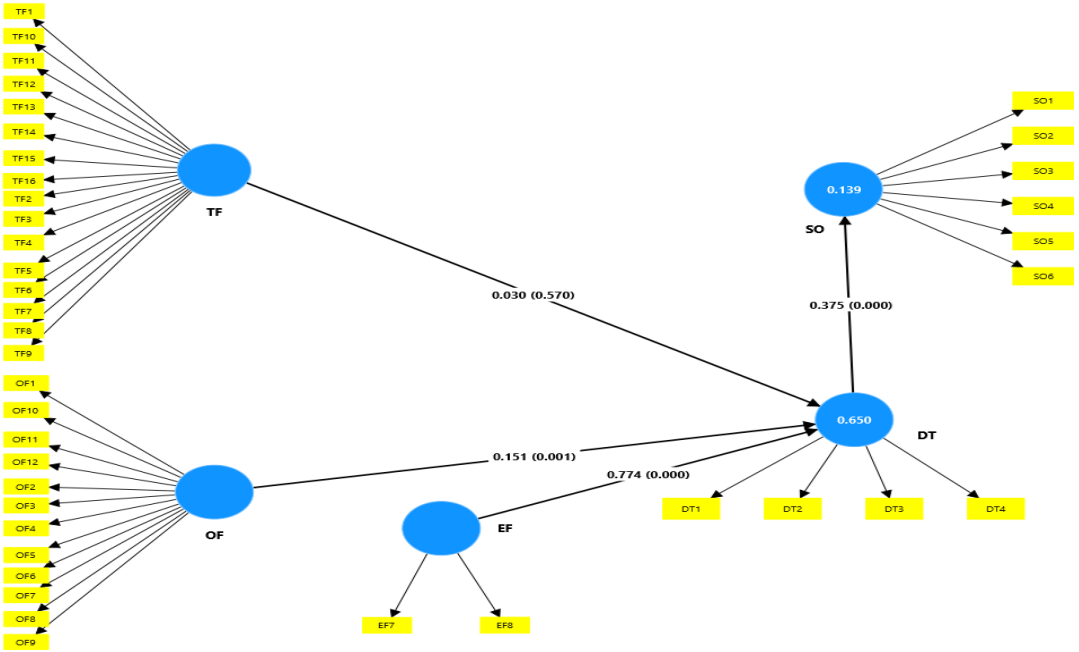

Fig. 2. Path Model Significance Results

Through the use of PLS-SEM, all of the research's hypotheses have been verified. A good match is suggested by the statistical finding. There are a total of eight hypotheses in the entire model. The t-value is taken into account when evaluating the structural relationships between the variables that have been identified for this research. In, the authors state that for a t-value to be deemed statistically significant, it must be 1.96 or above (one-tailed). The direct effect test, one sort of hypothesis testing, was employed in this research.

1) Hypothesis Testing (Direct Effect)

This section presents the result of hypotheses testing for direct effect. The direct effect test aims to examine the relationships between the independent variables and the dependent variable. The direct hypotheses (H1–H4) were evaluated through the bootstrapped path coefficients.

The analysis found that Technological Factors (H1) did not have a statistically significant influence on digital transformation ($\beta = 0.030$, $p = 0.570$), leading to the rejection of H1. This suggests that while the availability of technological infrastructure and tools exists, their mere presence does not necessarily translate into adoption unless accompanied by organizational and contextual support. This finding aligns with prior studies emphasizing that technology readiness alone is insufficient to drive transformation, as success depends on strategic alignment and human adaptability (Kane et al., 2019).

Conversely, Organizational Factors (H2) and Environmental Factors (H3) exhibited significant positive effects on Digital Transformation, with $\beta = 0.151$ ($p = 0.001$) and $\beta = 0.774$ ($p < 0.001$), respectively, leading to the acceptance of both hypotheses. These results indicate that organizational readiness, leadership commitment, and a supportive internal structure are crucial drivers of digital adoption (Ajibade, 2022). Furthermore, environmental dynamics such as competitive pressures, client expectations, and regulatory demands were found to be the strongest determinant of digital transformation in UAE construction firms consistent with the Technology–Organization–Environment (TOE) framework's postulation that external pressures strongly influence technological innovation decisions (Tornatzky & Fleischer, 1990; Adebowale & Agumba, 2023).

Regarding H4, the study confirmed that Digital Transformation significantly influences Sustainability Outcomes, though the relationship was negative ($\beta = 0.375$, $p < 0.001$). This result suggests that during the initial stages of digital adoption, sustainability performance may temporarily decline due to high implementation costs, resistance to change, and operational disruptions. However, previous literature indicates that the long-term effects of digital transformation eventually enhance sustainability by improving efficiency, reducing waste, and enabling data-driven decision-making (Ghobakhloo & Ching, 2019; Alassafi et al., 2024). Therefore, H4 is accepted, albeit with the understanding that the relationship is contextually dynamic and time-dependent as shown in Table 4.

Table 4. Direct Hypotheses

Hypotheses	Beta	Sample Mean (M)	SD	T statistics	P values	Decision
DT -> SO	0.375	0.379	0.041	9.108	0.000	Accepted
EF -> DT	0.774	0.771	0.026	30.203	0.000	Accepted
OF -> DT	0.151	0.144	0.045	3.338	0.001	Accepted
TF -> DT	0.030	0.048	0.053	0.568	0.570	Rejected

TF: Technology Factors; OF: Organizational Factors; EF: Environmental Factors; DT: Digital Transformation; OC: Organizational Culture; SO: Sustainability Outcomes

2) Hypothesis Testing (Mediation Effect)

The mediation analysis supports H5, showing that Digital Transformation mediates the relationships between organizational and environmental factors and sustainability outcomes, with significant indirect effects for EF → DT → SO ($\beta = 0.290$, $p < 0.001$) and OF → DT → SO ($\beta = 0.057$, $p = 0.001$). However, the mediation between TF → DT → SO was not significant ($\beta = 0.011$, $p = 0.596$), implying that technological readiness does not influence sustainability through digital transformation unless complemented by other drivers. These findings

reinforce the argument that digital transformation serves as a key mechanism through which organizational and environmental enablers contribute to sustainable development, validating H5 partially (Hair et al., 2021) as in Table 5.

Table 5. Mediation Testing (Indirect Effect)

Hypotheses	Beta	Sample Mean (M)	SD	T statistics	P values	Decision
EF -> DT -> SO	0.290	0.292	0.033	8.723	0.000	Accepted
OF -> DT -> SO	0.057	0.054	0.017	3.269	0.001	Accepted
TF -> DT -> SO	0.011	0.018	0.021	0.530	0.596	Rejected

TF: Technology Factors; OF: Organizational Factors; EF: Environmental Factors; DT: Digital Transformation; OC: Organizational Culture; SO: Sustainability Outcomes.

3) Hypothesis Testing (Moderation Effect)

The moderation analysis further explored the role of Organizational Culture (OC) in the model (H6–H8). Results indicate that OC significantly moderates the relationship between TF and SO ($\beta = 0.081$, $p = 0.036$), confirming H6. This demonstrates that a culture supportive of innovation and knowledge sharing strengthens the link between technological capacity and sustainable outcomes (Alieva & Powell, 2023). However, H7, which proposed that OC moderates the relationship between OF and SO, was rejected ($\beta = 0.031$, $p = 0.122$), suggesting that internal factors influence sustainability largely independent of cultural variations. Lastly, H8 was accepted, as OC significantly moderates the relationship between EF and SO ($\beta = 0.084$, $p < 0.001$), albeit in a negative direction, implying that strong organizational cultures may sometimes inhibit responsiveness to external environmental pressures due to established norms or rigid practices (Cameron & Quinn, 2011; Huy, 2011) as in Table 6.

Table 6. Moderation Testing (Indirect Effect)

Hypotheses	Beta	Sample Mean (M)	SD	T statistics	P values	Decision
OC x TF -> SO	0.081	0.007	2.250	0.036	0.000	Accepted
OC x OF -> SO	0.083	0.029	0.020	1.549	0.116	Rejected
OC x EF -> SO	0.222	0.086	0.017	4.865	0.000	Accepted

TF: Technology Factors; OF: Organizational Factors; EF: Environmental Factors; DT: Digital Transformation; OC: Organizational Culture; SO: Sustainability Outcomes.

RESULT AND DISCUSSION

The results of hypothesis testing provide a comprehensive understanding of the direct, mediating, and moderating relationships among the core constructs of the study Technology Factors (TF), Organizational Factors (OF), Environmental Factors (EF), Digital Transformation (DT), Sustainability Outcomes (SO), and Organizational Culture (OC) within the context of the UAE construction industry. The testing outcomes were derived from the structural model using the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach, in line with the recommendations of Hair et al. (2019).The results related to H1, H2, and H3 reveal the differential impacts of the TOE framework's antecedents on Digital Transformation (DT) adoption.

The results show that Environmental Factors (EF) exert the strongest and most significant influence on Digital Transformation ($\beta = 0.774$, $t = 30.203$, $p < 0.001$). This highlights the dominant role of external pressures such as regulatory requirements, client expectations, and market competitiveness in accelerating digital adoption. Recent studies confirm that environmental dynamism, policy direction, and institutional support serve as powerful catalysts for digital transformation, particularly in sectors undergoing rapid modernization such as construction (Nguyen, 2024; Piwowar-Sulej & Iqbal, 2024). These findings reflect the increasing emphasis placed on digital capability as a strategic response to evolving environmental demands.

Organizational Factors (OF) also demonstrate a significant positive effect on Digital Transformation ($\beta = 0.151$, $t = 3.338$, $p = 0.001$). This indicates that managerial commitment, resource readiness, and internal strategic alignment contribute meaningfully to successful digital adoption. Literature from 2024 underscores that leadership vision, collaboration structures, and the development of digital competencies are essential enablers that help organizations integrate new technologies effectively (Cosa, 2024; Omol, 2024). Although this influence is less pronounced than environmental forces, it reinforces the importance of organizational preparedness in digital transformation initiatives.

In contrast, Technology Factors (TF) show no significant effect on Digital Transformation ($\beta = 0.030$, $t = 0.568$, $p = 0.570$), leading to the rejection of the corresponding hypothesis. This finding suggests that the mere availability of digital tools, platforms, and technical infrastructure does not guarantee their effective adoption. As recent research indicates, technology readiness is often overshadowed by internal cultural, managerial, and environmental factors that determine whether digital tools are meaningfully utilized (Holopainen et al., 2024). This underscores that digital transformation is not driven solely by technological capability but by the broader organizational and contextual ecosystem.

The path from Digital Transformation (DT) to Sustainability Outcomes (SO) is significant and positive ($\beta = 0.375$, $t = 9.108$, $p < 0.001$), indicating that increased adoption of digital technologies contributes to improved sustainability outcomes within construction projects. This aligns with contemporary evidence showing that digital transformation enhances operational transparency, resource efficiency, and sustainability performance across project lifecycles (Johnstone, 2024; Ebekozien et al., 2024). The results suggest that as organizations embrace digital processes more extensively, they are better positioned to achieve environmental and operational sustainability targets.

The findings establish that Environmental and Organizational Factors are the principal drivers of Digital Transformation in the UAE construction sector, whereas Technology Factors alone are insufficient without supportive organizational and contextual conditions. Moreover, Digital Transformation significantly enhances Sustainability Outcomes, reinforcing its strategic value in promoting more sustainable construction practices. These insights emphasize the need for firms to strengthen their institutional responsiveness, leadership engagement, and digital capability development to maximize the benefits of digital transformation.

The results reveal that Environmental Factors (EF) exert a significant indirect effect on Sustainability Outcomes (SO) via Digital Transformation (DT), with a path coefficient of $\beta = 0.290$, $t = 8.723$, and $p < 0.001$. This indicates that DT acts as a substantial mediator between EF and SO, suggesting that external drivers such as regulatory expectations, client requirements, market competition, and pressure for innovation promote digital adoption, which in turn enhances sustainability-related performance. This finding is consistent with recent evidence that environmental and institutional pressures are powerful catalysts for digital transformation, particularly in sectors undergoing modernization and sustainability transitions (Nguyen, 2024; Cosa, 2024). In the context of the UAE construction industry, this implies that policies, standards, and stakeholder expectations surrounding sustainability and smart construction practices are translated into tangible sustainability outcomes primarily when contractors actively embrace digital transformation initiatives.

The indirect relationship between Organizational Factors (OF) and Sustainability Outcomes (SO) through Digital Transformation (DT) is also significant, with $\beta = 0.057$, $t = 3.269$, and $p = 0.001$. This finding confirms that DT partially mediates the link between internal organizational readiness and sustainability performance. Organizations that exhibit strong leadership support, clear digital strategies, investment in human capital, and robust internal processes are more likely to implement digital technologies in ways that deliver measurable sustainability benefits. Recent studies highlight that when digital transformation is anchored in organizational capabilities and change-oriented management, firms are better positioned to optimize resource use, improve process transparency, and support long-term sustainability goals (Omol, 2024; Peter et al., 2024; Holopainen et al., 2024). In construction, this may manifest through data-driven project monitoring, improved coordination, and more efficient management of materials and energy, which together contribute to sustainability outcomes in line with national development agendas (Ebekozien et al., 2024; Piwowar-Sulej & Iqbal, 2024).

Conversely, the mediation path between Technology Factors (TF) and Sustainability Outcomes (SO) via Digital Transformation (DT) is insignificant ($\beta = 0.011$, $t = 0.530$, $p = 0.596$), leading to the rejection of this indirect

effect. This result implies that having access to digital tools, platforms, or infrastructure alone does not automatically translate into improved sustainability performance through DT. Without supportive organizational conditions and external stimuli, technological readiness remains underutilized and may not drive meaningful change in project sustainability. This aligns with recent work emphasizing that technology must be embedded within coherent strategies, governance structures, and cultural practices to yield tangible operational or environmental benefits (Johnstone, 2024; Omol, 2024).

These mediation results affirm that Digital Transformation (DT) acts as a key mediating mechanism linking organizational and environmental determinants to sustainability outcomes, while the technological dimension alone is insufficient to produce such effects. In line with contemporary applications of the Technology–Organization–Environment (TOE) perspective, the findings demonstrate that sustainable value emerges when external pressures and internal capabilities jointly channel through effective digital transformation, reinforcing the importance of strategically managed digital initiatives for advancing sustainability in the UAE construction sector (Nguyen, 2024; Cosa, 2024; Peter et al., 2024).

The interaction between Organizational Culture (OC) and Technology Factors (TF) demonstrates a positive and significant moderating effect on Sustainability Outcomes (SO) ($\beta = 0.081$, $t = 2.250$, $p = 0.036$). This indicates that organizations with a supportive, collaborative, and innovation-oriented culture are more effective at leveraging technological readiness to enhance sustainability results. This is consistent with recent findings emphasizing that culture serves as a catalyst that enables firms to translate technological capability into operational and environmental improvements, particularly in digitally advancing sectors (Holopainen et al., 2024; Omol, 2024). A culture that promotes continuous learning and openness to digital tools therefore strengthens the capacity of construction firms to utilize technology for sustainable development.

However, the moderating effect of Organizational Culture on the relationship between Organizational Factors (OF) and Sustainability Outcomes (SO) is not significant ($\beta = 0.031$, $t = 1.549$, $p = 0.122$), leading to the rejection of this hypothesis. This suggests that internal organizational enablers such as leadership support, managerial readiness, and resource alignment affect sustainability outcomes directly, regardless of cultural variations. The result implies that even in the presence of a strong organizational culture, these internal factors operate independently and consistently, reflecting the structured and hierarchical nature of construction organizations, where managerial systems maintain influence irrespective of cultural shifts (Ebekozien et al., 2024). Thus, the influence of organizational readiness on sustainability remains stable and culture-independent within this context.

Conversely, the interaction between Organizational Culture (OC) and Environmental Factors (EF) shows a significant negative moderating effect on Sustainability Outcomes (SO) ($\beta = -0.084$, $t = 4.865$, $p < 0.001$). This indicates that in situations where environmental pressures such as regulatory requirements or market volatility intensify, a strong or rigid organizational culture may reduce the responsiveness of firms to these external demands. This outcome aligns with arguments that certain cultural norms, particularly those emphasizing stability or tradition, can create organizational inertia that hampers adaptive responses to external sustainability drivers (Nguyen, 2024; Johnstone, 2024). In such contexts, strong culture may restrict flexibility, limiting the extent to which environmental triggers can translate into improved sustainability performance.

The moderation analysis reveals that Organizational Culture plays a nuanced and dual role: it amplifies the effect of technological readiness on sustainability but may also dampen the influence of environmental pressures when cultural rigidity is present. These findings highlight the importance of cultivating a balanced cultural environment one that fosters digital openness and innovation while remaining adaptable to evolving external sustainability requirements. In doing so, construction firms in the UAE can better support sustainable digital transformation and optimize the benefits of technological, organizational, and environmental drivers.

Limitations And Future Research

Despite offering valuable insights into digital transformation and sustainability within the UAE construction industry, this study is subject to several limitations that warrant careful consideration.

First, the study adopts a cross-sectional research design, capturing organizational perceptions and practices at a single point in time. While this design is appropriate for examining structural relationships among technological,

organizational, environmental, and cultural variables, it constrains the ability to infer temporal dynamics or causal sequencing. Second, the contextual focus on contractors operating within the UAE construction industry restricts the external generalizability of the findings. Third, the study relies primarily on self-reported perceptual survey data collected from construction professionals. Although validated measurement scales and robust analytical procedures were employed to enhance reliability and construct validity, perceptual data remain susceptible to response bias, social desirability effects, and common method variance. Fourth, the study is limited by the absence of objective and longitudinal performance indicators, especially with respect to sustainability outcomes.

Building on the study's findings and the limitations identified above, several methodologically grounded directions for future research are proposed.

First, future studies should employ longitudinal research designs to examine how digital transformation and sustainability outcomes evolve over time. Longitudinal approaches such as panel surveys, repeated measures, or time-lagged designs would allow researchers to capture learning effects, adjustment phases, and delayed performance benefits associated with digital transformation. Second, comparative cross-national or cross-regional studies are needed to test the contextual robustness of the findings. Given the strong influence of environmental factors identified in the UAE context, future research could compare digital transformation dynamics across different regulatory regimes, such as other Gulf Cooperation Council (GCC) countries, emerging economies, or liberalized construction markets. Third, future research would benefit from mixed-method research designs that integrate quantitative modeling with qualitative inquiry. While the present study identifies statistically significant relationships and interaction effects, qualitative methods such as in-depth interviews, case studies, or ethnographic observation could provide richer insight into the underlying mechanisms driving these relationships.

CONCLUSION

This study highlights the critical role of digital transformation as a bridge connecting agile project management to improved performance outcomes. Furthermore, organizational culture significantly influences the effectiveness of this relationship. In the UAE's rapidly evolving business environment, aligning agile practices with digital capabilities and supportive cultural frameworks is essential for achieving sustainable success.

This study makes a substantive contribution to the understanding of digital transformation and sustainability within the construction industry by empirically demonstrating that digital transformation is fundamentally a strategic and organizational journey rather than a purely technical undertaking. By integrating the Technology–Organization–Environment framework with mediation and moderation mechanisms, the research advances knowledge on how external pressures, internal capabilities, and cultural conditions interact to shape digital transformation adoption and sustainability outcomes. The findings reaffirm that environmental forces are the primary catalyst for digital transformation in the UAE construction sector, organizational factors enable effective implementation, and technological readiness alone is insufficient to drive meaningful transformation or sustainable performance.

Implications Of The Research

The findings yield several actionable implications for contractors and project managers operating in the UAE construction industry.

The study demonstrates that organizational readiness and leadership commitment are more decisive than technology acquisition in enabling digital transformation. Senior executives and project directors should therefore prioritize governance and accountability mechanisms that embed digital transformation into strategic and operational decision-making.

Contractors should invest in human-centered change management rather than focusing exclusively on technical training. HR departments and project leadership teams should jointly design capability development programs that combine digital skills training with change readiness, collaboration practices, and sustainability literacy.

Over the long term, firms should align promotion criteria and incentive systems with demonstrated engagement in digital and sustainability initiatives to reinforce behavioral alignment.

The study also carries significant implications for policymakers and regulators, particularly given the dominant role of environmental factors in driving digital transformation.

First, the findings confirm that regulatory pressure is an effective catalyst for digital transformation in the UAE construction sector. Ministries, municipal authorities, and sectoral regulators should therefore continue to embed digital requirements within procurement regulations, sustainability reporting frameworks, and project approval processes. In the short term, this includes standardizing digital compliance requirements (e.g., BIM usage, digital reporting formats) across public-sector projects to reduce ambiguity and signal regulatory consistency.

Second, the results highlight the need to complement regulatory pressure with enabling incentives, particularly for small and medium-sized contractors. In the medium term, policymakers should expand incentive mechanisms such as subsidized digital training programs, shared digital infrastructure platforms, and preferential scoring in tenders for demonstrated digital readiness. These instruments reduce transition risk and prevent regulatory pressure from disproportionately disadvantaging SMEs.

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