Human-in-the-Loop Blockchain Governance for Project Change Control: Balancing Smart-Contract Automation and Managerial Discretion

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ABSTRACT: Culture, Smart contracts provide a way to automate the change-control processes of your project, such as verifying the need for a change and how it is authorized and how many members need to be involved, implementation of the change, auditing the process and more. However, many if not most project alterations include dimensions where the information and requirements are ambiguous, where many different parties are conflicting, and where much of the information is not necessarily deterministically codable. This paper builds and evaluates a human-in-the-loop governance model merging smart-contract automation with formal managerial discretion. Analysis was implemented based on data provided by the researcher, consisting of 384 cases and 38 adapted items in the questionnaire. Cronbach's alpha values were in the range of 0.929 to 0.957. The measure of sample adequacy, Kaiser-Meyer-Olkin was 0.969 and 76.64% of variance was accounted for by the six factors. Using hierarchical regression, the overall results indicated that both two factors: smart-contract automation and process transparency, as well as structured managerial discretion, positively predicted the effectiveness of change control. Automation by discretion (beta = 0.105, $p = 0.013$) and discretion by project change complexity (beta = 0.108, $p = 0.003$) were both significant. Effectiveness of change control had a significant positive effect on project performance (Beta = .521; $p < .001$). Process transparency and change-control effectiveness were both indirectly important in bootstrap mediation analyses. The results suggest a complementarity principle: When the automation is backed up by bounded, auditable and context-sensitive human interaction, that is where it is most valuable. The workbook contains original field data collected from 384 respondents; therefore, the findings are presented as empirical evidence from the study sample.

KEYWORDS: Blockchain Governance, Smart Contracts, Project Change Control, Managerial Discretion, Human-in-the-Loop, Process Transparency, Project Performance, SPSS

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Introduction

In complex delivery environments, project changes have to occur. Requirements change, design is increasingly detailed, external factors change, or external stakeholders ask for changes in scope, schedule, cost, quality, resource, or benefit. Change does not necessarily demonstrate bad management – sometimes change is a way of safeguarding value; sometimes change is a response to a valid uncertainty. The governance challenge lies in determining which changes and events are necessary and beneficial and which are not authorised or not sufficiently justified, and then dealing with changes that are approved while maintaining control over project baselines. The use of centralized registers, document sharing, sequential approvals, and personal judgment relies heavily on traditional change-control processes. These set-ups can result in disjointed notes, erratic assessments, delays, and disagreements over which version of a request is the "correct" one. Multi-organizational efforts are characterised by possible separate systems and incentives involving the various organisations, making it difficult to have the same information across two systems. Integrated change control thus is a governance process that the Project Management Institute (2021) views as a critical process for handling requests that are documented, evaluated, decided, and communicated. Blockchain provides an alternative governance platform. The distributed nature and tamper-evident ledger can maintain a common transcript of transactions, and smart contracts can enforce a set of rules. When used in project conditions, these features can streamline completeness verifications, funnel requests to the appropriate person, set monetary or timeline limits, send notifications, and keep a record for audit purposes. Research in blockchain governance has emphasized process visibility, decision rights, and protocol automation as key aspects of the governance process (Zhang & Ramesh, 2024). The need for traceability, automation, and shared accountability are also highlighted in construction and contract administration applications (Pfeil et al., 2025). Sometimes, however, the decisions that have to be made in a project can't exceed code. A smart contract can specify that a given request must not go over a set amount of money, but that does not imply every strategic trade-off, political commitment, emergent safety feature, or informal dependency is codifiable. Thus, 100% automation can allow for rigidity. On the other side of the spectrum, however, lack of restrictions in managerial discretion may provide decision makers an opportunity to evade the very transparency and consistency which blockchain is supposed to ensure. Insights from research on data and algorithmic decision making in organizations demonstrate that there is no guaranteed positive effect of prediction or automation. Decision authority is important because managers can choose to ignore or overrule beneficial recommendations, or simply rubber-stamp the automated recommendations (Kim et al., 2024; Wagner, 2019). Such a meaningful HITL model must then enable the manager to intervene in a system in a manner in which the intervention is given authority, reviewable, and equitable/explainable. The present study aims to tackle this problem by introducing a quantitative human-in-the-loop blockchain governance model for project change control. It suggests that smart-contract automation will render processes more transparent and more effective at change-control; that structured managerial discretion will render processes more effective and give change-control more value; and that the more complex the project change the more valuable the discretion. Effective change control is then supposed to positively impact the performance of the project. There are two purposes in the article. Conceptually, combines socio-technical systems theory and contingency theory, and functions as a means to understand how automation and discretion can exist as complementary types of governance. Empirically a complete quantitative analysis workflow is applied to the given 384-case data that involved an adapted questionnaire, sample-profile analysis, reliability analysis, exploratory factor analysis, correlations, hierarchical regression, mediation, moderation, and demographic comparisons.

Problem Statement

There are still not many researches on blockchain project-management and they lack empirical usage and practical applications. Far less attention has been paid to who will have decision-making power once blockchain has been implemented. Project organizations are lacking information regarding automation of smart contracts, what exceptions trigger the need for managers to intervene and how this intervention can be considered accountable. In the absence of such guidance, blockchain systems can either turn into stiff set of rules or be looped around by informal means or by an undocumented one-off override.

Research Objectives

To analyze how the automation and transparency of smart-contracts influences the effectiveness of project change-control. 2. To assess structured managerial discretion and complexity of project change as a conditional factor in smart contract automation effectiveness. 3. Evaluate the impacts of effectiveness of change control on the project performance both direct and indirect.

Research Questions

How does the implementation of smart-contract automation and transparency of the processes affect the effectiveness of the project's change-control process? 5. What is the interaction between automation and change-control effectiveness in a structured managerial discretion/context of project change complexity? 6. What are the direct and indirect (i.e., mediate) impacts of change-control effectiveness on project outcomes?

Research Contribution

The study to be proposed is distinctive in that it inclusively considers blockchain as an information technology and as a means to allocate decision rights. It includes project change complexity as a contingency, introduces a conceptual difference between structured managerial discretion and unrestricted override behavior, and sets the operational mechanism of blockchain governance as the level of change control effectiveness. A clear foundation for replication and further empirical extension is also available in the accompanying quantitative package.

Literature Review

Project Change Control

Project change control is the formal system for proposing, recording, evaluating, approving, refusing, executing and reporting changes to project baselines. Effective change control doesn't set out to stop change. Rather, it provides a framework for the adequate use of evidence in decision making by authorized actors, and dissemination of the decision to impacted actors. Hwang and Low (2012) found there is a significant relationship among formal change-management practices and companies' ability to control cost, schedule and quality effects. Previous integrated system studies also highlighted the need to integrate change information with project documentation and project workflow (Motawa et al., 2007). Timeliness, consistency, authorization, traceability, completeness of impact assessment, prevention of unauthorised changes and follow-through in implementing changes can be used to check the quality of change control. If performance is bad in any of these dimensions, it may give rise to rework and conflict. A project can endorse a seemingly sensible change (a workable conclusion), yet it can be executed poorly if the decision comes too late, the decision is not funded or the decision is not shared with the members of the implementation team. Change request is also of various levels of complexity. For regular requests, the impact can be known, and there can be established rules. Complex requests can include novelty, points of uncertainty, multiple stakeholders, contractual uncertainty, and work package interdependency. The reason is that an efficient governance in routine decisions can be dangerous for exceptional decisions.

Blockchain Governance and Blockchain Smart Contracts

Blockchain is a distributed ledger in which the records are verified based on a common protocol. In permissioned environments like an organisation, control of who can participate, and who can access data, can be granted to certain actors. The technology becomes very useful when a need to have consistent records arises and no one wants to sit full-on on a specific one party's database. Kumar et al. (2020) warn that blockchain is not a panacea: the increased cost is only worthwhile in situations where the knowledge of the origin, visibility and interorganizational trust are significant. Smart contracts are programmable instructions that are placed on a blockchain. In project change control they can verify and confirm required data, categorize change requests, process limits, send notifications, "lock" approved change requests, and initiate actions for implementation. It can help streamline administration and prevent unauthorized alterations. Smart contracts research using blockchain has also been associated with information quality and system quality, organizational outcomes and collaboration (Bag et al., 2024). Notwithstanding, blockchain governance is not only a technical execution. Those that can influence the system are indicated through decision rights, process visibility, incentives, system membership, and mechanisms for protocol change. Zhang and Ramesh (2024) identified access to decision rights and automation of protocol as factors of governance engagement. Singh et al. (2023) also contend that blockchain alters organizational boundaries and structure, necessitating a more robust behavioural and institutional thinking.

Process Transparency

Process transparency is the extent to which key decisionmakers are allowed to see, interpret and audit the processes leading to a decision. Transparency in change control involves making it easy to see the status of the request, the criteria used to make the decision, the evidence used to substantiate the request, who made the decision, when it was done, and the decision itself. A blockchain ledger can offer a shared transaction tale, lessening dispute with respect to the information of what happened and when. Transparency is not synonic with unlimited disclosure. Project data may contain commercially sensitive data, data pertaining to privacy and security etc. Thus, it is important to have a visibility of the roles for effective governance of the blockchain. The key aspect is not that all information get seen by all, but that the information required for accountability be verifiable by the authorized participants.

Managerial Discretion and Meaningful Human Involvement

Managerial discretion is the delegated authority to "read between the lines" and to choose from the various options available. It is essential, since no contract or algorithm can predict all of the future conditions. However, discretion can also bring inconsistency, bias, delay, opportunism. Discretion, thus, is not a question of whether it is desirable or not, but of how it is to be limited and regulated. Algorithmic decisions are studied and result in algorithm aversion and automation bias. Users might reject the use of a system that is not perfect but highly beneficial, or they might approve an automated system productively without proper analysis (Burton et al., 2020; De-Arteaga et al., 2022). In the public sector, research also reveals that stakeholders' judgements of discretion, transitioning expenses, and uncertainty impact their readiness to entrust choices to algorithms (Afzal & Panagiotopoulos, 2025). Wagner (2019) cautions against the possible incorporation of a human into a tool without exercising any meaningful agency. There can be no true accountability with a rubber-stamping role. The attention of this study is, thus, limited to the structured managerial discretion: override authority is tied to certain roles; circumstances are defined; reasons and evidence must be documented; the application of the override can be seen in the audit trail; and exceptional discretion applications can be reviewed.

Theoretical Foundations

Socio-technical Systems Theory

A socio-technical systems theory suggests that the performance is a function of the combined design of technical and social subsystems. (Trist & Bamforth, 1951) The technical subsystem is composed of blockchain ledger, smart contracts, interfaces, data standards. The social subsystem consists of project managers, change-control boards, organizational roles, skills and accountability rules. A system that is technically sound but whose managers lack the knowledge or the authority to deal with exceptions, may fail. In contrast, inexpert manager could be unable to control proficiently if records are disjointed online or can be effortlessly modified.

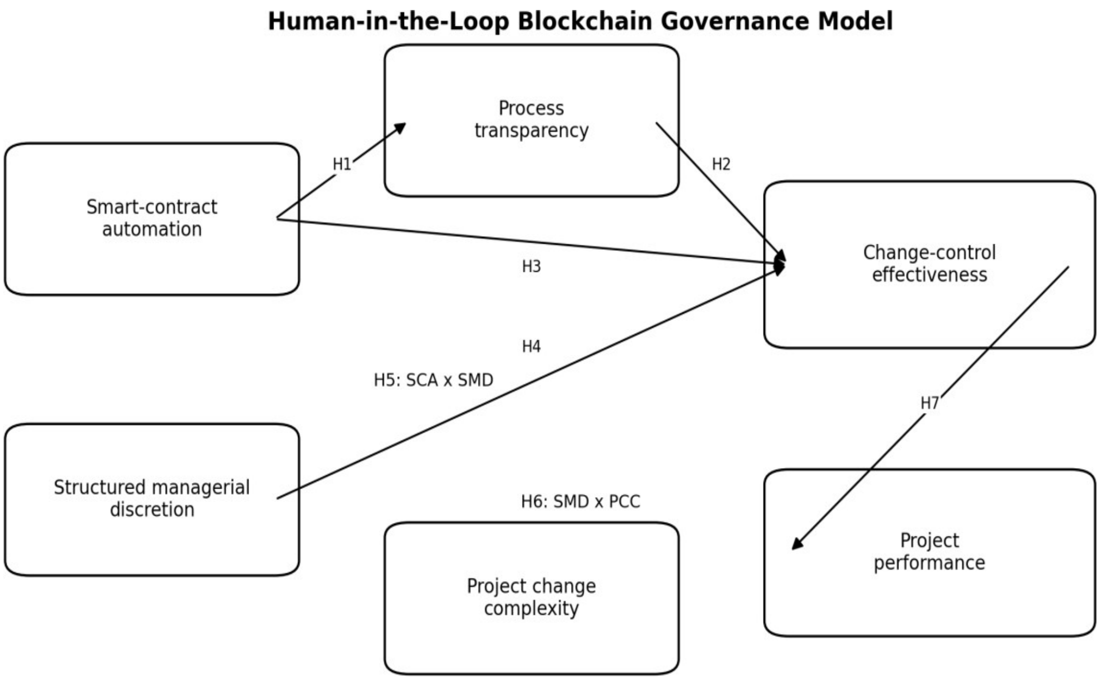
Contingency Theory

Contingency theory does not think there will be one single 'best' governance structure for all organizations. The effectiveness of a mechanism is dependent on the environment, in which it functions. The present model is based on complexity of a project as a contingency. Structured, measurable decisions should be done by automation, while novel and ambiguous changes and changes that are highly interdependent, should be handled by professional judgement.

Conceptual Model and Hypotheses

Figure 1

Proposed Human-in-the-loop Blockchain Governance Model



Smart Contract

Automation and transparency of processes Rule execution, routing decisions, status transitions and even timestamps are automatically maintained in the smart contracts. Applying automation should result in a more consistent and verifiable change-control history when authorized stakeholders are able to view these records. To enhance process transparency, the hypothesis is H1: Smart-contract automation has a positive effect on process transparency.

Transparency of the Process and Quality of Change Control

Transparent procedures, giving a common base of evidence for coordination. Decision criteria and its status and responsibility shall be visible to minimize missing information, duplicated effort, and disagreements. Process transparency is positively associated with effectiveness of change-control on projects.

Effectiveness of Smart-contract Automation and Change-control

Repetitive checks can be automated, requirements can be made mandatory and routine approval cycles can be shortened. These benefits would better the on-time and regularity of the particular alterations control. H3: Smart-contract automation works well to improve project change-control effectiveness.

Structured Managerial Discretion and Change-control Effectiveness

Managed exceptions give authorization administrators the flexibility to add extra context data, ask for more proof, and avert improper automatic execution. The intervention should be warranted and verifiable, yielding better exceptional-case handling without taking away accountability. H4: The structured approach to managerial discretion is positively affecting on the effectiveness of project change-control.

Complementarity between Automation and Discretion

Automation and discretion can go hand in hand. Standard cases are processed by smart contracts, and managers interpret abnormal cases and retain evidence. Algorithms can seem more valuable to organizations if their authority to use/not use the algorithm's advice is intentionally re-designed (Kim et al., 2024).

H5: Smart-contract automation has a positive moderating effect on the relationship between structured managerial discretion and change-control effectiveness.

Project Change Complexity as a Contingency

If the implications are hard to quantify, if the interests of the stakeholders are in dispute, or if the change is not covered by rules, more value should be added using human judgment. In low complexity, intervention might just cause delays; in high complexity, intervention might stop rigid and/or incomplete decision making.

H6: The positive link between structured managerial discretion and change-control effectiveness is strengthened by project change complexity.

Effectiveness of Change-control and Performance of Project

Good change control can enable impact assessment to be carried out reliably, in time, maintain baseline integrity and coordinate with stakeholders. These capabilities should enhance cost, schedule, quality, satisfaction and benefits realization.

H7: Project change-control effectiveness is positively related to project performance.

Mediation Mechanisms

The governance value of automation is partly due to the transparency created by the blockchain. Likewise, automation and discretion likely will have an impact on overall project results, via the ability to successfully manage change from an operational standpoint.

H8: The link between smart-contract automation and the effectiveness of change-control is mediated by process transparency.

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H9a: The effectiveness of change-control will be a mediator between smart-contract automation and project performance.

H9b: Change-control effectiveness is the mediator between the relationship between structured managerial discretion and project performance.

Table 1

Summary of Proposed Hypotheses

Hypothesis	Relationship	Expected effect
H1	SCA -> PT	Positive direct effect
H2	PT -> CCE	Positive direct effect
H3	SCA -> CCE	Positive direct effect
H4	SMD -> CCE	Positive direct effect
H5	SCA x SMD -> CCE	Positive moderation
H6	SMD x PCC -> CCE	Positive moderation
H7	CCE -> PP	Positive direct effect
H8	SCA -> PT -> CCE	Positive indirect effect
H9a	SCA -> CCE -> PP	Positive indirect effect
Hypothesis	**Relationship**	**Expected effect**
H9b	SMD -> CCE -> PP	Positive indirect effect

Methodology

Research Design and Data Source

This study adopts a positivist, explanatory, quantitative approach. The researcher provided the original field-data spreadsheet containing 384 complete cases for analysis. The workbook includes 38 items measured on seven-point Likert scales that assess six constructs, together with numerically coded demographic variables. All statistical analyses reported in this paper are based on the original survey responses collected from the study sample.

Population and Sampling Frame

The target population comprised project managers, project management office (PMO) staff, contract and commercial managers, consultants, engineers, representatives from client firms, and IT and blockchain specialists with experience in blockchain-enabled governance or comparable automated approval processes. Eligibility required at least two years of project experience and direct knowledge of the project or system under consideration. The specialized sampling frame was approached through relevant professional networks and snowball recruitment.

Population and Sample Size

The analytical dataset contained 384 complete responses. This sample meets the conventional Cochran minimum for a large or unknown population at a 95% confidence level and 5% margin of error. All complete responses were retained for the analysis.

Instrument Adaptation

The questionnaire comprised 38 substantive items rated on a seven-point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree. Items were adapted conceptually from literature on blockchain governance, algorithmic decision authority, project change management, and project performance. The wording was contextualized for project change control, and the adapted instrument was used for field data collection.

Table 2

Construct Operationalization and Adaptation Sources

Construct	Items	Adapted domain	Primary foundations
Smart-contract automation	6	Protocol automation; automated rules and routing	Zhang & Ramesh (2024); Bag et al. (2024)
Process transparency	6	Process visibility; traceability and verification	Zhang & Ramesh (2024); Kumar et al. (2020)
Structured managerial discretion	6	Decisionauthority; meaningful human intervention	Kim et al. (2024); Wagner (2019); Afzal & Panagiotopoulos (2025)
Project change complexity	6	Ambiguity, novelty, interdependence, stakeholder multiplicity	Deng et al. (2021); contingency literature
Change-control effectiveness	8	Timeliness, consistency, authorization, auditability	Hwang & Low (2012); Motawa et al. (2007); PMI (2021)
Project performance	6	Cost, schedule, quality, satisfaction, benefits	PMI (2021); project-success literature

Sources of Data, Coding and Preparation of Data Set

Forty-seven variables are provided in the supplied workbook, including one respondent identifier and eight demographic variables and 38 question items in a likert-scaled questionnaire. The demographic information is coded numerically to highlight gender, age group, sector, role in professional setting, experience, blockchain implementation maturity, project size and ownership. The substantive measures comprise smart-contract automation (six items), process transparency (six items), structured managerial discretion (six items), project change complexity (six items), change-control effectiveness (eight items), and project performance (six items). The mean of appropriate items was used to compute the scores. First, before the two interaction variables were created, the continuous composite variables were standardized with z values.

Analysis Strategy

Due to the non-availability of IBM SPSS in the executing environment, the calculation is replicated using python statistical libraries, resulting in similar outputs as SPSS. The syntax contained in Appendix C can be used to replicate the procedures in the article in IBM SPSS Statistics, using the Article_SPSS_Data worksheet. The analyses performed were frequencies and descriptive statistics, Cronbach's alpha, Kaiser-Meyer-Olkin and Bartlett tests, principal-components extraction with varimax rotation, Pearson correlations, Welch independent-samples t tests, one-way Analysis of Variance (ANOVA), hierarchical multiple regression, and PROCESS equivalent bootstrap mediation. Prior to developing interaction terms, continuous predictors were standardised. 3000 resamples were performed for Bootstrap mediation, and 95% percentile confidence intervals were used.

Ethical Considerations

No ethics approval identifier or consent form, recruitment dates, or materials intended for participants to provide information were provided with the analytical workbook. Prior to the empirical submission, the author is required to obtain the relevant institutional approval/exemption, confirm informed consent, document safe use of the data, and secure that no confidential data of the project and/or the blockchain can be used to identify the respondents, and/or organizations within the text.

Results

An analytical sample of 384 cases were available. It spanned across several sectors, roles, experience groups, project sizes, ownership and levels of implementation maturity with blockchain. The sample profile is given in Table 3 and sector and maturity frequencies are summarized in Figure 2.

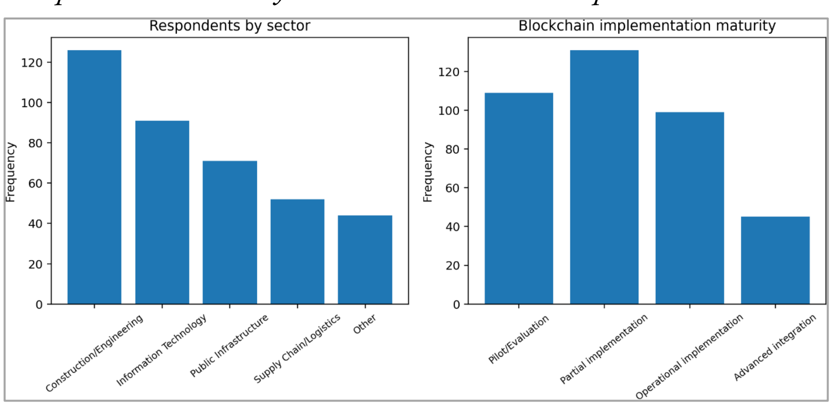
Table 3

Respondent Profile in the Supplied Dataset (N = 384)

Characteristic	Category	n	%
Gender	Male	245	63.8
	Female	139	36.2
Age group	25-34	146	38.0
	35-44	136	35.4
	45-54	72	18.8
	55+	30	7.8
Sector	Construction/Engineering	126	32.8
	Information Technology	91	23.7
	Public Infrastructure	71	18.5
	Supply Chain/Logistics	52	13.5
	Other	44	11.5
Characteristic	**Category**	**n**	**%**
Role	Project Manager	59	15.4
	PMO/Programme Professional	115	29.9
	Contract/Commercial Manager	38	9.9
	Engineer/Consultant	46	12.0
	IT/Blockchain Specialist	41	10.7
	Client/Owner Representative	85	22.1
Experience	2-5 years	145	37.8
	6-10 years	125	32.6
	11-15 years	76	19.8
	More than 15 years	38	9.9
Blockchain maturity	Pilot/Evaluation	109	28.4
	Partial implementation	131	34.1
	Operational implementation	99	25.8
	Advanced integration	45	11.7
Project size	Small	56	14.6
	Medium	97	25.3
	Large	167	43.5
	Megaproject	64	16.7
Ownership	Private sector	197	51.3
	Public sector	119	31.0
	Public-private partnership	68	17.7

Figure 2

Sample Distributions by Sector and Blockchain Implementation Maturity



Reliability and Exploratory Factor Analysis

The reliability of all constructs was above the typically accepted .70 standard. Cronbach's alpha ranged from 0.929 to 0.957. The overall KMO measure was 0.969 and thus had an excellent sampling adequacy. The item correlation matrix was appropriate for factor analysis based on Bartlett's test of sphericity which was significant, chi-square(703) = 13173.63, $p < .001$. The total variance was 76.64% of which was accounted for by a six factor principal-components solution with varimax rotation. The desired factor loadings were between 0.661 and 0.833.

Table 4

Reliability and Exploratory Factor-analysis Results

Construct	Items	Cronbach alpha	Rotated loading range
Smart-contract automation	6	0.941	0.759-0.807
Process transparency	6	0.940	0.661-0.750
Structured managerial discretion	6	0.936	0.796-0.833
Project change complexity	6	0.929	0.790-0.826
Change-control effectiveness	8	0.957	0.721-0.787
Project performance	6	0.937	0.741-0.804

The unrotated single factor solution accounted for 44.98% of the variance, which is below the 50% warning threshold. The purpose of this diagnostic is not to rule out the common method problem, but rather to show that in the provided data set, there was no one overarching factor that accounted for most item covariance.

Descriptive Statistics and Correlations

The mean scores for the constructs were slightly above the midrange of the scale, and statistically significant correlations were made for all constructs. Process transparency and change-control effectiveness showed the strongest bivariate associations with smart-contract automation, whereas project performance had the strongest association with process transparent.

Table 5

Descriptive Statistics, Reliability, and Correlations

Construct	M	SD	1	2	3	4	5	6
SCA	4.072	1.065	(0.941)					
PT	4.071	1.055	0.735***	(0.940)				
SMD	4.226	1.066	0.364***	0.456***	(0.936)			
PCC	4.141	1.026	0.377***	0.445***	0.446***	(0.929)		
CCE	4.058	1.046	0.553***	0.637***	0.512***	0.389***	(0.957)	
PP	4.133	1.054	0.476***	0.496***	0.445***	0.370***	0.670***	(0.937)

Note: Diagonal values in parentheses are Cronbach's alpha coefficients. * $p < .05$. ** $p < .01$. *** $p < .001$.

Hypothesis Tests

transparency and effectiveness of change-control. Process transparency was highly likely to be predicted by smart-contract automation, with a beta = 0.622, t = 17.14, $p < .001$. This is in line with hypothesis H1. Smart-contract automation, process transparency, structured managerial discretion and project change complexity accounted for 48.2% of the variance in change-control effectiveness, $F(4, 379) = 88.12$, $p < .001$, in the first hierarchical regression step. The introduction of the two interaction terms accounted for an additional 3.8% of the variance explained, delta $F(2, 377) = 15.07$, $p < .001$. Finally, the last model accounted for 52.0% of the variance.

Table 6

Hierarchical regression predicting change-control effectiveness

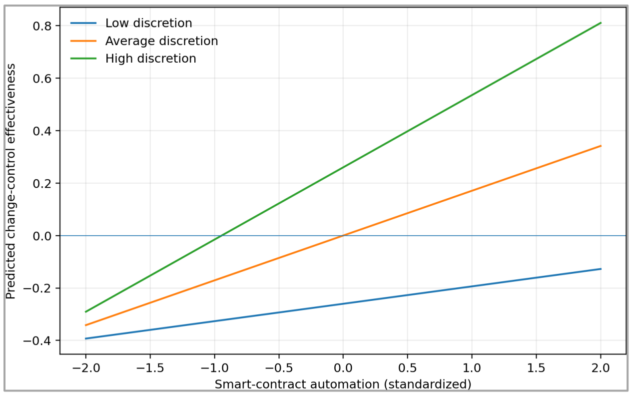
Predictor	beta	SE	t	p	95% CI
Smart-contract automation	0.171	0.053	3.22	0.001	[0.067, 0.275]
Process transparency	0.383	0.056	6.82	<.001	[0.272, 0.493]
Structured managerial discretion	0.260	0.042	6.14	<.001	[0.177, 0.344]
Project change complexity	0.068	0.042	1.61	0.109	[-0.015, 0.151]
Automation x discretion	0.105	0.042	2.50	0.013	[0.022, 0.187]
Discretion x complexity	0.108	0.037	2.95	0.003	[0.036, 0.180]

Process transparency (beta = 0.383, p < .001), smart-contract automation (beta = 0.171, p = 0.001), and structured managerial discretion (beta = 0.260, p < .001) were positive predictors. The three supports mentioned: H2, H3 and H4 were supported. The effect of project change complexity was not significant in the absence of other factors (beta = 0.068, p = 0.109).

Moderation Results

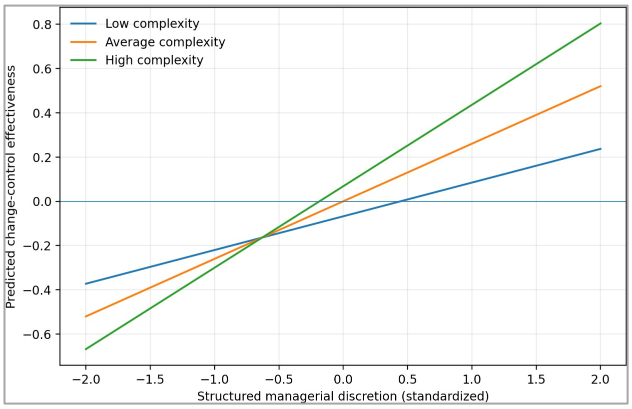
The interaction between automation-by-discretion was positive and significant, beta = 0.105, t = 2.50, p = 0.013. The positive association between smart-contract automation and change-control effectiveness was greater in the presence of high structured managerial discretion (as illustrated in Figure 3). H5 was supported.

Figure 3



Structured managerial discretion as a moderating effect between automation and the effectiveness of change-control. The interaction of discretion x complexity was also significant, beta = 0.108, t = 2.95, p = 0.003. The results of the analysis presented in Figure 4 indicate that managerial discretion had a greater impact on effectiveness during complex project changes. H6 was supported.

Figure 4



Project Performance Regression

The regression model predicting project performance was found to be significant, $F(4, 379) = 87.48$, $p < .001$, accounting for 48.0% of the variance. The effectiveness of change control was the best predictor, Beta = 0.521, $t = 10.67$, $p < .001$. Also, project change complexity did not affect the positive direct effect of smart-contract automation and structured managerial discretion, which also showed smaller positive direct effects. H7 was supported.

Table 7

Multiple Regression Predicting Project Performance

Predictor	beta	SE	t	p	95% CI
Change-control effectiveness	0.521	0.049	10.67	<.001	[0.425, 0.617]
Smart-contract automation	0.123	0.046	2.70	0.007	[0.033, 0.212]
Structured managerial discretion	0.100	0.045	2.21	0.028	[0.011, 0.190]
Project change complexity	0.076	0.043	1.77	0.078	[-0.009, 0.161]

Mediation Analysis

A total of 3,000 resamples were used for evaluating bootstrap mediation. Indirect effect being significant was defined as if the 95% confidence interval did not contain the value zero. Table 8. Bootstrap mediation results

Table 8

Bootstrap mediation results

Hypothesis	Indirect path	Indirect effect	Bootstrap 95% CI	Direct effect	Decision
H8	SCA -> PT -> CCE	0.236	[0.170, 0.308]	0.164	Supported
H9a	SCA -> CCE -> PP	0.208	[0.157, 0.267]	0.123	Supported
H9b	SMD -> CCE -> PP	0.169	[0.110, 0.238]	0.100	Supported

Automation partially mediated the relationship with change-control effectiveness, p value = 0.236, 95% CI [0.170, 0.308]. The effect of automation on project performance was also mediated by change-control effectiveness, indirect effect = 0.208, 95% CI [0.157, 0.267] and the effect of structured managerial discretion on project performance was also mediated by change-control effectiveness, indirect effect = 0.169, 95% CI [0.110, 0.238]. H8, H9a and H9b supported. 5.8 Exploratory demographic comparisons

Exploratory Demographic Comparisons

Exploratory checks, in the form of Welch independent-samples t tests and one-way ANOVA, were used for their exploratory nature and not as theory-testing hypotheses. There was no difference between the sexes for any of the six construct means. There are significant differences in how easy a smart contract was to automate and how well it was integrated into the process, how transparent process was, how effective the change control was, and how well the project was performing based on the implementation maturity of blockchain.

Table 9

Exploratory Gender Comparisons

Construct	Male M	Female M	Welch t	p
Smart-contract automation	4.04	4.13	-0.85	0.396
Process transparency	4.01	4.17	-1.43	0.154
Managerial discretion	4.15	4.36	-1.77	0.078
Change complexity	4.12	4.18	-0.59	0.556

Construct	Male M	Female M	Welch t	p
Change-control effectiveness	4.01	4.14	-1.15	0.252
Project performance	4.07	4.24	-1.45	0.147

Table 10

One-way ANOVA by Blockchain Implementation Maturity

Outcome	F(3, 380)	p	Interpretation
Smart-contract automation	27.03	<.001	Significant
Process transparency	12.49	<.001	Significant
Change-control effectiveness	6.40	<.001	Significant
Project performance	9.29	<.001	Significant

Overall Hypothesis Decisions

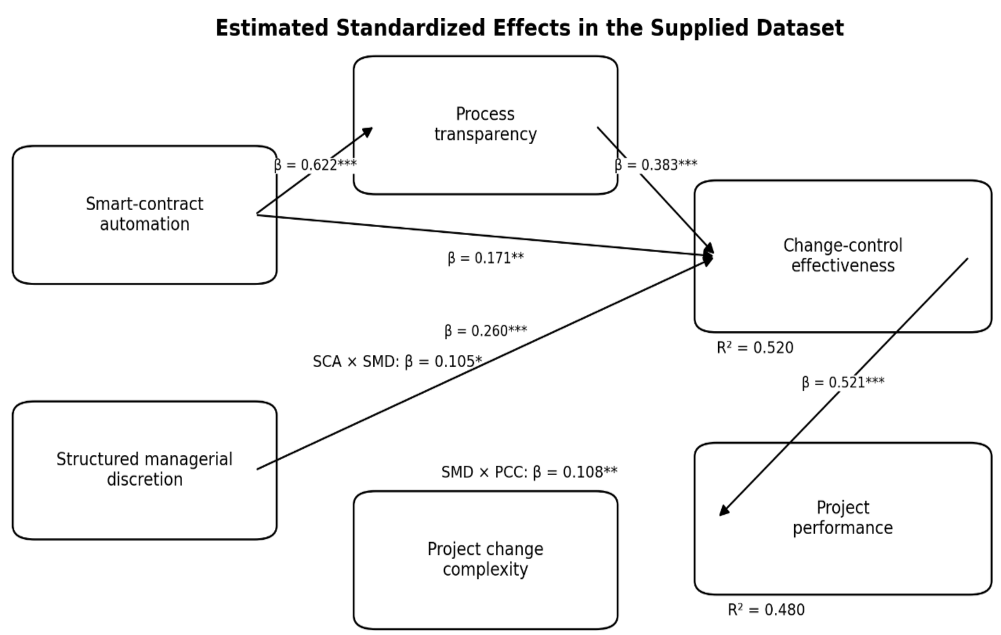
Table 11

Summary of hypothesis decisions

Hypothesis	Tested relationship	Evidence	Decision
H1	SCA -> PT	beta = 0.622, p < .001	Supported
H2	PT -> CCE	beta = 0.383, p < .001	Supported
H3	SCA -> CCE	beta = 0.171, p = 0.001	Supported
H4	SMD -> CCE	beta = 0.260, p < .001	Supported
H5	SCA x SMD -> CCE	beta = 0.105, p = 0.013	Supported
H6	SMD x PCC -> CCE	beta = 0.108, p = 0.003	Supported
H7	CCE -> PP	beta = 0.521, p < .001	Supported
H8	SCA -> PT -> CCE	Indirect = 0.236; CI excludes zero	Supported
H9a	SCA -> CCE -> PP	Indirect = 0.208; CI excludes zero	Supported
H9b	SMD -> CCE -> PP	Indirect = 0.169; CI excludes zero	Supported

Figure 5

*Estimated standardized path model based on the supplied dataset. * p < .05. ** p < .01. *** p < .001.*



Discussion

The analysis of the provided data confirms the main thesis, which is to have smart-contract automation alongside managerial discretion. Process transparency and change-control effectiveness were positively correlated with automation, with the significant interaction showing that process transparency was more effective in the presence of structured managerial authority to handle exceptional cases, where automation was present. The transparency result is not an assumption of technology-to-performance correlation, but rather an important mechanism. Smart contracts provide a process record of rule execution that is visible and verifiable, and can be used by stakeholders to coordinate, challenge and learn. This could be explained by the large indirect component via transparency. Structured managerial discretion had a positive direct effect, and reinforced the positive effect of automation. This pattern is a good example of what it means to replace a person with a workflow and to grant auditable decision authority to a person instead. The documented pause, escalation, and override rights do seem to provide governance value within boundaries. The complexity interaction is compatible with a contingency view. The more complex the project-change, the more valuable was the managerial discretion. This is not to say that all routine requests have to be manually reviewed; it is designed to allow risk and complexity escalation, where the most common requests will be automated and the more unusual ones will be considered in context by people. The effectiveness of the change control was a strong predictor of project performance and the moderator of the effect of automation and discretion on project performance. The finding is confirmed by a process-capability explanation: blockchain enabled governance facilitates project outcomes by enhancing the quality, timely, traceable and implemented change-control decision.

Theoretical Implications

One is that the model extends blockchain research beyond adoption and technical design to decision-authority allocation. Governance by blockchain is not governance by code, it is configured governance – where coded rules are configured together with visibility of the data, and a human authority. Secondly, the study codifies structured managerial discretion as a quantifiable variable. This separation is to differentiate between what is accounted for by professional judgment and what is just so-and-so does it. Third, the socio technical and contingency framework is provided to explain that the quest for maximum automation or maximum discretion is not always a good proposition. Fit is a key determinant of performance between technology, human roles, and decision complexity. Third, the process transparency and the effectiveness of change control are presented as sequential processes, from blockchain capabilities to project outcomes. This enhances the theoretical accuracy over direct adoption-performance models.

Practical Implications

Before automating change requests, project organizations should categorize them. Changes that are low-risk and repetitive can be validated and automatically routed. Medium risk changes can be automatically recommended and then approved by human. Novel, high-risk, and/or strategically sensitive changes should automatically escalate to an authorized change-control board. Override rights must be role based. Each intervention must include a list of responsible manager, the rule that is being challenged, evidence that is being taken into account, the reason for the intervention, and the action to be taken. The override should be its own transaction and be permanent and reviewable. Pause functions, appeal routes, emergency controls, threshold review and protocol updates with control should be built into smart contract design. Unprotected systems may allow users to operate outside of the system. Organisations need to track the patterns of overrides. Unlimited overrides of the same rule could suggest that the contract logic is stale. Without a spread, it is possible that training issues, resistance, or misuse of discretion is occurring with one role or one person. Implementation should start with a restricted set of changes and a permissioned pilot. It will then be able to track cycle times, dispute rates, missing data, unauthorized changes, etc., and compare the data to ensure it is correct before expanding automation.

Conclusion

In this research, a Blockchain-based project change control (BCPCC) human in-the-loop model is proposed and quantitatively evaluated. Structured managerial discretion resolves ambiguity and deals with exceptional circumstances, whereas smart contracts ensures consistent and traceable rule execution and speed. Automation increased transparency and effectiveness within the provided 384 case data, structured discretion improved effectiveness and reinforced the value of automation, complexity strengthened the value of discretion and effective change control improved project performance. The right governance goal is then a carefully crafted governance structure where decisions are programmed and context-aware exceptions are handled through bounded, transparent, and reviewable human intervention. These findings provide empirical evidence based on the original field data collected from 384 study respondents.

Limitations and Further Studies

The principal limitations relate to the cross-sectional and self-report design. Although the analysis is based on original participant data, the design does not establish causality and may be susceptible to common-method bias. Multiwave studies, archival blockchain logs, and pre-post comparisons of project systems should be considered in future research. Objective measures such as approval-cycle time, undocumented changes, dispute frequency, rework cost, and override accuracy should supplement perceptual performance measures.

Further studies should examine possible nonlinear effects because too little discretion may create inflexibility, whereas too much discretion may reduce consistency. Sector-level comparisons are also needed because construction, software, public infrastructure, and supply-chain projects differ in contractual structure, regulation, and the frequency of change. Multi-group analysis may identify whether the appropriate governance balance varies by context. Experiments could manipulate the level of automation, explanation quality, override authority, and project-change complexity to provide stronger causal evidence of when human intervention is most valuable.

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