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BEYOND AWARENESS: A MODERATED-MEDIATION MODEL OF TECHNOLOGICAL CAPACITY AND PERCEIVED ADOPTION BARRIERS IN CONSTRUCTION INDUSTRY READINESS FOR BLOCKCHAIN ADOPTION

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A B S T R A C T

Blockchain technology has the potential to overcome the ongoing inefficiencies in the construction industry, but its adoption is still very limited, especially in regional and developing-economy settings. In this study, a moderated-mediation model based on the Technology-Organization-Environment (TOE) framework was used to find out whether the indirect effect of Awareness on Organizational Preparedness through Technological Capacity changes depending on Perceived Adoption Barriers. The data were obtained from 99 professionals working in the construction sector in Bataan, Philippines, by means of convenience sampling. Applying Hayes' (2015) conditional process modeling approach, the results showed significant moderated mediation (index = 0.046, 95% CI [0.002, 0.152]), meaning that the mediating role of Technological Capacity becomes more prominent as Perceived Adoption Barriers rise, the conditional indirect effects lying between 0.147 and 0.210. Harman's single-factor test indicated that common method bias was not likely to account for the results. The findings show that technological capacity allows professionals to turn their awareness of adoption barriers into organizational readiness. This research extends existing TOE-based blockchain adoption studies by illustrating a conditional and capability-dependent mechanism of readiness and offers practical recommendations for construction companies and policymakers who are designing blockchain readiness initiatives.

1. INTRODUCTION

Blockchain technology is widely recognized as a digital innovation with the potential to enhance trust, transparency, and collaboration within the construction industry's fragmented and paper-intensive processes. Its core features—decentralization, immutability, and traceability—are often presented as solutions to persistent industry challenges, including payment disputes, data tampering, and inadequate information sharing among stakeholders (Rajeswari et a., 2026). Despite these advantages, empirical evidence of blockchain implementation in real-world construction

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projects remains limited, and industry adoption continues to lag behind technological advancements and academic interest.

An expanding body of research has utilized the Technology – Organization - Environment (TOE) framework (Tornatzky & Fleischer, 1990) to investigate the drivers and barriers of blockchain adoption in construction. TOE-based studies have identified organizational readiness, top management support, compatibility, and competitive pressure as significant determinants of adoption intention (Senanayake, 2026). Additional factors such as relative advantage, regulatory support, cost, and firm size have also been found to influence blockchain adoption among construction professionals. However, findings are not entirely consistent; for example, one study reported that organizational readiness had a small negative effect on perceived usefulness of blockchain, which was attributed to resistance arising from the substantial workflow and behavioral changes required by blockchain's decentralized nature (Raddatz et al., 2023). This variability indicates that relationships among readiness-related constructs are conditional and context-dependent, highlighting the need for empirical examination of mediation and moderation mechanisms, especially across different national and regional contexts (Wang et al., 2022; Li et al., 2022).

In addition, barrier-focused studies using the TOE framework have consistently identified limited technical expertise, high implementation costs, system integration complexity, and regulatory uncertainty as major obstacles to blockchain adoption in construction (Končár et al., 2026). These barriers persist alongside technological drivers such as relative advantage and organizational drivers like top management support. Recent moderation analyses in blockchain adoption research have shown that barrier-related variables, such as perceived cost, act as significant moderators rather than simple negative predictors of the relationship between technology readiness and adoption intention. Technology readiness enablers have been identified as the most influential factors, while perceived cost demonstrated the highest explanatory power in these models. This evidence suggests that barriers may shape, rather than merely inhibit, the pathways to readiness—a hypothesis not yet examined within the Philippine construction sector (Putri et al., 2026; Abu Salim et al., 2022).

The application of moderated-mediation designs within TOE-based technology adoption research is not unprecedented in the project management literature. A recent study published in the Journal of Project Management examined the adoption of hybrid project management methodology among Malaysian FinTech organizations using an extended TOE framework, incorporating attitude as a mediating variable between technological, organizational, and environmental antecedents and adoption intention, finding partial mediation between top management support and adoption intention, and between industry pressure and adoption intention, while noting that this was among the first studies to extend the TOE framework by introducing mediating and moderating variables for organizational technology adoption decisions (Xiang et al., 2023). This precedent demonstrates both the theoretical viability and the publication relevance of moderated-mediation TOE models within project management research, and specifically within this journal, supporting the appropriateness of a similar analytical approach applied to blockchain readiness in construction.

Despite this growing interest, empirical studies on blockchain adoption readiness in the Philippine construction industry are scarce. To date, no research has applied a moderated-mediation TOE model to examine the interactions among awareness, technological capacity, organizational preparedness, and perceived barriers within a regional Philippine construction workforce (Waqar et al., 2026). Existing assessments have primarily been descriptive, focusing on mean readiness levels without investigating the mechanisms linking these constructs. Addressing this gap is important, as understanding how awareness translates into organizational readiness—and under what conditions perceived barriers influence this relationship—provides more actionable insights for policy and organizational planning than descriptive scores alone.

This study examines industry readiness for blockchain adoption in Bataan, applying a Technology-Organization-Environment framework to test a moderated-mediation model in which Technological Capacity mediates the relationship between Awareness and Organizational Preparedness, and Barriers moderates the relationship between Technological Capacity and Organizational Preparedness. In doing so, this study contributes empirically grounded evidence to a still-developing area of TOE-based blockchain adoption research, extends the applicability of moderated-mediation designs to a Philippine regional construction context, and offers practical guidance for construction firms, industry associations, and policymakers seeking to move beyond awareness-building toward genuine organizational readiness for blockchain adoption.

1.1 Statement of the Problem

Specifically, this study sought to answer the following questions:

- Does Awareness of blockchain technology significantly predict Technological Capacity among construction professionals in Bataan?
- Does Technological Capacity significantly predict Organizational Preparedness for blockchain adoption?
- Does Technological Capacity mediate the relationship between Awareness and Organizational Preparedness?
- Does perceived Barriers moderate the relationship between Technological Capacity and Organizational Preparedness?

1.2 Significance of the Study

This study is expected to benefit construction firms and industry professionals by clarifying which readiness dimensions merit prioritized investment; industry associations and local government units in Bataan by informing the design of more effective, capacity-focused adoption support programs rather than awareness-only initiatives; and the academic community by extending TOE-based moderated-mediation modeling to an underrepresented regional and national context within the blockchain-construction literature.

2. METHODOLOGY

2.1 Research Design

This study employed a quantitative, non-experimental, explanatory-correlational research design to examine the readiness of the construction industry for blockchain technology adoption. Building on a Technology-Organization-Environment (TOE) theoretical framework, the study tested a moderated-mediation model in which technological capacity mediates the relationship between awareness and organizational preparedness, while the strength of this indirect effect is itself conditional on the level of perceived adoption barriers. This design is appropriate for establishing not only whether a mediating mechanism exists, but whether that mechanism operates differently under varying conditions — a distinction formally tested through the index of moderated mediation (Hayes, 2015) rather than through mediation and moderation analyzed as separate, independent effects.

2.2 Theoretical Framework

The study is anchored on the Technology-Organization-Environment (TOE) framework (Tornatzky & Fleischer, 1990), which posits that technology adoption within firms is shaped by three contextual dimensions: the technological context, the organizational context, and the environmental context. In this study, Awareness and Technological Capacity represent the technological context, and Organizational Preparedness represents the organizational context.

The fourth construct, originally framed as representing TOE's environmental context, is more precisely operationalized in this study as Perceived Adoption Barriers — a general, respondent-perceived measure of obstacles to blockchain adoption. While this construct demonstrated strong internal consistency as a unidimensional scale ($\alpha = .945$), item-level review indicates it spans more than the environmental dimension alone: some items reflect genuinely external, environmental conditions (e.g., regulatory uncertainty, absence of industry standards), while others reflect internal organizational or technological limitations (e.g., limited technical expertise, dependence on existing paper-based systems). Accordingly, this study treats Perceived Adoption Barriers as a general obstacle-perception construct that functions as a boundary condition on the technological-organizational relationship, rather than claiming it to be a strict, theoretically pure measure of TOE's environmental context. This distinction is treated as a limitation of the original instrument's construct mapping rather than as a flaw in the analytical model itself, and is elaborated further in the Discussion.

The following hypotheses were tested:

- **H1:** Awareness of blockchain technology positively predicts Technological Capacity.
- **H2:** Technological Capacity positively predicts Organizational Preparedness.
- **H3:** Technological Capacity mediates the relationship between Awareness and Organizational Preparedness.
- **H4:** Perceived Adoption Barriers moderates the relationship between Technological Capacity and Organizational Preparedness, such that the *indirect effect* of Awareness on Organizational Preparedness (through Technological Capacity) varies significantly across levels of Perceived Adoption Barriers.

2.3 Population and Sampling

The respondents comprised construction industry professionals operating within Bataan, selected through convenience sampling due to practical constraints in accessing personnel across active project sites and firms. Inclusion was purposively limited to roles directly relevant to technology adoption decisions and project execution, namely civil and construction engineers, project engineers, site engineers, project managers, and office-based personnel involved in planning, cost estimation, or information systems. This role composition ensured that respondents possessed sufficient occupational exposure to meaningfully assess awareness, technological capacity, and organizational preparedness related to blockchain adoption. A total of 99 valid responses were obtained, which is considered adequate for mediation analysis employing bootstrapped confidence intervals (Fritz & MacKinnon, 2007).

2.4 Instrumentation

Data were gathered using a structured questionnaire consisting of 35 items measured on a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree), organized into four constructs: Awareness (4 items), Technological Capacity (6 items), Organizational Preparedness (12 items), and Perceived Adoption Barriers (12 items). Data used in this study were drawn from a survey originally administered to assess construction industry readiness for blockchain adoption, subsequently reanalyzed here using a moderated-mediation framework not applied in the original administration. Internal consistency reliability was

excellent across all constructs, with Cronbach's alpha values of .923 (Awareness), .902 (Technological Capacity), .928 (Organizational Preparedness), and .945 (Perceived Adoption Barriers), all well above the .70 threshold conventionally accepted for social science research (Nunnally, 1978).

2.5 Data Collection Procedure

Data collection was conducted through a hybrid administration mode, combining physical (paper-based) and Google Forms distribution to accommodate respondents' varying availability and accessibility across construction sites and offices in Bataan. Physical responses were subsequently encoded into a consolidated digital dataset for analysis. This mixed-mode approach was adopted deliberately to maximize response rate and inclusivity across respondents with differing access to digital platforms, particularly field-based personnel who may not have had consistent access to online forms during working hours.

2.6 Ethical Considerations

Formal ethics clearance was not required at the level at which this data was originally collected. Nonetheless, the data collection process followed standard ethical principles: participation was voluntary, informed consent was obtained from all respondents before administration, responses were collected and stored anonymously with no personally identifiable information retained, and confidentiality of individual responses was maintained throughout. Data were used strictly for academic research purposes.

2.7 Statistical Treatment

Descriptive statistics (means and standard deviations) were computed for each construct. Given the ordinal nature of Likert-scale composite scores, Spearman's rank correlation was used to examine bivariate relationships among constructs. Common method bias was assessed using Harman's single-factor test on all 34 construct items; the first unrotated factor accounted for 41.4% of total variance, below the 50% threshold associated with substantial common method bias concern (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

A moderated mediation analysis was conducted following Hayes' (2015) conditional process modeling approach (equivalent to PROCESS Model 14), in which Technological Capacity mediates the relationship between Awareness and Organizational Preparedness, and Perceived Adoption Barriers moderates the second stage of this indirect pathway (Technological Capacity → Organizational Preparedness). The index of moderated mediation — the product of the a-path coefficient and the interaction coefficient — was computed and tested for significance using bias-corrected bootstrapped confidence intervals (5,000 resamples), following Hayes (2015). Conditional indirect effects were additionally estimated at low (−1 SD), mean, and high (+1 SD) levels of Perceived Adoption Barriers to characterize the form of the moderated mediation, with each conditional effect accompanied by its own bootstrapped 95% confidence interval. Variance inflation factors (VIF) were computed to rule out multicollinearity among predictors. All analyses were performed in Python (pandas, statsmodels, numpy), with statistical significance set at $\alpha = .05$ and significance for indirect and index effects determined by whether the bootstrapped 95% confidence interval excluded zero.

3. RESULTS

3.1 Descriptive Statistics, Reliability, and Common Method Bias

Table 1 presents the descriptive statistics for the four study constructs (N = 99). Technological Capacity recorded the highest mean rating (M = 3.83, SD = 0.77), followed by Barriers (M = 3.68, SD = 0.69), Organizational Preparedness (M = 3.67, SD = 0.71), and Awareness (M = 3.42, SD = 0.95), which also showed the greatest response variability. All four constructs demonstrated excellent internal consistency ($\alpha = .90$–$.95$), supporting the reliability of the composite scores used in subsequent analyses.

Table 1. Descriptive Statistics and Reliability of Study Constructs

Construct	Items	M	SD	α
Awareness	4	3.42	0.95	.923
Technological Capacity	6	3.83	0.77	.902
Organizational Preparedness	12	3.67	0.71	.928
Barriers	12	3.68	0.69	.945

Harman's single-factor test was conducted to assess the risk of common method bias, given the self-report nature of all measures. The first unrotated factor accounted for 41.4% of total variance across the 34 construct items, below the 50% threshold associated with substantial common method bias (Podsakoff et al., 2003), suggesting the observed relationships among constructs are unlikely to be primarily an artifact of shared method variance.

3.2 Correlation Analysis

Table 2 presents Spearman's rank correlations among the four constructs. All relationships were positive and statistically significant ($p < .001$). Technological Capacity showed the strongest association with Organizational Preparedness ($\rho = .711$), suggesting these two constructs are closely intertwined. Notably, Barriers correlated positively — rather than negatively — with all three readiness constructs, most strongly with Organizational Preparedness ($\rho = .558$), indicating that respondents who perceived higher organizational

readiness also perceived greater adoption barriers, rather than the two functioning as opposing forces.

Table 2. Spearman Correlation Matrix

	Awareness	**Tech Capacity**	**Org Preparedness**	**Barriers**
Awareness	1.000			
Tech Capacity	.391**	1.000		
Org Preparedness	.400**	.711**	1.000	
Barriers	.433**	.514**	.558**	1.000

Note. ***p* < .001*

3.3 Test of Moderated Mediation (H1–H4)

A moderated mediation analysis was conducted following Hayes' (2015) conditional process modeling approach, in which Technological Capacity mediates the relationship between Awareness and Organizational Preparedness, with Perceived Adoption Barriers moderating the second-stage path (Technological Capacity → Organizational Preparedness).

First-stage (a) path. Awareness significantly predicted Technological Capacity ($b = 0.288$, $SE = 0.077$, $t = 3.74$, $p < .001$), supporting H1.

Second-stage (b) path, with moderation. In the full conditional process model, Technological Capacity significantly predicted Organizational Preparedness ($b = 0.620$, $SE = 0.067$, $p < .001$), supporting H2. The interaction between Technological Capacity and Perceived Adoption Barriers was also significant ($b = 0.158$, $SE = 0.076$, $p = .040$), indicating that the strength of the Technological Capacity → Organizational Preparedness relationship depends on the level of Perceived Adoption Barriers. The direct effect of Awareness on Organizational Preparedness, controlling for Technological Capacity, Barriers, and their interaction, remained non-significant ($b = 0.012$, $SE = 0.053$, $p = .823$) (Table 3). The full model explained a substantial proportion of variance in Organizational Preparedness, $R^2 = .628$ (adjusted $R^2 = .612$), with all variance inflation factors below 1.5 (range: 1.06–1.49), indicating no multicollinearity concerns.

Table 3. Full Conditional Process Model (Model 14) Predicting Organizational Preparedness

Predictor	**b**	**SE**	**t**	**p**
Awareness (direct effect, c')	0.012	0.053	0.22	.823
Technological Capacity (b-path)	0.620	0.067	9.19	<.001
Perceived Adoption Barriers	0.164	0.078	2.09	.039
Technological Capacity × Barriers	0.158	0.076	2.08	**.040**

Index of Moderated Mediation. To formally test whether the *indirect effect* of Awareness on Organizational Preparedness (through Technological Capacity) varies significantly across levels of Perceived Adoption Barriers — rather than treating mediation and moderation as separate, independent findings — the index of moderated mediation was computed (product of the a-path coefficient and the interaction coefficient) and tested using bias-corrected bootstrapped confidence intervals (5,000 resamples). The index was significant: 0.046, 95% CI [0.002, 0.152], confirming genuine moderated mediation and directly supporting H3 and H4 jointly — the mediating role of Technological Capacity is itself conditional on the level of Perceived Adoption Barriers (Table 4).

Table 4. Conditional Indirect Effects of Awareness on Organizational Preparedness at Levels of Perceived Adoption Barriers

Level of Barriers	**Conditional Indirect Effect**	**95% CI**
Low (−1 SD)	0.147	[0.026, 0.290]
Mean	0.178	[0.059, 0.330]
High (+1 SD)	0.210	[0.078, 0.384]
Index of Moderated Mediation	**0.046**	**[0.002, 0.152]**

The conditional indirect effect was significant at all three levels of Perceived Adoption Barriers, and its magnitude increased as Barriers increased — indicating that Technological Capacity's mediating role becomes progressively stronger among respondents who perceive greater adoption barriers.

3.4 Summary of Hypothesis Testing

Table 5. Summary of Findings

Hypothesis	**Result**
H1: Awareness → Technological Capacity	Supported
H2: Technological Capacity → Organizational Preparedness	Supported
H3: Technological Capacity mediates Awareness → Organizational Preparedness	Supported
H4: Perceived Adoption Barriers moderates the indirect effect (moderated mediation)	**Supported** — index of moderated mediation significant (0.046, 95% CI [0.002, 0.152])

Summary of Findings is presented on Table 5.

4. DISCUSSION

4.1 Interpretation of the Moderated Mediation Effect

Unlike the earlier draft, which reported mediation and moderation as separate findings, the revised analysis formally confirms **moderated mediation**: the index of moderated mediation was significant (0.046, 95% CI [0.002, 0.152]), meaning the indirect pathway from Awareness to Organizational Preparedness through Technological Capacity is itself conditional on the level of Perceived Adoption Barriers, rather than being a fixed effect that simply co-occurs with a separate moderation finding. The conditional indirect effect strengthened monotonically across levels of Perceived Adoption Barriers — from 0.147 at low barrier-perception to 0.210 at high barrier-perception — indicating that the conversion of awareness into organizational readiness, via technological capacity, becomes progressively more efficient among professionals who perceive greater adoption obstacles.

4.2 A More Careful Theoretical Account of the Positive Moderation

The earlier "informed readiness" framing described this pattern without offering a mechanism for *why* barrier perception would strengthen, rather than weaken, the capacity-to-preparedness pathway. A firmer theoretical account is available in absorptive capacity theory (Cohen & Levinthal, 1990), which holds that an organization's or individual's capacity to recognize the value of external information, and to convert that recognition into productive action, depends on their existing level of related knowledge and capability. Applied here, this suggests that only professionals or firms with sufficient technological capacity are positioned to translate barrier-recognition into concrete preparedness activity, such as risk-mitigation planning, vendor evaluation, or workflow adaptation. Among respondents with low technological capacity, recognizing a barrier (e.g., regulatory uncertainty or limited technical expertise) may simply register as a reason for inaction, whereas among those with higher technological capacity, the same recognition can be absorbed and acted upon, feeding directly into organizational preparedness. This reframing shifts the explanation from a descriptive pattern ("aware people are also prepared people") to a mechanism grounded in established organizational learning theory.

This interpretation is also consistent with, and extends, prior findings that perceived-cost and barrier-type constructs in blockchain adoption research function as conditioning variables rather than simple negative predictors — for instance, perceived cost was found to moderate, rather than mediate, the relationship between technology-readiness factors and blockchain adoption intention in a UAE-based study , with the enablers construct identified as the most important factor in shaping adoption intention despite the presence of perceived-cost concerns. Read through an absorptive capacity lens, this earlier finding and the present study's result both suggest that barrier-type constructs interact with underlying capability, rather than acting as independent deterrents.

4.3 Reconsidering the Operationalization of "Perceived Adoption Barriers"

A further consideration concerns the construct itself. As detailed in the Methodology, item-level review indicated that the twelve items comprising this scale span more than TOE's environmental context alone: items such as regulatory uncertainty and absence of industry standards are genuinely external and environmental, while items such as limited technical expertise and dependence on paper-based systems reflect internal organizational or technological limitations. This construct breadth means the significant moderation effect should be interpreted as reflecting a general perceived-obstacle orientation — encompassing both external and internal barriers — rather than a narrowly defined environmental-context effect in the strict TOE sense. This is not presented as invalidating the finding; rather, it clarifies what is actually being tested: the moderation result indicates that professionals with a broader, more differentiated awareness of *all* categories of adoption obstacles (not environmental barriers specifically) are those in whom technological capacity most decisively shapes organizational preparedness. Future studies employing a TOE-partitioned barriers scale — distinguishing environmental, organizational, and technological sub-barriers explicitly at the item level — would allow a more precise test of whether this moderation effect is driven specifically by environmental barriers, or by the construct's broader obstacle-perception content, as the present data suggests.

4.4 Ruling Out Common Method Bias as an Alternative Explanation

Because all constructs were measured via self-report on the same instrument and at the same point in time, one plausible alternative explanation for the positive correlations observed — including between Perceived Adoption Barriers and the other constructs — is common method bias, whereby respondents with a general tendency to rate items highly (or critically) inflate relationships that would not otherwise exist. Harman's single-factor test indicated that a single factor accounted for only 41.4% of total variance across all items, below the 50% threshold conventionally used to flag substantial common method bias concern (Podsakoff et al., 2003). While this does not rule out common method variance entirely, it suggests the moderated mediation effect is unlikely to be primarily an artifact of shared method

variance, lending greater confidence to the absorptive capacity-based interpretation offered above.

4.5 Comparison with Existing TOE-Based Models

The finding that Technological Capacity positively predicts Organizational Preparedness is consistent with TOE-based studies elsewhere identifying organizational readiness as a significant positive predictor of blockchain adoption intention . At the same time, at least one prior study found organizational readiness to have a small negative effect on perceived usefulness of blockchain among construction practitioners, attributed to resistance stemming from the operational changes blockchain adoption would require . These divergent findings, together with the present study's more granular moderated-mediation result, reinforce that readiness-related relationships in blockchain adoption research are conditional and context-dependent, varying by how constructs are operationalized, by sector, and potentially by underlying absorptive capacity differences across study populations — a consideration prior studies in this area have not directly tested.

4.6 Theoretical Contributions

This study contributes to TOE-based blockchain adoption literature in three ways. First, it provides a formally tested demonstration of moderated mediation — rather than mediation and moderation treated as separate effects — clarifying that the technological-to-organizational readiness pathway is itself conditional, not fixed. Second, it introduces absorptive capacity theory (Cohen & Levinthal, 1990) as a mechanism explaining why barrier perception strengthens, rather than weakens, this pathway, offering a more theoretically grounded account than a purely descriptive interpretation. Third, it offers a transparent, critical reassessment of how "environmental" barrier constructs are operationalized in TOE-based survey instruments, highlighting that barrier scales may capture a broader, multi-dimensional obstacle-perception construct rather than a theoretically pure environmental-context measure — a methodological caution relevant to future TOE-based instrument design.

4.7 Practical Implications

For construction firms, these findings suggest that capacity-building investments should be prioritized specifically among professionals who already demonstrate awareness of adoption barriers, since this is the group in whom capacity-building is likely to yield the greatest gains in organizational preparedness. Firms should avoid treating barrier-aware staff as resistant to change; rather, these individuals may possess the absorptive capacity needed to convert barrier recognition into concrete readiness planning, and may be well-positioned to lead pilot initiatives or serve as internal champions for blockchain adoption efforts.

4.8 Limitations

This study's findings should be interpreted in light of several constraints. The convenience sampling approach and Bataan-specific geographic scope limit generalizability to other regions or national contexts. The cross-sectional, self-report design cannot establish causal directionality with certainty, despite the moderated-mediation modeling employed. As discussed above, the Perceived Adoption Barriers construct, while internally consistent, spans multiple conceptual dimensions (environmental, organizational, and technological) at the item level, limiting the precision with which this study's findings can be mapped onto TOE's environmental-context dimension specifically. Finally, as this study reanalyzes existing survey data under a new theoretical and statistical framework, the original instrument was not purpose-built to measure TOE constructs or to support conditional process modeling, which may limit the precision of construct-to-theory alignment relative to an instrument designed explicitly for this purpose.

5. CONCLUSION

This study examined the readiness of the construction industry in Bataan for blockchain technology adoption through a Technology-Organization-Environment (TOE) lens, testing a formally specified moderated-mediation model among 99 construction professionals. The findings confirmed that Technological Capacity mediates the relationship between Awareness and Organizational Preparedness, and — critically — that this indirect pathway is itself conditional on the level of Perceived Adoption Barriers, as confirmed by a significant index of moderated mediation (0.046, 95% CI [0.002, 0.152]). The conditional indirect effect strengthened as perceived barriers increased, indicating that the conversion of awareness into organizational readiness, through technological capacity, becomes more pronounced among professionals who perceive greater adoption obstacles.

Drawing on absorptive capacity theory (Cohen & Levinthal, 1990), this pattern is best understood as reflecting a capability-dependent process: professionals and firms with sufficient technological capacity are positioned to convert barrier-recognition into concrete preparedness action, while those with limited capacity may recognize the same barriers without being able to act on them. Common method bias was assessed and found unlikely to primarily explain these results (Harman's single-factor test, 41.4% variance explained by one factor), lending confidence to this substantive interpretation. At the same time, item-level review of the Perceived Adoption Barriers construct revealed that it spans environmental, organizational, and technological dimensions rather than representing a theoretically pure measure of TOE's environmental context alone — a finding that refines, rather than undermines, the study's

contribution by clarifying precisely what the moderation effect represents.

Together, these findings reframe blockchain readiness in the construction industry not as a linear accumulation of awareness, but as a conditional, capacity-driven process whose strength depends on the breadth of obstacles professionals perceive — offering a more precise and theoretically grounded account than earlier descriptive readiness assessments in this research area.

6. RECOMMENDATIONS

6.1 For construction firms:

- Prioritize technological capacity-building — digital infrastructure, staff training, and systems integration — over general awareness campaigns, since capacity is the mechanism through which awareness converts into organizational readiness, and this conversion is strongest precisely among staff who already perceive adoption barriers clearly.
- Identify and engage employees who demonstrate strong awareness of adoption barriers (cost, technical expertise, integration challenges, regulatory uncertainty) as potential leads for pilot programs, since absorptive capacity theory suggests these individuals are best positioned to convert that awareness into concrete organizational readiness activity.
- Firm leadership should pair awareness-building initiatives with concrete capacity investment concurrently, rather than treating the two as sequential phases, given that the benefit of capacity-building is conditional on the presence of barrier awareness.

6.2 For industry associations and policymakers:

- Design blockchain readiness programs that combine technical skills training with infrastructure support, rather than standalone information/awareness seminars, given that awareness alone showed no direct effect on preparedness once capacity was accounted for.
- Support the development of clearer regulatory and industry standards for blockchain use in construction, since regulatory uncertainty and absence of industry standards were among the environmental-type barriers captured within this study's broader adoption-barriers construct.

6.3 For future research:

- Future studies should develop or validate a TOE-partitioned barriers instrument that distinguishes environmental, organizational, and technological sub-barriers explicitly at the item level, to test whether the moderation effect identified in this study is driven specifically by environmental barriers or by the broader, multi-dimensional obstacle-perception construct used here.
- Future studies should test this moderated-mediation model longitudinally to establish directional and causal claims that the current cross-sectional design cannot fully support.
- Comparative studies across regions beyond Bataan, or across ASEAN construction sectors, would help establish whether the capacity-mediation and barrier-moderation patterns observed here generalize beyond this study's geographic and sampling scope.
- Future research should explicitly test absorptive capacity as a measured construct, rather than as an interpretive lens applied post hoc, to more directly verify the mechanism proposed in this study's Discussion.

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