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DETERMINANTS TO BLOCKCHAIN TECHNOLOGY ADOPTION: A SURVEY IN VIETNAM CONSTRUCTION ENTERPRISES

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Abstract. In recent years, blockchain technology has demonstrated significant potential benefits for the construction industry, yet its adoption remains limited. This study investigates the determinants influencing blockchain adoption within construction organizations in Vietnam. The research combined Technology Acceptance Model (TAM) and Technology–Organization–Environment (TOE) framework to identify and organize determinants into latent constructs including technology, organization and environment dimensions. A questionnaire was developed to collect data from 122 construction practitioners, the model was then empirically tested and validated through using structural equation modeling (SEM). The results indicate that technological factors significantly affect users' perceived usefulness and perceived ease of use regarding blockchain technology. In contrast, organizational and environmental factors do exhibit no significant impact on perceived ease of use. Moreover, perceived usefulness emerges as a critical determinant of user acceptance of blockchain technology. Collectively, these insights contribute to valuable data to develop a roadmap for promoting blockchain implementation in the Vietnamese construction industry.

Keywords: blockchain technology; technology acceptance model; TOE; structural equation modeling; construction industry; adoption factors.

1. INTRODUCTION

Amid the 4.0 Industry context, technological innovation has become a strategic priority to enhance the competitiveness of the Vietnamese construction industry. Wherein, blockchain technology appears as a revolutionary solution by enabling secure, transparent, and tamper-proof data management across decentralized systems compared to traditional transaction systems [1,2]. In the construction industry, blockchain applications vary, such as smart contract automation, secure information sharing, and enhanced traceability across the supply chain and building lifecycle [3,4]. Nevertheless, the adoption of blockchain remains limited, primarily rooted in entrenched reliance on manual practices and an inherent reluctance among stakeholders to embrace technological change. Thus, these characteristics have contributed to a growing innovation gap between Vietnam and more technologically advanced economies. Collectively, a comprehensive examination of the underlying causes of resistance is essential to inform strategic interventions aimed at accelerating blockchain adoption and fostering sustainable technological progress within the Vietnamese industry.

In this responses, numerous studies have been conducted to examine the factors influencing blockchain technology adoption in the construction industry. However, previous studies have shown a limited comprehensive theoretical foundation, thereby reduced the reliability and constrained managerial decision-making from an enterprise-centric perspective. Thus, a consolidated, theory-driven model that explicitly links user-acceptance constructs to organizational capabilities and environmental contingencies is needed to isolate firm-level determinants of adoption and translate them into actionable levers for policy and management. Thus, such a model can guide targeted interventions (e.g., capability building, incentive realignment, standards alignment, and change-management programs) that accelerate diffusion, lower implementation risk, and ultimately bridge Vietnam's development gap in construction management.

To this end, the objectives of this study are to identify and examine influence factors to blockchain adoption within construction organization. To achieve these research objectives, the following research questions were posed:

- RQ1. What are the influence factors to blockchain adoption in construction?
- RQ2. What are the effects of these factors on blockchain adoption in construction?

This research combines the TOE framework with the TAM to explore the factors influencing blockchain technology adoption in construction firms. The integration of these models enhances the conceptual framework, offering a broader understanding of the key players involved in blockchain adoption. Empirical data was gathered from industry professionals, and the model was validated through SEM. The findings of this study provide strategic recommendations that promote technological advancements in Vietnam's construction industry.

This paper is structured as follows: Section 2 presents a review of the relevant literature, highlighting the challenges identified in previous studies. Section 3 details the proposed research model and the hypotheses developed to examine the factors impacting blockchain technology adoption in construction companies. Section 4 provides the empirical findings associated with comprehensive discussions. Finally, Section 5 and 6 concludes the study by summarizing the key insights and implications.

2. LITERATURE REVIEW

2.1. Blockchain technology and its applications in the built environment

Blockchain is a distributed ledger that records digital transactions in an append-only sequence of programmatically defined "blocks." Each block carries a unique cryptographic hash and a tamper-evident timestamp, linking it to its predecessor and producing an auditable chain of records. This design underpins a network that is transparent, verifiable, and highly resistant to unauthorized alteration, thereby promoting shared accountability for data integrity among participants [5,6]. As outlined by Mansfield-Devine (7), blockchains are commonly classified by their permissioning and governance arrangements namely, who may join the network and who validates transactions into public, private, and consortium systems. Public (permissionless) blockchains permit open participation and pseudonymous access to the ledger, whereas private and consortium (permissioned) variants restrict membership and validation rights, characteristics that often make them preferable for industrial deployments [8,9].

Building on these foundational mechanisms, interest in blockchain as a lever for construction-sector productivity has accelerated in both research and practice. Numerous studies have advanced this research trajectory by proposing blockchain-enabled frameworks and prototypes for specific use cases, including: (1) secure progress claims and payment workflows [10, 11]; (2) smart-contract architectures to streamline information exchange [12, 13]; (3) BIM-integrated, collaborative design environments [14,15]. Collectively, this trajectory indicates a maturing research landscape moving from conceptual promise toward targeted, domain-specific implementations.

2.2. Previous studies on blockchain technology adoption

In light of this trend, blockchain technology adoption has become a focal point for scholars and practitioners because of its demonstrated potential to strengthen construction management. Thus, numerous studies have analysed the determinants of this technology uptake aimed at improving productivity in the built environment. For instance, Li, Zhang (16) employed a hybrid approach combining Partial Least Squares Structural Equation Modelling (PLS-SEM) to assess determinants of blockchain adoption in construction industry. They highlighted factors such as compatibility, top management support, and regulatory support as significant influencers. Nevertheless, the study's cross-sectional design and limited geographic scope may affect the generalizability of the results. In the same efforts, Wang, Liu (17) leveraged TAM model to explore blockchain adoption drivers in the construction industry. Their research indicated that perceived usefulness and ease of use significantly impact adoption intentions. However, the study still not addresses environmental factors, potentially limiting its comprehensiveness. Singh, Kumar (18) employed fuzzy sets based DEMATEL to investigate barriers to the adoption of Blockchain technology in Indian construction supply chain management. They identified market-related risks, significant expenses for sustaining sustainability, and the use of Blockchain in the underground economy as the primary obstacles to its adoption. In the same manner, Xu, Chong (19) interviewed 11 industry practices based DEMATEL approach to model barriers to blockchain technology adoption in China. Their findings revealed that the lack of information technology infrastructure and legal and regulatory uncertainty are the most prominent barriers in this country. However, researchers highlighted studies based DEMATEL are challenged by subjectivity in expert judgements, thereby posing potential biases and less interpretable [20].

2.3. Research gaps

Despite substantial efforts have been conducted to examine blockchain technology adoption within the construction sector, the literature reveals several gaps. First, many studies often neglect or oversimplify proper theoretical models and/or insufficient samples, which weakens measurement validity, constrains causal inference, and limits the practical applicability of findings for construction enterprises. Second, the reliability and validity of these models are uncertain because of the constraints in their theoretical frameworks and methodological rigor. Third, prior works still not provide a comprehensive discussion of the determinants of blockchain adoption in construction organizations, that is, how technological, organizational, and environmental factors collectively shape adoption strategies within enterprises. To address these gaps, this study implements a mixed- research methods design to examine the determinants of blockchain technology adoption to respond to the study's two guiding research questions

3. RESEARCH METHODS

3.1. Theoretical framework

Technology acceptance model: Proposed by Davis (21), TAM posits that two belief constructs: perceived usefulness (PU) and perceived ease of use (PEOU) that shape users' attitude and behavioural intention, which in turn predict actual use. PU reflects the extent to which a technology improves task performance, while PEOU captures the effort required to learn and operate it (e.g., usability of field apps). External variables (training, interface quality, prior experience, social norms) influence PU/PEOU, allowing researchers to test targeted interventions. Therefore, TAM has been widely implemented to understand users' behaviors to ICT adoption in construction management [22].

Technology-Organization-Environment: Utterback (23) conceptualized adoption decisions within enterprises as a function including three contextual dimensions: technology, organization, and environment (TOE). The framework positions firm choices at the intersection of internal capabilities and external pressures, enabling multi-level diagnosis that extends beyond individual attitudes. Applied to blockchain, TOE clarifies why ostensibly "useful" tools may stall: binding organizational constraints and environmental uncertainties can impede diffusion despite favourable user perceptions. Nevertheless, Awa, Ukoha (24) argued its potential construct sprawl and collinearity; this is best mitigated through disciplined operationalization and by pairing TOE with user-level models to achieve theory-complete, managerially actionable explanations.

3.2. Questionnaire design and data collection

Grounded by these theoretical frameworks, this study employed a structured questionnaire designed to capture both demographic information and key variables related to users' intentions to adopt blockchain technology. Initially, a comprehensive literature review was conducted to identify 20 potential determinants influencing blockchain adoption in the construction industry. These factors were then evaluated through semi-structured interviews with three experienced construction management experts in Vietnam to verify their contextual relevance and appropriateness. During the interviews, the experts assessed each item on clarity, accuracy, and suitability for the Vietnamese construction context. Based on their feedback, 15 determinants were retained as the most relevant for further analysis (Table 1).

Then, we developed the final questionnaire, which comprised two sections: (1) demographic and organizational background information, and (2) measurement items representing the identified determinants of blockchain adoption. All items were rated on a five-point Likert scale ranging from 1 (“strongly disagree”) to 5 (“strongly agree”). Before full-scale distribution, the questionnaire was pilot-tested with ten industry professionals and three academic reviewers to ensure clarity, content validity, and reliability. This iterative development process ensured that the instrument was both contextually grounded and methodologically robust.

A total of 200 questionnaires were distributed to contractors’ company in Vietnam, because they play a central role in project delivery and information coordination across the construction supply chain regarding manage contracts, payments, and material flows, which core processes where blockchain applications traceability are most relevant for assessing adoption determinants. This resulted in 122 valid responses for analysis. Figures 1 and 2 summarize the professional characteristics of the respondents. As illustrated in Figure 1, the sample encompassed a diverse cross-section of Vietnam’s construction industry, including site engineers (26%), senior managers (40%), and company directors (34%). Regarding professional experience (Figure 2), most respondents had 6–10 years of experience (35%), followed by those with 1–5 years (30%). Participants with 11–15 years and more than 16 years of experience accounted for 29% and 6%, respectively. Collectively, this distribution reflects a balanced representation of both managerial and technical perspectives within the Vietnamese construction sector, thereby enhancing the contextual relevance and generalizability of the study’s findings.

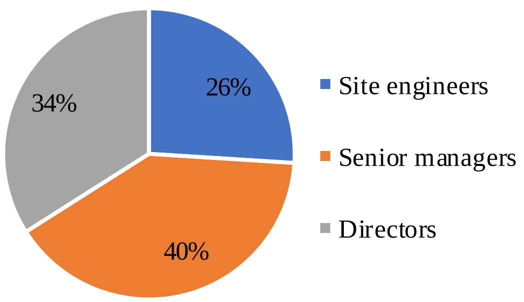

Figure 1: Respondent’s working positions.

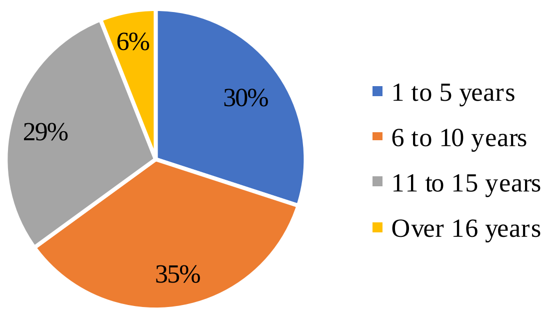

Figure 2: Respondent’s working experience.

3.3. Research model and hypothesis development

Figure 3 presents the SEM model in this study. According to Chatterjee, Rana (25), the variable attitude was found to have an insignificant impact on technology adoption models. Moreover, the proposed research model prioritizes behavioural intention over actual behaviours and other variables, as it has been consistently identified as a robust predictor of technology adoption in the construction sector [26]. Consequently, in this research, non-essential factors were excluded to streamline the model structure.

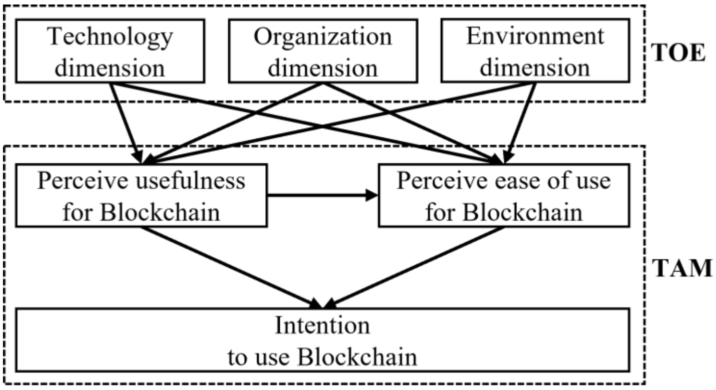

Figure 3: The developed SEM model.

Technological dimension: The technological context encompasses factors such as vendor support, compatibility, complexity, and relative advantage. As noted by Ibrahim, Leng (27), the availability of vendor support significantly enhances the likelihood of successful technological innovation. Furthermore, technologies that are compatible with existing systems and user-friendly tend to accelerate the adoption process. In addition, potential economic benefits and improvements in organizational reputation are critical considerations when evaluating new technology for implementation. Thus, this study proposes the following hypothesis:

- Hypothesis H1a. The technological will positively influence perceived ease of use.
- Hypothesis H1b. The technological will positively influence perceived usefulness.

Organizational Dimension: The organizational context includes factors such as infrastructure, financial resources, organizational culture, and workforce readiness, all of which influence the adoption of new technologies [28]. These elements serve as indicators of an organization's preparedness to implement and benefit from technological innovations. Greater availability of internal resources generally facilitates smoother adoption and enhances the practical effectiveness of the technology. Thus, this study proposes the following hypothesis:

- Hypothesis H2a. The organizational will positively influence perceived ease of use.
- Hypothesis H2b. The organizational will positively influence perceived usefulness.

Environmental Dimension: The environmental context encompasses factors such as competitive pressure, regulatory policies, and infrastructure conditions [29]. Competitive pressure drives organizations to adopt innovative technologies in order to maintain market relevance and avoid obsolescence. Additionally, government regulations and the state of supporting infrastructure play a significant role in shaping an organization's adoption decisions. Understanding these external influences is essential for sustaining competitiveness. Thus, this study proposes the following hypothesis:

- Hypothesis H3a. The environmental will positively influence perceived ease of use.
- Hypothesis H3b. The environmental will positively influence perceived usefulness.

Internal Variables of TAM: Within the TAM, PU refers to an individual's belief that using a particular system will enhance their job performance, while PEOU denotes the belief that the system can be operated with minimal effort [21]. Previous research has consistently shown that both PU and PEOU significantly influence an individual's behavioural intention to adopt new technologies. Thus, this study proposes the following hypothesis:

- Hypothesis 4. PEOU positively influences PU.
- Hypothesis 5. PEOU positively influences behavioural intention to adopt blockchain.
- Hypothesis 6. PU positively influences behavioural intention to adopt blockchain.

4. RESULTS

4.1. Reliability and validity

Reliability: Internal consistency was evaluated using Cronbach' s alpha (α) and composite reliability (CR) (Table 1). All constructs exceeded the conventional $\alpha \geq 0.70$ threshold, wherein technology (0.871), organization (0.852), environment (0.851), PEOU (0.811), PU (0.788), and Users' Intention (0.790), indicating acceptable to high reliability of the item sets.

Validity: Convergent validity was assessed via standardized factor loadings, average variance extracted (AVE), and CR. All items loaded substantively on their intended constructs meeting the common ≥ 0.70 threshold. AVE exceeded 0.50 threshold for every construct, wherein technology (0.551), organization (0.522), environment (0.767), PEOU (0.701), PU (0.712), and Intention (0.722), indicating that each latent variable explains more than half of the variance in its indicators, thereby validating the structural model.

Table 1. Convergent validity results

Variables	Items	Factor loading	Cronbach's α	Composite reliability (CR)	AVE
Technology	TE1	0.821	0.871	0.941	0.551
	TE2	0.778			
	TE3	0.712			
Organization	OR1	0.856	0.852	0.860	0.522
	OR2	0.851			
	OR3	0.875			
Environment	EN1	0.913	0.851	0.900	0.767
	EN2	0.887			
	EN3	0.833			
Perceived ease of use	PE1	0.912	0.811	0.914	0.701
	PE2	0.877			
Perceived usefulness	PU1	0.865	0.788	0.826	0.712
	PU2	0.791			
Users' intention	IN1	0.845	0.790	0.916	0.722
	IN2	0.770			

Discriminant validity: Discriminant validity was assessed using the criterion presented in Table 2. The square roots of the AVE for each latent construct (diagonal entries: TE = 0.742, OR = 0.723, EN = 0.876, PU = 0.844, PEOU = 0.837, IN = 0.850) all exceed their corresponding inter-construct correlations (off-diagonal cells). This suggests that each construct exhibits greater variance with its own indicators compared to other constructs, fulfilling the necessary criterion and confirming the discriminant validity of the measurement model.

Model fit: Overall model adequacy was assessed using multiple indices (Table 3). The ratio of chi-square to degrees of freedom indicates acceptable absolute fit (X^2/df = 2.121, criterion < 3.0). The RMR = 0.075 falls below the 0.10 threshold, further supporting absolute fit, while the GFI = 0.880 approaches the conventional 0.90 benchmark and exceeds the > 0.80 criterion. For incremental fit, the CFI = 0.915 surpasses the 0.90 standard. Taken together, these indicators suggest that the proposed measurement/structural specification provides an acceptable representation of the observed data.

Table 2. Discriminant validity results.

Variables	TE	OR	EN	PU	PEOU	IN
TE	0.742					
OR	0.254	0.723				
EN	0.344	0.325	0.876			
PU	0.388	0.322	0.322	0.844		
PEOU	0.278	0.185	0.178	0.318	0.837	
IN	0.341	0.151	0.261	0.251	0.222	0.850

Table 3. Evaluation of fit indices results.

Factors	Criteria	Measurement
X^2/df	< 3.0	2.121
RMR	< 0.1	0.075
GFI	> 0.8	0.880
CFI	> 0.9	0.915

4.2. Hypothesis testing results

Table 4 provides a comprehensive summary of the results from the hypothesis testing of the structural equation model, examining the influence of external and internal factors on blockchain technology adoption. The analysis reveals that technological factors have a statistically significant and positive impact on both PEOU and PU, confirming hypotheses H1a and H1b. Specifically, the relationship between technology and PEOU showed a standardized coefficient of 0.214 (t = 2.930, p = 0.004), which is well above the 0.05 significance threshold, supporting the idea that technological factors improve the ease of use of blockchain. Similarly, technology's positive influence on PU is reflected in a standardized coefficient of 0.211 (t = 2.778, p = 0.004), further supporting the significant role of technology in enhancing the perceived usefulness of blockchain for potential users.

Table 4. Structural equation model results.

Hypotheses	Relationship			Estimate	CR	ρ -Value	Result
H1a	PEOU	←	TE	0.214	2.930	0.004	Supported
H1b	PU	←	TE	0.211	2.778	0.004	Supported
H2a	PEOU	←	OR	0.165	1.561	0.126	Not supported
H2b	PU	←	OR	0.241	3.189	0.001	Supported
H3a	PEOU	←	EN	0.145	0.122	0.215	Not supported
H3b	PU	←	EN	0.213	2.891	0.002	Supported
H4	PU	←	PEOU	0.143	2.156	0.041	Supported
H5	IN	←	PEOU	0.156	2.149	0.030	Supported
H6	IN	←	PU	0.371	3.245	0.001	Supported

Notes: *SE is standardized Error, CR is Critical Ratio (t-value), ρ-Value is significant at the level of 0.05*

In contrast, organizational and environmental factors demonstrated a mixed effect on adoption. Organizational factors positively influenced PU with a standardized coefficient of 0.241 (t = 3.189, p = 0.001), supporting hypothesis H2b, while environmental factors also significantly influenced PU with a coefficient of 0.213 (t = 2.891, p = 0.002), confirming hypothesis H3b. However, neither organizational nor environmental factors significantly influenced PEOU. The relationship between organizational factors and PEOU was found to be weak, with a coefficient of 0.165 ($t = 1.561$, $p = 0.126$), failing to meet the 0.05 threshold, which led to the rejection of hypothesis H2a. In the same manner, environmental factors had a minimal effect on PEOU, with a coefficient of 0.145 ($t = 0.122$, $p = 0.215$), which is far below the 0.05 significance level, leading to the rejection of hypothesis H3a.

Furthermore, the findings underscore the critical role of PEOU in the blockchain adoption process. PEOU was found to positively influence both PU and IN to adopt blockchain technology. The strongest path was observed from perceived usefulness to intention to adopt, with a standardized coefficient of $\beta = 0.371$ ($t = 3.245$, $p = 0.001$), which is highly significant, suggesting that perceived usefulness is the most influential determinant for behavioural intention. In contrast, the environmental factor's influence on adoption intention was relatively weak, with a standardized coefficient of $\beta = 0.145$ ($t = 0.122$, $p = 0.215$), indicating that it has limited practical significance in the adoption process. This low impact is further evidenced by the non-significant p-value of 0.215, which exceeds the conventional 0.05 threshold for statistical significance.

5. DISCUSSION

The results indicate that technological factors exert significant positive effects on PEOU and PU of Blockchain (H1a, H1b), consistent with prior technology-adoption evidence in adjacent sectors (e.g., telecommunications). In practical terms, attributes such as usability, reliability, interoperability with BIM/ERP, and data security appear to translate directly into user beliefs about effort and performance gains. Organizational factors also show a positive association with PU (H2b), aligning with earlier findings that top-management support, slack resources, training provision, and IT governance increase the perceived performance value of new systems. However, the non-significant H2a (organization → PEOU) departs from evidence reported in China and India, suggesting that in Vietnamese construction firms, structural supports may not yet translate into day-to-day ease likely due to entrenched workflows, resistance to change, subcontractor fragmentation, and uneven digital skills. A mediation test (organization → tech capability → PEOU) and multi-group analyses by firm size/tier could clarify these dynamics [30].

On the environmental dimension, the lack of an effect on PEOU (H3a) is plausible given site-level constraints (intermittent power, variable connectivity, rugged environments) that limit perceived day-to-day ease regardless of external pressure. In contrast, the positive effect on PU (H3b) implies that competitive intensity, client/insurer requirements, and regulatory expectations raise the perceived performance value of Blockchain, even if usage still feels effortful in the field.

Downstream, both PU (H4) and PEOU (H5) significantly drive behavioural intention, and intention predicts use (H6), reinforcing the canonical TAM pathway. For practice, this implies a dual strategy: (1) raise PU via use-cases with measurable ROI (e.g., automated progress payments, immutable QA/QC logs, and auditable safety records) and (2) raise PEOU via UX simplification, mobile-first interfaces, role-based templates, and targeted training. Policy makers and clients can amplify these effects through standards, procurement signals (lifecycle value over lowest bid), and interoperability guidelines.

Thus, future work should incorporate cultural and social variables (e.g., power distance, trust, safety climate), map supply-chain interdependencies (GC–subcontractor–consultant), and test moderation (e.g., environmental turbulence, project type) and serial mediation (technology → PU → intention → use). Given the SME-dominant structure of Vietnam construction sector, sampling across firm size, project delivery methods, and regions will improve external validity, while longitudinal designs can separate intention from habitual use and capture post-adoption stabilization.

6. CONCLUSION

This study examines determinants of Blockchain adoption in construction firms using an integrated research model that combines the TAM and TOE framework. Empirical results indicate that technological, organizational, and environmental conditions significantly shape users' PU of blockchain. Among the modelled pathways, PU emerges as a pivotal driver in the adoption process, underscoring that end users are most responsive when blockchain demonstrably improves task performance (e.g., faster progress payments, auditable records, and reduced disputes). Practically, the findings suggest two complementary levers for industry stakeholders: (1) strengthen technology attributes (reliability, interoperability, security) and organizational supports (leadership commitment, training, governance) to elevate PU; and (2) align external pressures (client standards, regulatory guidance, insurer requirements) to reinforce perceived performance gains. Academically, the study contributes by extending TAM with TOE contingencies in a construction context, offering an empirically validated account of how multi-level factors coalesce to influence blockchain acceptance in the built environment. Although the structural model demonstrated satisfactory reliability and validity, no multi-group or robustness analysis was conducted to test potential differences across respondent subgroups. Such analysis would provide valuable insights into whether the determinants of blockchain adoption vary across organizational hierarchies or firm characteristics. Future studies with more balanced samples are encouraged to perform multi-group SEM or invariance testing to examine these moderating effects more comprehensively.

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