

Digital Transformation Capability and Construction Project Success: A Mixed-Methods Study of Data Integration, Organizational Agility, and Project Resilience

Tohid Karami[1*]

[1] M.Sc., Department of Civil Engineering – Surveying (Remote Sensing Specialization), ST.C., Islamic Azad University, Tehran, Iran

*** Corresponding author email address**: Tohid.karami@iau.ir

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Abstract

This study aimed to examine the direct and indirect effects of digital transformation capability on construction project success and to determine the mediating roles of data integration, organizational agility, and project resilience among construction professionals in Tehran. An explanatory sequential mixed-methods design was employed. In the quantitative phase, 384 construction professionals from construction companies, consulting firms, contractors, and project management organizations in Tehran completed a structured questionnaire measuring digital transformation capability, data integration, organizational agility, project resilience, and construction project success. The measurement model was assessed using reliability, convergent validity, discriminant validity, and confirmatory factor analysis, followed by structural equation modeling and bootstrap mediation analysis with 5,000 resamples. In the qualitative phase, 24 experienced professionals were selected purposively for semi-structured interviews, and thematic analysis was conducted to explain and contextualize the quantitative findings. Digital transformation capability significantly predicted data integration ($\beta = .71$, $p < .001$), organizational agility ($\beta = .66$, $p < .001$), project resilience ($\beta = .60$, $p < .001$), and construction project success ($\beta = .22$, $p < .001$). Data integration ($\beta = .21$, $p = .001$), organizational agility ($\beta = .24$, $p < .001$), and project resilience ($\beta = .33$, $p < .001$) each significantly predicted project success. Significant indirect effects were observed through data integration ($\beta = .149$, 95% CI [.084, .225]), organizational agility ($\beta = .158$, 95% CI [.091, .239]), and project resilience ($\beta = .198$, 95% CI [.126, .288]). The model explained 64.8% of the variance in project success. Qualitative findings supported these pathways by highlighting integrated project visibility, accelerated responsiveness, digitally enabled resilience, and supportive organizational conditions. Digital transformation capability contributes to construction project success both directly and indirectly, particularly by strengthening data integration, organizational agility, and project resilience, with resilience emerging as the strongest mediating mechanism.

Keywords: *Digital Transformation Capability; Construction Project Success; Data Integration; Organizational Agility; Project Resilience; Mixed-Methods; Construction Management*

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1. Introduction

The construction industry is undergoing a profound transition as digital technologies increasingly reshape how projects are planned, coordinated, monitored, and delivered. Construction projects are inherently characterized by organizational fragmentation, temporary coalitions of multiple stakeholders, interdependent workflows, high capital intensity, schedule sensitivity, and substantial exposure to environmental, technical, financial, and supply-related uncertainty. Under these conditions, conventional project management practices based on isolated information systems, delayed reporting, and functionally separated decision structures may be insufficient to maintain consistent performance. Digital transformation has consequently become a strategic priority for project-based organizations seeking to improve visibility, coordination, responsiveness, and adaptability across complex project environments. More broadly, contemporary strategic

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management research increasingly considers digitalization not merely as the implementation of discrete technologies but as an organizational transformation process involving capabilities, structures, leadership, decision systems, information flows, and organizational culture [1]. This perspective is particularly relevant to construction, where the value of digital technologies depends not simply on adoption but on whether organizations can translate technological resources into integrated and adaptive project capabilities.

Digital transformation capability can be understood as an organization's capacity to acquire, assimilate, integrate, deploy, and continuously reconfigure digital technologies and associated managerial practices in response to changing environmental and operational requirements. From a dynamic capabilities perspective, competitive and operational advantages arise when organizations are able not only to possess resources but also to sense changes, seize emerging opportunities, and reconfigure resources and processes accordingly. Recent research has increasingly linked digital leadership, digital readiness, analytics, artificial intelligence, and platform capabilities with superior organizational performance and enhanced adaptability [2, 3]. Digital capabilities can enable more rapid information processing, improve managerial visibility, support evidence-based decisions, and facilitate coordinated responses across organizational boundaries. At the same time, the strategic effects of digital transformation are not automatic. Their realization depends on organizational mechanisms that translate technological resources into meaningful changes in decision-making, workflow coordination, learning, and operational execution.

One particularly important mechanism is data integration. Construction projects generate substantial quantities of information through design, procurement, scheduling, budgeting, site operations, quality control, safety management, logistics, and stakeholder communication. When these data remain fragmented across departments, contractors, consultants, and incompatible information systems, managers may face delayed, inconsistent, or incomplete information. Such fragmentation can hinder timely decision-making and increase the risk of coordination failures. In contrast, integrated digital environments can support a more unified representation of project conditions by connecting information from multiple functions and organizational actors. This is increasingly important as organizations move toward analytics-based and artificial intelligence-assisted decision systems. Research on AI-powered business analytics indicates that advanced analytics can enhance organizational agility and competitive positioning by increasing the speed and quality of organizational interpretation and response [4]. Similarly, analytics-enabled supply chain systems can strengthen resilience when information visibility is combined with organizational agility and active top-management participation [5]. These findings suggest that the strategic contribution of digital transformation may depend substantially on the capacity to connect data, systems, and decision processes rather than on technology acquisition alone.

The importance of integration is also reflected in research on organizational ambidexterity and performance under disruption. Organizations must simultaneously exploit existing capabilities and explore new approaches when environmental conditions become unstable. Integration mechanisms can facilitate this balance by enabling cross-functional coordination and more coherent allocation of organizational resources. Rahman et al. demonstrated the importance of integration and agility in improving organizational performance under supply chain disruption, emphasizing that integrated capabilities help organizations respond more effectively when established routines are challenged [6]. Likewise, research concerning Industry 4.0 technologies and dynamic capabilities has highlighted the importance of combining advanced technological infrastructure with organizational capabilities in order to improve sustainable supply chain performance [7]. These insights are directly applicable to construction projects, where project success frequently depends on whether organizations can integrate design information, procurement data, cost information, scheduling data, and site-level observations into coherent and actionable managerial knowledge.

A second critical mechanism through which digital transformation may affect construction project outcomes is organizational agility. Organizational agility refers to the capacity to detect changes, make timely decisions, reconfigure resources, coordinate organizational units, and respond rapidly to emerging opportunities and threats. Agility has become increasingly important in environments characterized by uncertainty, turbulence, technological change, and changing stakeholder expectations. Research across different industries has shown that organizational resources and dynamic capabilities can substantially shape agility [8], while digital agility has been described as a distinct organizational capacity through which digital resources facilitate flexible and rapid strategic responses [9].

In practical terms, digital systems can reduce the time required to collect and distribute information, improve communication across functional boundaries, and enable managers to revise decisions on the basis of near-real-time project conditions.

The strategic importance of agility has been demonstrated in several organizational contexts. Probojakti et al. identified organizational agility as a central mechanism for building sustainable competitive advantage [10], while related research showed that transformational leadership and digital transformation can jointly strengthen agility and corporate resilience [11]. Studies of workplace culture likewise indicate that cultural conditions influence organizational performance and agility, underscoring that responsiveness is shaped by social and managerial factors in addition to technological resources [12]. During periods of crisis, employees' perceptions of strategic agility can also influence engagement and well-being, suggesting that agility has both operational and human dimensions [13]. Systematic evidence from the healthcare context similarly indicates that agility is multidimensional and should be understood as a broader organizational capacity rather than merely a rapid operational response [14]. Taken together, these studies suggest that in construction organizations, digital transformation may enhance project success when digital tools are converted into faster coordination, more flexible decision processes, and stronger capacity to respond to changing project requirements.

However, agility alone may not be sufficient in highly uncertain project environments. Construction organizations must also develop resilience, defined broadly as the capacity to anticipate, absorb, adapt to, and recover from disruptions while maintaining essential functions and objectives. The concepts of agility and resilience are related but distinct. Agility emphasizes speed, flexibility, and responsiveness, whereas resilience additionally encompasses preparedness, continuity, recovery, learning, and adaptation under adverse conditions. Their interaction has been increasingly emphasized in research on global supply chains and dynamic environments [15]. Supply chain research has also demonstrated that agile strategies and resilient capabilities can jointly support organizational performance under volatile conditions [16]. This distinction is especially important for construction projects, which frequently face material shortages, price volatility, design changes, contractor delays, regulatory changes, labor constraints, and unexpected technical conditions.

Organizational resilience has therefore become a central concern in contemporary management research. Studies conducted across different sectors indicate that resilience emerges from combinations of human, strategic, technological, and organizational resources. Talent management practices, for example, can strengthen organizational resilience by enhancing the availability and adaptability of human resources [17]. Inclusion management practices can also contribute to resilience during periods of crisis by improving organizational capacity to respond to uncertainty through more effective use of human resources [18]. Reviews of resilience during the COVID-19 pandemic have further demonstrated that organizational resilience has important implications for employees and organizational continuity [19]. More generally, business resilience planning provides organizations with structured mechanisms for confronting turbulence and sustaining critical operations during periods of instability [20]. These findings reinforce the view that resilience is not a single reaction to crisis but a broader organizational capability involving preparation, adaptation, recovery, and learning.

Recent studies increasingly connect digital transformation with resilience. Digital technologies can support resilience by improving environmental sensing, information availability, scenario analysis, communication, coordination, and decision quality. Alaskar showed that AI-driven decision-making and digital platform capabilities can contribute to firm resilience, highlighting the importance of digital information processing in strengthening adaptive capacity [21]. Similarly, digital transformation has been linked to organizational resilience through strategic agility, with digital leadership influencing the strength and sustainability of these relationships [22]. Research adopting hybrid modeling approaches has likewise emphasized that resilience develops through interconnected institutional and technological mechanisms rather than through digital transformation in isolation [23]. These arguments suggest that the effect of digital transformation on construction project success may operate through improved capacity to recognize disruption signals, coordinate responses, and maintain continuity under adverse conditions.

The broader literature on resilience and strategic renewal also emphasizes the importance of dynamic capabilities. During organizational crises, turnaround strategies are more effective when firms can reconfigure resources and mobilize capabilities in response to changing conditions [24]. Organizational dynamism, creativity, and agility can likewise foster resilience by enabling institutions to adapt

rather than remain dependent on rigid routines [25]. Environmental scanning provides another important resilience mechanism because organizations that systematically detect changes in their external environment are better positioned to anticipate threats and preserve competitive advantage [26]. Strategic mastery under uncertain conditions similarly requires continuous adjustment of organizational resources and priorities rather than reliance on static planning systems [27]. In construction projects, these capabilities are particularly consequential because unexpected events can quickly propagate across schedules, budgets, supply systems, and stakeholder relationships.

Leadership represents another critical condition shaping whether digital transformation produces agility and resilience. Organizational transformation requires leaders who can interpret uncertainty, mobilize resources, support experimentation, and encourage coordinated adaptation. Contemporary leadership research increasingly describes organizational environments as conditions of persistent turbulence in which leaders must simultaneously provide direction, maintain flexibility, and facilitate learning [28]. Digital leadership extends these responsibilities by incorporating technological understanding and the ability to connect digital strategy with organizational capabilities. Evidence suggests that digital leadership can strengthen sustainable performance and resilience through agility, reinforcing the mediating role of adaptive organizational processes [2]. Strategic digital leadership is similarly associated with digitalization, organizational culture, agility, and superior performance [1]. These findings indicate that construction organizations cannot assume that technological investments will automatically yield project benefits unless leadership and organizational arrangements support the effective use of digital resources.

The increasing integration of artificial intelligence into organizational systems further amplifies these issues. Emerging research suggests that AI-driven systems can decentralize decision processes, improve operational responsiveness, and support new forms of technologically enabled coordination [29]. AI-related capabilities are also increasingly conceptualized as contributors to strategic agility and resilience, particularly in smaller and resource-constrained firms [30]. Yet the effectiveness of such systems remains dependent on human readiness, adaptive performance, and organizational resilience [3]. Even financial and executive capabilities may become relevant during periods of recovery, as organizational leaders require combinations of analytical, strategic, and adaptive skills to navigate post-crisis environments [31]. Therefore, the relationship between digital transformation and project success should be examined as a multidimensional capability system in which technology, data, organizational processes, leadership, and human competencies interact.

Despite growing research on digital transformation, agility, resilience, dynamic capabilities, and technology-enabled performance, important gaps remain. Much of the existing literature has examined these constructs in manufacturing, healthcare, banking, hospitality, higher education, supply chains, or general business environments rather than within construction projects. This limits the extent to which existing findings can be transferred directly to construction because project-based organizations differ substantially from permanent organizations in their temporary structures, interorganizational dependencies, contractual complexity, and fragmented information environments. In addition, previous studies frequently examine digital transformation, organizational agility, or resilience separately, although contemporary evidence increasingly suggests that these capabilities operate as interdependent mechanisms. Research on AI-driven decision systems, supply chain analytics, strategic agility, and resilient performance points toward a more integrated explanation in which digital capability enhances organizational outcomes through information integration, adaptive responsiveness, and resilience [5, 21, 30].

A further limitation is that quantitative models alone may identify statistical relationships without adequately explaining how these relationships are realized in everyday project environments. For construction organizations, it is important to understand not only whether digital transformation capability predicts project success, but also how integrated data improve coordination, how digital systems increase organizational agility, how they contribute to resilience under disruption, and what organizational barriers may prevent digital investments from generating expected benefits. A mixed-methods design is therefore particularly appropriate because it allows quantitative testing of direct and indirect relationships while also using qualitative evidence to clarify the practical mechanisms underlying those relationships. Such integration is consistent with contemporary conceptualizations of organizational transformation as a complex process shaped by technology, leadership, culture, information, and adaptive capability rather than as a single technological intervention [25, 29].

Accordingly, the aim of this study was to examine the direct and indirect effects of digital transformation capability on construction project success and to explain the mediating roles of data integration, organizational agility, and project resilience through a mixed-methods investigation of construction professionals in Tehran.

2. Methodology

This study employed a mixed-methods design to investigate the relationship between digital transformation capability and construction project success, with particular attention to the roles of data integration, organizational agility, and project resilience. An explanatory sequential mixed-methods approach was adopted, consisting of a quantitative phase followed by a qualitative phase. The quantitative phase was designed to examine the direct and indirect relationships among the study variables and test the proposed conceptual model, whereas the qualitative phase was conducted to provide a deeper explanation of the quantitative findings and clarify the organizational and project-level mechanisms through which digital transformation capabilities contribute to successful construction project outcomes. The study population consisted of professionals involved in construction projects in Tehran, Iran, including project managers, construction managers, site managers, civil engineers, project control specialists, information technology and digital transformation specialists, consultants, contractors, and senior technical or administrative personnel working in construction companies and project-based organizations. Participants were required to have at least three years of professional experience in the construction industry, direct involvement in the planning, execution, monitoring, or management of construction projects, and sufficient familiarity with the organizational processes and digital technologies used in their organizations. Individuals whose responsibilities were unrelated to project management, construction operations, organizational decision-making, or digital systems were excluded from the study. For the quantitative phase, 420 questionnaires were distributed using a purposive and convenience sampling strategy across construction companies, engineering consulting firms, contractors, and project management organizations operating in Tehran. After eliminating incomplete questionnaires and responses with substantial missing data or evident response-pattern irregularities, 384 valid questionnaires were retained for statistical analysis. The final quantitative sample therefore consisted of 384 construction professionals. Participants represented different organizational positions and levels of professional experience, thereby providing perspectives from both managerial and operational levels of construction projects. Following completion of the quantitative analysis, purposive maximum-variation sampling was used to select participants for the qualitative phase. Twenty-four professionals with substantial experience in construction project management, organizational digitalization, project control, data management, risk management, or organizational transformation were interviewed. Selection of the qualitative participants was intended to capture a range of organizational roles, professional experiences, company sizes, and levels of digital maturity. Interviews continued until theoretical and thematic saturation was achieved, meaning that additional interviews no longer generated substantively new concepts regarding the relationships among digital transformation capability, data integration, organizational agility, project resilience, and project success. All participants were informed about the objectives and procedures of the research before participation, and participation was voluntary. Confidentiality and anonymity were maintained throughout data collection and analysis, and participants were informed that they could discontinue their participation at any stage without consequence.

Data collection in the quantitative phase was conducted using a structured questionnaire composed of demographic and professional characteristics and multi-item measures of digital transformation capability, data integration, organizational agility, project resilience, and construction project success. All substantive constructs were measured using five-point Likert-type scales ranging from 1, indicating strongly disagree, to 5, indicating strongly agree. The digital transformation capability measure assessed the extent to which construction organizations possessed the strategic, technological, managerial, and human capabilities required to adopt, integrate, and exploit digital technologies within their projects and organizational processes. The items covered dimensions such as digital strategic orientation, management commitment to digital transformation, availability of technological infrastructure, employee digital competence, integration of digital tools into project workflows, capability for technology-based process redesign, and the organizational ability to convert digital investments into operational and managerial improvements. Data integration was assessed in terms of the organization's capacity to collect, connect, exchange, standardize, and

utilize project information across different functional units, organizational systems, and project stakeholders. The items examined the integration of information generated by planning, design, procurement, financial, engineering, site management, and project control functions; interoperability among digital systems; real-time accessibility of reliable project information; reduction of fragmented information environments; and the ability of decision-makers to obtain a unified view of project data. Organizational agility was measured through items addressing responsiveness, flexibility, rapid decision-making, cross-functional coordination, resource reconfiguration, and the organization's ability to identify and react effectively to changes in project conditions, client requirements, technological developments, supply conditions, and environmental uncertainties. Project resilience was operationalized as the capacity of a construction project and its management system to anticipate, absorb, adapt to, and recover from disruptions while maintaining essential project functions and objectives. Its indicators included preparedness for unexpected events, adaptive problem solving, continuity of critical project activities, rapid recovery from disruptions, flexible allocation of resources, learning from adverse events, and the ability to maintain project performance under uncertain or changing conditions. Construction project success was assessed as a multidimensional outcome rather than exclusively through the traditional criteria of cost, time, and quality. Accordingly, the measure addressed adherence to planned schedules and budgets, achievement of required quality and technical standards, stakeholder and client satisfaction, achievement of project objectives, effective resource utilization, safety and operational performance, and the perceived overall success of the project.

The questionnaire items were adapted from established conceptualizations and empirical measures reported in the digital transformation, information systems, organizational agility, project resilience, and project management literature and were modified where necessary to ensure their applicability to the construction industry. Content validity was evaluated by a panel of eight experts consisting of university faculty members in construction management and project management, senior construction project managers, and specialists with experience in organizational digital transformation. The experts assessed the relevance, clarity, comprehensiveness, and contextual appropriateness of the questionnaire items, and minor modifications were made to eliminate ambiguous expressions and improve their correspondence with construction project practices. A pilot study involving 35 construction professionals who were not included in the final sample was subsequently conducted to evaluate the clarity and preliminary reliability of the questionnaire. Internal consistency was examined using Cronbach's alpha, with coefficients of .70 or higher considered acceptable. Construct reliability and validity were subsequently reassessed in the main sample using composite reliability, average variance extracted, factor loadings, and discriminant validity criteria. For the qualitative component, data were collected through semi-structured, in-depth interviews. The interview guide was developed on the basis of the quantitative results and the conceptual framework of the study. Participants were asked to explain how digital technologies had altered project planning, coordination, monitoring, communication, and decision-making; how integrated project data influenced managerial decisions; how digital transformation affected organizational responsiveness and flexibility; how digital systems contributed to the anticipation and management of project disruptions; and under what organizational conditions digital transformation improved or failed to improve project success. Additional probing questions were used to explore practical experiences with fragmented information systems, resistance to technological change, digital competencies, interoperability, leadership support, real-time project monitoring, supply-chain disruptions, uncertainty, and organizational learning. Interviews were conducted individually in a confidential setting, lasted approximately 45 to 70 minutes, and were audio-recorded with participants' permission. Audio recordings were transcribed verbatim, anonymized, and reviewed against the original recordings to ensure transcription accuracy before qualitative analysis.

Quantitative data were analyzed using SPSS and structural equation modeling software. Prior to hypothesis testing, the dataset was screened for completeness, data-entry errors, univariate and multivariate outliers, and the distributional characteristics of the measured variables. Missing data were evaluated before analysis, and questionnaires containing substantial missing responses were excluded. Descriptive statistics, including frequencies, percentages, means, and standard deviations, were calculated to summarize participants' demographic and professional characteristics and the distribution of the principal study variables. The assumptions required for multivariate analysis were examined through measures of skewness and kurtosis, assessment of linear relationships,

inspection of residuals, and evaluation of multicollinearity using tolerance and variance inflation factor values. Common method bias was also assessed because the principal quantitative constructs were measured through the same survey instrument. The measurement model was evaluated before examination of the structural relationships. Indicator loadings were examined to determine the contribution of individual items to their intended latent constructs, while Cronbach's alpha and composite reliability were used to assess internal consistency. Convergent validity was evaluated using average variance extracted, with values of .50 or greater regarded as evidence that a construct explained an adequate proportion of variance in its indicators. Discriminant validity was examined by assessing the empirical distinctiveness of the latent constructs and ensuring that measures of digital transformation capability, data integration, organizational agility, project resilience, and project success demonstrated adequate separation. Overall measurement and structural model adequacy was evaluated using commonly accepted goodness-of-fit indices, including the chi-square to degrees-of-freedom ratio, comparative fit index, Tucker-Lewis index, root mean square error of approximation, and standardized root mean square residual.

After confirmation of the measurement model, structural equation modeling was used to estimate the direct and indirect relationships specified in the conceptual framework. The analysis first examined the direct effect of digital transformation capability on construction project success. Paths from digital transformation capability to data integration, organizational agility, and project resilience were then estimated, together with the effects of these three variables on project success. The model therefore made it possible to determine whether organizations with stronger digital transformation capabilities achieved higher levels of project success and whether this relationship operated partly through improved information integration, greater organizational responsiveness, and stronger resilience to project disruptions. Indirect effects were assessed using a bootstrap procedure with 5,000 resamples and bias-corrected 95% confidence intervals. An indirect effect was considered statistically significant when its confidence interval did not include zero. Standardized path coefficients, standard errors, critical ratios, p values, coefficients of determination, and indirect-effect estimates were reported to evaluate the magnitude and statistical significance of the hypothesized relationships. Statistical significance was established at $p < .05$.

Qualitative data were analyzed using thematic analysis to explain and contextualize the statistical relationships identified during the quantitative phase. The analysis began with repeated reading of the interview transcripts to develop familiarity with participants' experiences and interpretations. Meaningful units related to digital transformation, information integration, organizational responsiveness, project disruption, adaptive capability, and project outcomes were identified and assigned initial codes. Similar codes were compared and grouped into conceptually related categories, after which higher-order themes were developed to capture recurring mechanisms and organizational conditions described by the participants. Coding was conducted iteratively, allowing categories and themes to be refined through continuous comparison across interviews. Particular attention was given to evidence explaining why data integration, organizational agility, and project resilience strengthened or constrained the contribution of digital transformation to project success. Contradictory or divergent cases were retained and examined rather than removed, because they provided information about organizational circumstances under which digital transformation investments did not necessarily result in improved project outcomes. Credibility of the qualitative findings was enhanced through systematic comparison of coded segments, repeated review of themes against the original transcripts, peer review of the coding structure, and maintenance of an analytical record documenting the development and refinement of themes. The final stage of the mixed-methods analysis involved integration of the quantitative and qualitative findings. Quantitative relationships were compared with the qualitative themes to determine convergence, complementarity, or divergence between the two strands of evidence. The qualitative findings were specifically used to explain the organizational mechanisms underlying statistically significant paths and to identify contextual factors that could not be captured adequately through the survey measures alone. This integration enabled a more comprehensive interpretation of how digital transformation capability contributes to construction project success through interconnected processes of data integration, organizational agility, and project resilience within the construction sector in Tehran.

3. Findings and Results

A total of 384 valid questionnaires were included in the quantitative analysis. Of the participants, 267 (69.5%) were

men and 117 (30.5%) were women. Participants ranged in age from 25 to 61 years, with a mean age of 39.84 years (SD = 8.17). Regarding age distribution, 61 participants (15.9%) were younger than 30 years, 129 (33.6%) were between 30 and 39 years, 126 (32.8%) were between 40 and 49 years, and 68 (17.7%) were aged 50 years or older. In terms of educational attainment, 76 participants (19.8%) held a bachelor's degree, 226 (58.9%) held a master's degree, and 82 (21.4%) held a doctoral or equivalent professional degree. Participants had an average of 13.27 years of professional experience in the construction industry (SD = 7.04). Ninety-three participants (24.2%) reported less than 8 years of professional experience, 157 (40.9%) reported between 8 and 15 years, and 134 (34.9%) reported more than 15 years of experience. With respect to organizational position, the sample consisted of project managers and construction managers (n = 86, 22.4%), civil and structural engineers (n = 92, 24.0%), project planning and control specialists (n = 68, 17.7%), consultants and design professionals (n = 51, 13.3%), digital transformation, information technology, or building information modeling specialists (n = 39, 10.2%), and senior technical or administrative personnel involved in construction projects (n = 48, 12.5%). Approximately 58.1% of the respondents worked for private contractors or construction companies, 23.4% worked for engineering consulting or project management organizations, and 18.5% worked in public or semi-public construction organizations. These characteristics indicated that the sample incorporated participants with diverse technical and managerial responsibilities and substantial exposure to construction project planning, coordination, digital systems, and project delivery processes.

Table 1. Descriptive Statistics, Distributional Characteristics, and Correlations among the Study Variables

Variable	M	SD	Skewness	Kurtosis	1	2	3	4	5
1. Digital Transformation Capability	3.74	0.63	-0.34	-0.21	1.00				
2. Data Integration	3.62	0.67	-0.28	-0.18	.68***	1.00			
3. Organizational Agility	3.69	0.61	-0.31	0.09	.64***	.59***	1.00		
4. Project Resilience	3.77	0.58	-0.37	0.16	.61***	.55***	.66***	1.00	
5. Construction Project Success	3.71	0.60	-0.29	-0.06	.67***	.63***	.65***	.69***	1.00

As shown in Table 1, the mean scores of all principal constructs were above the theoretical midpoint of the five-point response scale, indicating generally favorable evaluations of digital capability and project-related organizational performance among the participating construction professionals. Project resilience had the highest mean score (M = 3.77, SD = 0.58), followed by digital transformation capability (M = 3.74, SD = 0.63), construction project success (M = 3.71, SD = 0.60), organizational agility (M = 3.69, SD = 0.61), and data integration (M = 3.62, SD = 0.67). The relatively moderate standard deviations indicated adequate dispersion in participants' responses without evidence of excessive clustering at either end of the response scale. Skewness values ranged from -0.37 to -0.28 and kurtosis values ranged from -0.21 to 0.16, remaining well within conventional thresholds for approximate univariate normality. The correlation analysis showed that all study variables were positively and significantly associated at $p < .001$. Digital transformation capability demonstrated strong positive correlations with data integration (r = .68), organizational agility (r = .64), project resilience (r = .61), and construction project success (r = .67). Data integration was positively associated with construction project success (r = .63), while organizational agility (r = .65) and project resilience (r = .69) also showed substantial positive relationships with project success. The strongest bivariate association with project success was observed for project resilience, suggesting that projects characterized by stronger adaptive and recovery capacity tended to report higher levels of overall success. Although several correlations were moderately high, none exceeded .80, providing preliminary evidence that the constructs were related but empirically distinguishable and that problematic multicollinearity was unlikely to affect subsequent structural analyses.

Table 2. Measurement Model Reliability, Convergent Validity, and Standardized Factor Loadings

Construct	Number of Items	Standardized Loading Range	Cronbach's α	Composite Reliability	AVE
Digital Transformation Capability	7	.71-.86	.91	.92	.62
Data Integration	6	.72-.88	.90	.91	.63
Organizational Agility	6	.69-.85	.89	.90	.60

Project Resilience	7	.70-.87	.92	.93	.65
Construction Project Success	7	.73-.89	.93	.94	.68

The measurement model demonstrated satisfactory reliability and convergent validity across all five latent constructs. As reported in Table 2, standardized factor loadings ranged from .69 to .89, indicating that all retained indicators made substantial contributions to their corresponding latent variables. No item exhibited a critically low loading, and consequently all theoretically relevant items were retained in the final measurement model. Cronbach's alpha coefficients ranged from .89 for organizational agility to .93 for construction project success, substantially exceeding the minimum acceptable threshold of .70 and demonstrating strong internal consistency. Composite reliability coefficients ranged from .90 to .94, further confirming the reliability of the latent-variable measures. Average variance extracted values ranged between .60 and .68, exceeding the recommended criterion of .50 for all constructs and providing evidence of adequate convergent validity. Construction project success displayed the highest AVE (.68), while organizational agility showed the lowest AVE (.60), although the latter remained clearly above the minimum criterion. Discriminant validity was also supported because the square roots of the AVE values for the respective constructs exceeded their correlations with the other latent variables, and examination of cross-loadings showed that each indicator loaded more strongly on its theoretically assigned construct than on competing constructs. Furthermore, variance inflation factor values for the predictor constructs ranged between 1.73 and 2.46, remaining substantially below conventional thresholds for problematic multicollinearity. The confirmatory factor analysis therefore supported the adequacy of the five-factor measurement structure and justified proceeding to structural model estimation.

The overall measurement model provided a satisfactory fit to the observed data. The chi-square statistic was significant, $\chi^2(550) = 912.64$, $p < .001$, as is common in structural equation models with moderately large samples; however, the normed chi-square ratio was acceptable, $\chi^2/df = 1.66$. Additional goodness-of-fit indices likewise supported the measurement model, including CFI = .953, TLI = .947, GFI = .908, and AGFI = .893. The RMSEA was .041, with a 90% confidence interval from .036 to .046, and the SRMR was .039. Taken together, these indices indicated that the proposed latent-variable measurement structure corresponded closely to the empirical covariance matrix and provided an acceptable basis for testing the hypothesized structural relationships.

Table 3. Structural Model Path Estimates for the Relationships among Digital Transformation Capability, Data Integration, Organizational Agility, Project Resilience, and Project Success

Structural Path	B	SE	β	CR	p
Digital Transformation Capability → Data Integration	0.72	0.06	.71	12.31	< .001
Digital Transformation Capability → Organizational Agility	0.63	0.06	.66	10.91	< .001
Digital Transformation Capability → Project Resilience	0.56	0.06	.60	9.72	< .001
Digital Transformation Capability → Project Success	0.21	0.06	.22	3.72	< .001
Data Integration → Project Success	0.19	0.06	.21	3.42	.001
Organizational Agility → Project Success	0.23	0.06	.24	4.11	< .001
Project Resilience → Project Success	0.31	0.06	.33	5.39	< .001

The structural model supported all hypothesized direct relationships. Digital transformation capability had a strong and statistically significant positive effect on data integration ($\beta = .71$, $p < .001$), indicating that organizations with stronger technological, strategic, managerial, and human capabilities for digital transformation were considerably more capable of integrating project-related information across functional units and information systems. Digital transformation capability also exerted a significant positive effect on organizational agility ($\beta = .66$, $p < .001$), suggesting that greater digital capability was associated with enhanced organizational responsiveness, faster decision-making, and increased flexibility in responding to changing project conditions. A further significant relationship was observed between digital transformation capability and project resilience ($\beta = .60$, $p < .001$), indicating that digital capability strengthened the capacity of projects to anticipate, absorb, adapt to, and recover from disruptions. The direct effect of digital transformation capability on construction project success also remained statistically significant after

inclusion of the three intermediate variables (β = .22, p < .001), thereby indicating that digital transformation had an independent contribution to project outcomes beyond the effects transmitted through data integration, organizational agility, and project resilience.

The results further demonstrated that all three proposed organizational and project capabilities were significant predictors of construction project success. Data integration positively predicted project success (β = .21, p = .001), indicating that improved connectivity, interoperability, and availability of project information contributed to more successful project delivery. Organizational agility also showed a significant positive association with project success (β = .24, p < .001), suggesting that projects benefited when organizations could rapidly reconfigure resources, coordinate functions, and respond to changing requirements. Project resilience emerged as the strongest direct predictor of project success among the three intermediate constructs (β = .33, p < .001), highlighting the importance of maintaining continuity, adapting to disruptions, and recovering rapidly from adverse events. Collectively, digital transformation capability, data integration, organizational agility, and project resilience explained 64.8% of the variance in construction project success (R^2 = .648). Digital transformation capability independently explained 50.4% of the variance in data integration (R^2 = .504), 43.6% of the variance in organizational agility (R^2 = .436), and 36.0% of the variance in project resilience (R^2 = .360). These coefficients of determination suggested substantial explanatory power for the proposed model.

The structural model itself demonstrated satisfactory goodness of fit. The chi-square statistic was $\chi^2(553)$ = 944.18, p < .001, and the relative chi-square value was 1.71. The comparative fit index was .949, the Tucker-Lewis index was .943, the goodness-of-fit index was .904, and the adjusted goodness-of-fit index was .889. The RMSEA was .043, with a 90% confidence interval between .038 and .048, and the SRMR was .042. These values indicated that the hypothesized structural model provided an acceptable representation of the observed relationships among digital transformation capability, data integration, organizational agility, project resilience, and construction project success.

Table 4. Bootstrap Analysis of Indirect Effects of Digital Transformation Capability on Construction Project Success

Indirect Path	Indirect Effect (β)	Boot SE	Lower 95% CI	Upper 95% CI	p
Digital Transformation Capability → Data Integration → Project Success	.149	.036	.084	.225	< .001
Digital Transformation Capability → Organizational Agility → Project Success	.158	.038	.091	.239	< .001
Digital Transformation Capability → Project Resilience → Project Success	.198	.041	.126	.288	< .001
Total Indirect Effect	.505	.058	.399	.622	< .001
Total Effect of Digital Transformation Capability on Project Success	.725	.049	.629	.815	< .001

The bootstrap mediation analysis presented in Table 4 confirmed that data integration, organizational agility, and project resilience each significantly mediated the relationship between digital transformation capability and construction project success. The indirect effect through data integration was statistically significant (β = .149, 95% CI [.084, .225], p < .001), demonstrating that part of the beneficial effect of digital transformation capability occurred because digitalized organizations were better able to integrate project information across technological platforms, departments, and stakeholders. The indirect effect through organizational agility was similarly significant (β = .158, 95% CI [.091, .239], p < .001), indicating that digital transformation enhanced project success partly by improving organizational responsiveness and the ability to reconfigure resources and decisions in response to rapidly changing project requirements. The strongest indirect effect was observed through project resilience (β = .198, 95% CI [.126, .288], p < .001), suggesting that a particularly important mechanism linking digital transformation to project success was the enhancement of preparedness, adaptive capacity, operational continuity, and recovery capability in the face of project disruptions. Because none of the bootstrap confidence intervals included zero, all three indirect pathways were considered statistically significant.

The combined indirect effect of digital transformation capability on construction project success through the three intermediate variables was β = .505 (95% CI [.399, .622], p < .001), while the total effect was β = .725 (95% CI [.629, .815], p < .001). Because the direct effect remained

significant after the mediating mechanisms were incorporated into the structural model, the findings supported partial multiple mediation. Accordingly, digital transformation capability was not merely a technological antecedent of project performance but appeared to influence project success through several complementary organizational mechanisms. Data integration supported the availability and consistency of project information, organizational agility facilitated rapid and coordinated responses to emerging requirements, and project resilience allowed project teams to sustain performance and recover when disruptions occurred. Among these mechanisms, resilience accounted for the largest individual indirect effect, reinforcing the interpretation that the value of digital transformation in complex construction environments depends substantially on the extent to which digital capabilities improve the organization's ability to manage uncertainty and disruption.

The qualitative phase was conducted after completion of the quantitative analysis to clarify the mechanisms underlying these statistical relationships. Analysis of the 24 semi-structured interviews produced four closely interconnected themes: integrated project visibility and evidence-based coordination, accelerated organizational responsiveness, digitally enabled resilience to project disruption, and organizational conditions shaping the realization of digital value. Participants consistently described digital transformation as valuable when digital systems produced an integrated and accessible information environment rather than merely adding isolated technological tools. Interviewees emphasized that fragmented databases, disconnected software platforms, duplicate data entry, and inconsistent reporting structures limited the usefulness of digital technologies even when substantial investments had been made. In contrast, organizations in which scheduling, procurement, cost control, design information, site reporting, and management dashboards were connected reported greater visibility of emerging deviations and faster escalation of problems. Participants explained that integrated data reduced dependence on delayed manual reporting and allowed project managers to identify discrepancies in cost, schedule, supply, and site progress before such discrepancies developed into major project problems. These qualitative observations were consistent with the significant quantitative pathway from digital transformation capability to data integration and from data integration to project success.

A second prominent theme concerned the contribution of digital transformation to organizational agility. Participants reported that real-time reporting systems, cloud-based collaboration platforms, building information modeling environments, mobile site applications, and integrated project dashboards shortened communication cycles between site teams, technical offices, project managers, consultants, and senior executives. Several interviewees noted that in traditionally managed construction projects, decision-making was frequently delayed because project information moved sequentially across organizational levels. Digital systems were perceived as reducing this delay by making the same information simultaneously visible to multiple decision-makers. Participants also indicated that the effectiveness of these technologies depended strongly on organizational structures and managerial practices. Digitally generated information did not automatically create agility when decisions remained highly centralized, when employees lacked authority to act, or when departments continued to protect information within functional boundaries. Thus, the interviews suggested that technological capability facilitated organizational agility but that managerial decentralization, cross-functional collaboration, and employee competence were necessary to translate digital information into timely action. This qualitative pattern supported the statistically significant indirect effect of digital transformation capability on project success through organizational agility.

Project resilience emerged as the most prominent explanatory mechanism in the qualitative findings and was consistent with its comparatively strong effect in the structural model. Participants described construction projects in Tehran as operating under conditions of substantial uncertainty arising from design changes, delays in material supply, price fluctuations, contractor coordination problems, workforce constraints, regulatory requirements, and unexpected site conditions. Interviewees stated that digitally mature organizations were better able to anticipate disruptions because they possessed more current information concerning project progress, resource availability, procurement schedules, financial commitments, and emerging risks. Digital monitoring tools were also described as facilitating scenario assessment and allowing managers to evaluate the consequences of schedule changes, resource reallocations, or supply interruptions before implementing corrective measures. Participants frequently distinguished between merely detecting disruptions and possessing the organizational capacity to respond to them. In

their accounts, digital transformation strengthened resilience when information systems were coupled with flexible decision-making, access to alternative resources, established contingency procedures, and a willingness to learn from previous disruptions. The qualitative evidence therefore reinforced the quantitative finding that project resilience represented the strongest mediating pathway between digital transformation capability and construction project success.

The final qualitative theme concerned the organizational conditions determining whether digital transformation produced meaningful improvements in project performance. Participants emphasized that technology acquisition alone was insufficient and sometimes resulted in additional administrative complexity when platforms were poorly integrated or employees continued to rely simultaneously on manual and digital processes. Senior management commitment, sustained investment in digital infrastructure, employee training, interoperability standards, data quality, clearly defined responsibilities, and organizational acceptance of technology-based decision-making were repeatedly identified as critical implementation conditions. Resistance to digital systems was reported to occur particularly when employees perceived them as monitoring mechanisms rather than as tools for improving coordination and problem solving. Participants also noted that inconsistent data entry and insufficient technical skills could undermine confidence in digital dashboards and cause managers to return to informal or manual sources of information. Conversely, organizations with strong digital leadership and clearly standardized information processes were described as achieving more consistent benefits from digital transformation initiatives. These findings provided an explanation for the significant direct effect of digital transformation capability on project success that remained even after the mediating variables were considered, because broader aspects of digital leadership, workforce competence, technological infrastructure, and digitally oriented management practices appeared to improve project outcomes through mechanisms extending beyond data integration, agility, and resilience alone.

Integration of the quantitative and qualitative findings demonstrated substantial convergence between the two strands of the study. The quantitative model established that digital transformation capability had significant direct effects on data integration, organizational agility, project resilience, and construction project success, while the qualitative interviews explained how these relationships were manifested in daily construction project practices. Data integration improved visibility and reduced information fragmentation; organizational agility shortened decision cycles and improved cross-functional responsiveness; and project resilience enhanced the ability to anticipate, absorb, and recover from project disruptions. At the same time, the qualitative findings qualified the statistical relationships by demonstrating that the benefits of digital transformation were conditional on organizational factors such as leadership support, employee competencies, information governance, system interoperability, and decision-making flexibility. The mixed-methods findings therefore suggested that digital transformation capability should be understood not simply as the possession or adoption of technological tools but as an integrated organizational capability through which technology, information, managerial processes, and human competencies jointly contribute to successful construction project delivery.

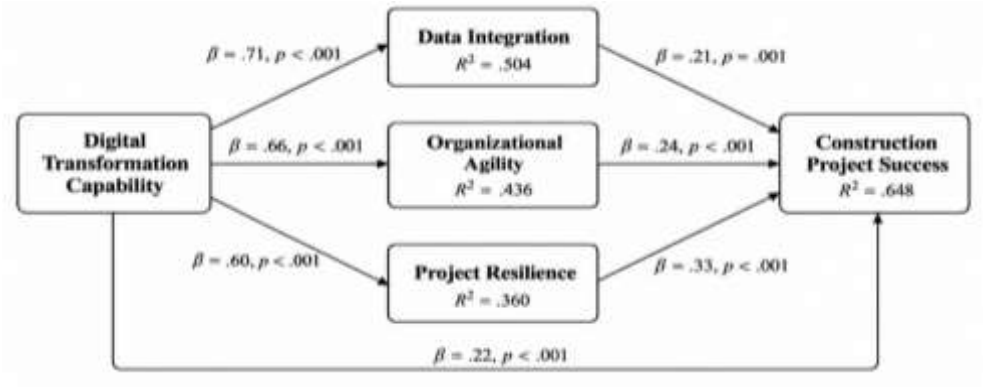


Figure 1. Structural Model

The structural model depicted in Figure 1 illustrates both the direct pathway from digital transformation capability to construction project success and the three indirect mechanisms operating through data integration,

organizational agility, and project resilience. The standardized coefficients indicated that digital transformation capability had its strongest effect on data integration, followed by organizational agility and project resilience. However, among the immediate predictors of construction project success, project resilience demonstrated the largest standardized coefficient. The persistence of a statistically significant direct path from digital transformation capability to project success after inclusion of the three mediating variables indicated partial rather than complete mediation. Thus, the structural pattern suggested that digital transformation capability contributes to successful construction project outcomes both directly and indirectly by creating more integrated information environments, strengthening adaptive organizational responses, and increasing the capacity of projects to withstand and recover from disruptions.

4. Discussion and Conclusion

The present study examined the relationship between digital transformation capability and construction project success and assessed whether data integration, organizational agility, and project resilience functioned as explanatory mechanisms within this relationship. The findings demonstrated that digital transformation capability had significant positive effects on all three intermediate constructs and also retained a significant direct effect on construction project success. In addition, data integration, organizational agility, and project resilience each showed significant positive effects on project success, and all three variables significantly mediated the relationship between digital transformation capability and project success. Among the mediating mechanisms, project resilience produced the strongest indirect effect, followed by organizational agility and data integration. The qualitative findings reinforced these relationships by showing that the practical value of digital transformation was realized when digital systems improved project visibility, reduced fragmentation in information flows, accelerated decision-making, enabled adaptive coordination, and strengthened the ability of project teams to anticipate and recover from disruption. Collectively, these results support a capability-based interpretation of digital transformation in which digital technologies contribute to project performance not merely through their technical presence but through the organizational capacities they enable.

The significant direct relationship between digital transformation capability and construction project success indicates that digitally capable construction organizations are better positioned to achieve favorable project outcomes. This finding is consistent with the broader literature suggesting that digital transformation contributes to performance when it is embedded in organizational strategy, leadership, operational processes, and culture rather than implemented as a stand-alone technological initiative [1]. The result also aligns with dynamic capability perspectives in which digital resources generate value when organizations can reconfigure and mobilize them in response to changing conditions [2]. In the construction context, this relationship is particularly important because project performance depends on timely information, coordination across multiple actors, and the ability to adjust to changing technical and environmental conditions. The qualitative interviews supported this interpretation by indicating that organizations with stronger digital capabilities were able to monitor project conditions more continuously, support more informed managerial decisions, and coordinate project activities with less dependence on delayed manual reporting. These observations are consistent with recent research emphasizing that digital transformation and strategic digital leadership can improve organizational performance by strengthening digitalization and adaptive organizational capabilities [1, 22].

The strong effect of digital transformation capability on data integration was one of the most substantial relationships in the structural model. This result suggests that digitally mature construction organizations are more capable of connecting information across functions, systems, and project stakeholders. This finding is theoretically meaningful because construction projects generate heterogeneous streams of data related to design, procurement, scheduling, budgeting, site operations, logistics, quality, safety, and stakeholder communication. Without integration, these data may remain fragmented and therefore have limited decision-making value. The observed relationship is consistent with research showing that AI-supported analytics and digital platforms improve the capacity of organizations to integrate information and support more effective decision-making [4, 21]. It also corresponds with findings that analytics-enabled systems can strengthen organizational resilience when they are combined with effective participation and coordination mechanisms [5]. In the present study, qualitative participants repeatedly emphasized that the benefits of digital

transformation were greatest when systems shared information rather than operating as disconnected applications. This finding reinforces the argument that digital capability should be evaluated in terms of interoperability and information integration rather than the number of technologies adopted.

Data integration also showed a significant positive effect on construction project success and significantly mediated the relationship between digital transformation capability and project success. This indicates that part of the performance benefit of digital transformation is transmitted through the creation of more coherent and accessible project information. The finding is consistent with evidence that integration capabilities can strengthen organizational performance under disruption by improving coordination and reducing information fragmentation [6]. Similar conclusions emerge from research on Industry 4.0 and sustainable supply chain performance, where technological capabilities produce better outcomes when combined with dynamic and integrative organizational mechanisms [7]. In construction, integrated data may reduce inconsistencies between scheduling, procurement, cost control, and site execution and thereby support more accurate and timely decisions. The qualitative findings were closely aligned with this interpretation: participants reported that integrated dashboards, connected planning systems, and shared digital platforms improved visibility of emerging deviations and allowed managers to respond before problems escalated. Thus, the significant mediating role of data integration suggests that digital transformation creates value in part by converting dispersed project information into coordinated managerial knowledge.

The findings further showed that digital transformation capability had a strong positive effect on organizational agility. This relationship supports the view that digitalization can enhance the speed and flexibility of organizational response by improving information access, communication, and decision processes. Previous studies have similarly linked digital capabilities with organizational agility and competitive advantage [4, 9]. The present result is also consistent with evidence that organizational resources and dynamic capabilities support agility by enabling firms to adapt rapidly to environmental changes [8]. In the construction environment, agility can be especially important because project conditions frequently change as a result of design revisions, client requirements, material availability, regulatory developments, or site-level uncertainties. The qualitative findings illustrated this process by showing that digital systems shortened information cycles and allowed technical teams, project managers, and decision-makers to respond more quickly to emerging issues. However, participants also noted that digital systems alone did not create agility when decision-making remained overly centralized or when organizational units were unwilling to share information.

The significant positive effect of organizational agility on project success further supports the importance of rapid and coordinated response capability in complex project settings. This finding is aligned with research showing that organizational agility contributes to sustainable competitive advantage and organizational performance [10]. It is also consistent with findings that digital transformation and transformational leadership can strengthen both agility and resilience, thereby improving organizational outcomes [11]. The present results suggest that construction projects benefit when organizations can quickly reallocate resources, revise priorities, coordinate functions, and adjust decision-making in response to changing project conditions. This interpretation is supported by studies emphasizing the role of strategic agility during crisis and the relationship between agility, employee engagement, and organizational functioning [13]. It is also compatible with broader evidence that workplace culture influences agility and performance by shaping the extent to which organizations can respond constructively to change [12]. Therefore, the mediating effect of organizational agility found in this study can be understood as a mechanism through which digital transformation accelerates and improves organizational response.

Project resilience emerged as the strongest direct predictor of construction project success among the three mediating variables and also produced the largest indirect effect between digital transformation capability and project success. This is one of the most important findings of the study. Construction projects operate under conditions in which disruptions are not exceptional but recurrent, including supply delays, cost escalation, contractor coordination failures, design modifications, workforce constraints, and unexpected site conditions. Under such circumstances, resilience becomes a critical project capability. The present findings are consistent with the conceptual distinction between agility and resilience in the literature, where agility emphasizes rapid response and resilience encompasses preparedness, absorption, recovery, and adaptation [15]. They also align with evidence that agile and resilient capabilities can jointly improve performance in

supply chains and other dynamic operational environments [16]. The stronger effect of resilience relative to the other mediators suggests that the ultimate value of digital transformation may depend substantially on whether digital resources help projects remain functional and recover effectively when disruption occurs.

The significant relationship between digital transformation capability and project resilience is also consistent with recent research connecting digitalization with adaptive and recovery capabilities. Alaskar showed that AI-driven decision-making and digital platform capabilities can support firm resilience by improving information processing and response capability [21]. Likewise, Hamad and Çelebi identified strategic agility as an important mechanism through which digital transformation contributes to organizational resilience [22]. Alharbi similarly emphasized that resilience emerges through interconnected institutional and digital mechanisms rather than from technological adoption alone [23]. The qualitative findings in the present study strongly supported this view. Participants explained that digitally mature organizations could identify disruptions earlier, evaluate alternative actions more rapidly, and maintain better continuity of project operations. They also emphasized, however, that digital information contributed to resilience only when organizations possessed flexible resource arrangements, contingency procedures, and managerial authority to act. This illustrates that digital transformation supports resilience through a combination of information visibility and adaptive organizational response.

The results are further compatible with broader research on organizational resilience and dynamic capabilities. Resilience has been linked to talent management, inclusive management practices, and human resource adaptability [17, 18]. Reviews of organizational resilience during major crises have also emphasized the importance of organizational structures, employee resources, and continuity mechanisms [19]. Similarly, business resilience planning has been shown to support organizations in managing turbulence and maintaining critical activities [20]. These studies support the present finding that resilience is not merely a technological outcome but a broader organizational capacity. In construction organizations, digital systems may enhance resilience by enabling earlier detection of risks and faster coordination, but the actual capacity to absorb and recover from disruption depends on organizational preparedness and learning.

The qualitative findings also highlighted the importance of leadership and organizational conditions in determining whether digital transformation produces meaningful project benefits. This aligns with research showing that effective digital leadership contributes to sustainable performance and resilience through organizational agility [2]. Leadership becomes particularly important in turbulent environments where managers must provide direction while enabling flexibility and distributed problem solving [28]. The interviews indicated that organizations obtained greater benefit from digital systems when senior management supported data-driven decision-making, invested in employee capabilities, and encouraged cross-functional collaboration. These findings also align with the broader argument that organizational dynamism and creativity strengthen resilience by enabling firms to adapt beyond rigid routines [25]. Similarly, evidence on strategic mastery and environmental scanning suggests that organizations perform more effectively under uncertainty when they actively detect changes and reconfigure resources accordingly [26, 27].

The results also have implications for the increasing role of advanced analytics and artificial intelligence in project management. Emerging research suggests that AI-enabled systems can support decentralized and responsive decision-making architectures [29]. AI-driven strategic capabilities have also been increasingly linked to resilience and agility, particularly in environments where organizations must respond rapidly to uncertainty [30]. Nevertheless, technological sophistication alone is unlikely to generate superior performance if organizations lack digital readiness, adaptive human capital, and organizational resilience [3]. The present findings reinforce this point by showing that the effects of digital transformation on project success were partly mediated by organizational capabilities rather than being purely direct. The practical implication is that construction firms should not equate digital maturity with software adoption alone; instead, they should assess whether digital systems improve information integration, accelerate organizational response, and strengthen resilience.

The persistence of a significant direct effect of digital transformation capability on project success after the mediators were introduced indicates partial rather than complete mediation. This suggests that additional mechanisms may also connect digital transformation to project success. These may include improved innovation capability, enhanced stakeholder collaboration, better forecasting, stronger knowledge management, more accurate cost and schedule control, or improvements in

workforce productivity. The broader literature supports such an interpretation by demonstrating that digital transformation operates through multiple organizational channels rather than a single pathway [1, 29]. Accordingly, the present model captures three important mechanisms but should not be interpreted as exhaustive.

This study has several limitations that should be considered when interpreting the findings. First, the quantitative data were cross-sectional, which limits the ability to establish definitive causal relationships among digital transformation capability, data integration, organizational agility, project resilience, and project success. Although the structural model was theoretically grounded and the qualitative phase provided explanatory support, longitudinal evidence would be required to determine how these capabilities evolve over time. Second, the sample was drawn from construction professionals in Tehran, and the findings may not generalize fully to construction environments with different regulatory, technological, economic, or organizational conditions. Third, the principal variables were measured using self-reported perceptions, which may introduce common method bias and subjective evaluation effects despite the procedures used to assess measurement quality. Fourth, the study focused on organizational and project-level capabilities and did not explicitly examine project size, contract type, organizational ownership, digital maturity stage, or technological platform as potential moderators. Finally, the qualitative phase included experienced professionals but did not systematically compare perspectives across all stakeholder groups, such as clients, subcontractors, consultants, and technology vendors.

Future research should build on these findings by using longitudinal and multi-wave designs to examine whether changes in digital transformation capability lead to subsequent improvements in integration, agility, resilience, and project success. Comparative studies across cities, countries, and construction sectors would also be valuable for assessing the contextual stability of the proposed model. Future studies may test additional mediators such as knowledge sharing, innovation capability, collaborative governance, digital trust, or decision quality and may examine whether project complexity, uncertainty, contract type, organizational size, or digital maturity moderate the observed relationships. Researchers could also integrate objective project indicators, including schedule variance, cost variance, safety performance, rework rates, and change-order frequency, with survey-based measures. Multi-level designs examining individual, team, project, and organizational capabilities would further improve understanding of how digital transformation operates across levels of analysis. Finally, future qualitative studies could compare digitally successful and digitally unsuccessful projects to identify boundary conditions and implementation failures in greater depth.

From a practical perspective, construction organizations should treat digital transformation as an integrated capability-building process rather than as a technology procurement initiative. Managers should prioritize interoperability among project systems, standardized data structures, real-time information visibility, and clear governance of project data. Investments in digital platforms should be accompanied by training, role redesign, and decision-making procedures that allow employees to use digital information rapidly and effectively. Organizations should also strengthen organizational agility by reducing unnecessary approval delays, encouraging cross-functional coordination, and granting project teams sufficient authority to respond to emerging problems. Because project resilience emerged as the strongest mediating mechanism, construction firms should integrate digital tools with contingency planning, scenario analysis, supplier alternatives, risk monitoring, and recovery procedures. Senior leaders should actively support digital adoption, monitor data quality, and establish a culture in which digital information is trusted and used in operational decisions. The practical objective should therefore be to develop a coordinated system in which digital technology improves information integration, agility, and resilience simultaneously, thereby increasing the probability of successful project delivery.

Authors' Contributions

Authors equally contributed to this article.

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Declaration of Interest

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All procedures performed in this study were under the ethical standards.

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