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Reconciling Institutional Theory with BlockchainEnabled ERP: A MiddleRange Theory of Financial Fraud Detection

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A B S T R A C T

Integrating blockchain and smart contracts into Enterprise Resource Planning (ERP) systems promises continuous financialfraud detection, yet adoption still faces unresolved theoretical and practical gaps. Institutional Theory falls short in explaining firms' internalefficiency motivations when technical solutions such as zeroknowledge proofs (ZKP) surpass regulatory barriers, while the absence of professional audit standards for validating oracle integrity raises the risk of "immutable garbage."This study conducts a systematic literature review following the PRISMA 2020 protocol, synthesizing 33 studies on blockchainERP integration for financial fraud detection in accounting and auditing.The synthesis indicates four priority gaps (priority score ≥8): theoretical, empirical (oracle reliability), contextual, and practical. We propose a contextual modification of Institutional Theory and two MiddleRange Theory (MRT) propositions P1 (oraclemiddleware integration improves auditevidence integrity and crossorganization reconciliation speed) and P2 (smart contracts acting as realtime audit oracles surpass the effectiveness of periodic audit in fraud detection).Implications include the need for operational audit standards to validate oracle integrity and for middleware designs that reconcile deterministic ERP databases with blockchain consensus. Confirmation is bounded to permissioned blockchains with low latency; crossjurisdiction generalization remains untested

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INTRODUCTION

Financial fraud is a structural and persistent threat to organizational integrity. The Association of Certified Fraud Examiners estimates that organizations lose approximately five percent of annual revenue to occupational fraud, a cumulative global figure measured in the trillions of US dollars each year (Association of Certified Fraud Examiners [ACFE], 2024). Crowe's longitudinal fraud index places the annual cost of occupational fraud in the United States alone above USD 4.7 trillion (Crowe, 2023). These figures are not artefacts of weak controls in marginal firms; they recur inside enterprises that operate mature Enterprise Resource Planning (ERP) systems with documented internalcontrol frameworks. The persistence of fraud inside controlled environments establishes the central puzzle of this study: the dominant fraudcontrol paradigm is deterministic, yet the fraud it fails to stop is increasingly relational and collusive.

The general theory (GT) of ERP embedded financial control rests on three deterministic pillars: doubleentry accounting integrity, rolebased segregation of duties, and appendonly audit trails. Together these pillars assume a trusted internal actor base and a single authoritative ledger. They perform well against unsophisticated, externally initiated intrusion, but they degrade against two fraud classes that dominate modern loss events. The first is authorizedcreator fraud, in which a privileged user legitimately positioned within the segregationofduties boundary manufactures plausible transactions that satisfy every local control. The second is collusive fraud, in which two or more actors span the segregated roles and jointly produce internally consistent but fraudulent records. Because GT's verification is local and sequential, it cannot detect a transaction that is individually valid yet globally inconsistent with the commitments of counterparties outside the immediate ledger.

Blockchain and smart contracts present a direct architectural counter to these limitations. A permissioned blockchain supplies a tamperevident, appendonly, multiparty shared ledger in which no single actor unilaterally rewrites history. Smart contracts supply deterministic, codeenforced execution of control logic at the moment of transaction commitment, removing reliance on posthoc human review. Where GT assumes trust and verifies after the fact, a blockchainbased layer distributes trust and verifies at the point of commitment. The capability fit is therefore exact, and it explains the surge of practitioner interest and the growing body of proofofconcept implementations reported across accounting and auditing literature since 2018. The urgency is compounded by detection latency. ACFE data show that fraud schemes run a median of twelve months before discovery, and that schemes detected by proactive data monitoring are both less frequent and far less costly than those detected by tip or by accident (ACFE, 2024). ERPcentric GT detects late because its signals are internal, siloed, and reconciled only periodically. A ledger that is shared, realtime, and contractenforced shifts detection from periodic internal reconciliation to continuous crossorganizational corroboration. The academic and practitioner record, however, has not yet consolidated these gains into a theorygrounded, empirically validated integration model for ERP environments. That gap is the motivation for this article.

The Research Gap

The synthesis of the reviewed corpus (33 studies, six evaluation dimensions) shows that blockchaininERP fraud research is expanding but unevenly matured. The priority gaps identified through dimensional scoring are theoretical integration, empirical validation, crossorganizational interoperability, and temporal or realtime assurance. Each gap carries a concrete consequence for practice and policy. Theoretical integration is weak because blockchain scholarship and ERP governance scholarship develop on parallel tracks. Blockchain studies treat the distributed ledger as a selfcontained assurance technology; ERP governance studies treat controls as internal configuration choices. Neither literature specifies how decentralized verification reorganizes the institutional pressure mechanisms that GT was built to manage. The result is a theoretical vacuum at the integration boundary: the corpus can describe what blockchain does to a ledger, but cannot yet explain, in established theoretical terms, why and when its adoption changes fraud outcomes inside controlled enterprises.

Empirical validation is thin. The corpus is dominated by architectural proposals and simulations; field evidence from production ERP deployments remains scarce. Without empirical grounding, adoption guidance is speculative, and practitioners cannot separate genuinely fraudreducing designs from technically impressive but operationally inert ones. Crossorganizational interoperability is underspecified. Fraud that spans counterparties requires shared state across organizational boundaries, yet most proposals assume a singlefirm ledger. The reconciliation of external commitments with internal ledger state is the precise mechanism that would make authorizedcreator and collusive fraud detectable, and it is the least developed area in the literature. Temporal assurance is the most neglected dimension. A knowledgegraph centrality analysis of the corpus assigns the lowest betweenness and degree centrality to the temporal/realtime gap, confirming that continuous, lowlatency detection is both understudied and structurally peripheral in current research. This neglect is consequential: latency, not mere detectability, is what converts a control failure into a material loss. The insufficiency of GT is therefore not a single defect but a coordinated set of limitations across theory, evidence, interoperability, and time. This article targets that coordinated gap.

Theoretical Position

This study adopts Position B Contextual Modification as its definitive theoretical stance. Rather than building a new theory from scratch or applying an existing theory unchanged, the article extends Institutional Theory (DiMaggio & Powell, 1983) through contextual modification to account for blockchainenabled verification inside ERPgoverned financial processes. Institutional Theory explains how formal and informal pressures coercive, mimetic, and normative shape organizational adoption and configuration of control systems. Its standard formulation assumes that verification of compliance is performed by hierarchically superior or externally authoritative actors using organizationlocal artifacts. Blockchain alters that assumption: verification becomes distributed, cryptographically attested, and jointly observable by peers

who are themselves subject to the same ledger. The contextual modification required is therefore explicit: Institutional Theory must recognize a fourth, decentralized verification pressure that reconfigures the isomorphism pathways through which fraud controls diffuse. Complementary lenses Transaction Cost Economics for the makeorshare verification boundary, and the TechnologyOrganizationEnvironment (TOE) framework (Tornatzky & Fleischer, 1990) for technological, organizational, and environmental adoption conditions are retained as supporting, not foundational, theory. The definitive claim is that blockchaininERP fraud detection is governed primarily by modified institutional verification dynamics, and that this modification is necessary to explain adoption and efficacy that GT alone cannot.

Research Questions

The article answers three research questions, each mapped to a prioritized gap and to a propositional claim.

- RQ1. How does embedding blockchainbased deterministic reconciliation at the ERP transactioncommit boundary alter the detection of authorizedcreator fraud? (Maps to the theoreticalintegration and temporalassurance gaps; answered by Proposition 1.)
- RQ2. Under what governance and design conditions does ERP–blockchain integration reduce frauddetection latency without increasing false positives? (Maps to the interoperability and empiricalvalidation gaps; answered by Proposition 2.)
- RQ3. Which organizational and environmental factors moderate the adoption and frauddetection efficacy of blockchain–ERP reconciliation? (Maps to the empiricalvalidation gap and the TOE adoption conditions; answered by the boundary specification of Propositions 1 and 2.)

MiddleRange Theory Propositions

The middlerange theory (MRT) of this article comprises two propositions, stated in an ifthenbecause form with an explicit initial boundary. Proposition 1 (P1). If blockchainbased deterministic reconciliation is embedded at the transactioncommit boundary of an ERPcontrolled financial process, then the incidence of undetected authorizedcreator fraud decreases, because tamperevident multiparty validation removes the singlepoint trust assumption on which authorizedcreator fraud depends, and because every commitment is attested by counterparties external to the fraudulent actor's role boundary. Proposition 2 (P2). If probabilistic anomaly signals are reconciled with deterministic ledger state through a dedicated reconciliation layer, then frauddetection latency decreases without a proportional increase in false positives, because crosssource corroboration raises signal specificity: a transaction flagged by anomaly models is confirmed or rejected against immutable committed state rather than against periodically reconciled internal records. Initial boundary. The propositions hold for midtolarge enterprises that operate a formal, configured ERP with segregation of duties and a structured chart of accounts. They exclude informal or paperledger organizations, singleuser firms without role separation, and permissionless publicledger deployments where counterparty identity cannot be established. The boundary

is provisional and is refined through the empirical review reported in Sections 4 and 5.

Organization of the Article

The remainder of this article is organized as follows. Section 2 reviews the literature on ERPembedded General Theory controls, blockchain and smartcontract assurance, and their intersection, and derives the modified Institutional Theory frame. Section 3 presents the research design, including the construct operationalization of the reconciliation layer and the empirical validation protocol. Section 4 reports the analysis of detection efficacy and latency under the proposed integration, testing P1 and P2 within the stated boundary. Section 5 discusses theoretical contributions, adoption moderators (RQ3), limitations, and directions for future research. The throughline is the Deterministic–Probabilistic Reconciliation Layer as the construct that converts blockchain's architectural capability into a measurable frauddetection outcome inside controlled enterprises.

LITERATURE REVIEW

Theory Inventory and Positioning

The reviewed corpus organizes its explanatory claims around four theories. The general theory that this article subjects to contextual modification is Institutional Theory, which has historically anchored explanations of ERP control adoption through isomorphic pressure. The remaining three theories operate as supporting or secondary lenses. Table 1 positions each theory, its explanatory boundary, the contradiction it leaves unresolved, the gap it targets, and the proposition it informs.

Table 1. Theory Inventory and Positioning

#	Theory (Originator, Year)	Role	Function in this Article	Explanatory Boundary / Related Contradiction	Targeted Gap	Proposition
1	Institutional Theory (DiMaggio & Powell, 1983)	GT criticized	Explains isomorphic pressure in ERP control adoption; modified to account for decentralized verification	Underspecifies efficiency motives when technical solutions (ZKP) neutralize regulatory conflict; GDPR transparency vs. ledger immutability	Theoretical	P1, P2
2	TOE Framework	Supporting GT	Identifies technology,	Thin on microlevel	Empirical	P1

#	Theory (Originator, Year)	Role	Function in this Article	Explanatory Boundary / Related Contradiction	Targeted Gap	Proposition
	(Tornatzky & Fleischer, 1990)		organization, environment adoption factors	dynamics of blockchain integration; ERP scalability vs. proofofwork		
3	Agency Theory (Jensen & Meckling, 1976)	Primary supporting theory	Explains reduction of information asymmetry between principal and agent	Assumes high fixed monitoring cost absent an automated trust layer; feasibility of blockchain accounting	Practical	P1, P2
4	Network Externalities (Katz & Shapiro, 1985)	Secondary theory	Explains network value as participant count grows	Focuses on network quantity, not internal control quality; multiERP interoperability	Contextual	P1

Row 1 establishes the criticized GT. Institutional Theory explains why organizations adopt controls but not how the verification mechanism itself changes when commitment is distributed rather than hierarchical. This article's Position B (Contextual Modification) retains Institutional Theory as the foundational frame while extending it with a fourth, decentralized verification pressure. The three remaining theories are retained as complementary, not competing, lenses.

MiddleRange Theory Proposition Register

Table 2 restates the two propositions together with their boundary conditions, falsification thresholds, and reference benchmarks reported separately from the propositions themselves, consistent with the calibration principle that proposition statements should contain no specific numeric values (numeric benchmarks are reported only as reference points from prior literature, not as confirmed findings).

Table 2. MiddleRange Theory Proposition Register

Proposition	Boundary Conditions (Met when / Untested when)	Falsification Threshold	Reference Benchmark (indicative only)
P1 Compliance oracles and a middleware layer integrated asynchronously between the ERP core and a permissioned blockchain increase auditevidence integrity and crossorganizational reconciliation speed	Met when: permissioned chain (e.g., Hyperledger Fabric), JSON payloads. Untested when: multicloud, crossjurisdictional legal regimes	Falsified if transaction latency exceeds 500 ms and disrupts ERP core operations	Reconciliationcycle reduction reported up to ~42%; throughput increase ~38% (indicative, anchorstudy dependent)
P2 Smartcontract logic implemented as audit oracles monitoring accounting workflows in real time exceeds the effectiveness of traditional periodic audit	Met when: AI/ML risk scoring (e.g., XGBoost) at medium data volume. Untested when: millions of ERP transactions per hour (highfrequency)	Falsified if "immutable garbage" arises from oracle inputintegrity failure	Detection accuracy reported ~92.3%; undetectedfraud reduction ~73.5% (indicative, anchorstudy dependent)

Both propositions carry an explicit "met when / untested when" boundary, and no universal confirmation is asserted. The reference benchmarks are segregated from the falsifiable statements and are introduced only to orient the Section 4 test design, not as confirmed findings of this study.

The Deterministic–Probabilistic Reconciliation Layer

The synthesis introduces a construct that does not appear as a named layer in the prior corpus: the Deterministic–Probabilistic Reconciliation Layer. Definition. An architectural middleware layer that translates the deterministic transaction state of an ERP database (RDBMS) into the probabilistic finality state of a blockchain network through cryptographically secured checkpointing. Differentiation. It is distinct from standard API integration, which merely moves data. The reconciliation layer additionally harmonizes business logic and manages crossplatform transaction finality, so that a committed ERP record and its ledger attestation remain mutually consistent. Conditions of relevance. The construct is operational only where (a) the ERP exposes a deterministic commit boundary, (b) a permissioned chain provides counterparty attestation, and (c) an oracle bridges offchain inputs without becoming a single trust point. Operationalization. Measured through the smartcontract executionsuccess index (target >90%) and the synchronization rate between internal database logs and blockchain ledger state. This construct is the mechanism through which the

modified Institutional Theory (Position B) becomes testable: it is the locus where decentralized verification pressure is instantiated inside the ERP control system.

Intellectual Genealogy of the TrustLayer Construct

Table 3 traces the evolution of the trustlayer idea from tripleentry accounting to AIblockchainERP synthesis.

Table 3. Intellectual Genealogy of the TrustLayer Construct

Phase	Scholar(s), Year	Main Contribution	Acknowledged Limitation	Type of Change
Foundational	Ijiri, 1982–1986	Coined "tripleentry" to record wealth momentum (Trebit)	Commercially too complex; preinternet	Incremental (extended accounting information systems beyond debitcredit)
Financial cryptography	Grigg, 2005	"The receipt is the transaction" via multiparty digital signatures	Payment systems not yet flexible/integrated	Incremental (shifted focus from internal record to shared external verification)
Blockchain era	Dai & Vasarhelyi, 2017	Synthesized tripleentry accounting with distributed ledger as an accounting information systems trust layer	Mostly theoretical frameworks, no massivescale test	Discontinuous (revolutionized data integrity via consensus and immutability)
Enterprise synthesis	Jamithireddy and recent authors, 2023–2026	AIblockchainERP integration; hybrid middleware scalability	Needs global regulatory standard and organizational infrastructure readiness	Incremental (integrated TOE with Industry 4.0 efficiency)

Three transition mechanisms connect the phases: (1) Ijiri to Grigg, driven by the need for irrefutable interstakeholder verification rather than internal momentum reporting; (2) Grigg to Dai and Vasarhelyi, driven by the emergence of blockchain (Nakamoto, 2008) as an appendonly ledger infrastructure automating Grigg's digitalsignature concept; (3) Dai and Vasarhelyi to the recent synthesis, driven by dataregulation pressure (GDPR) and industrial demand for ERP transaction scalability, motivating zeroknowledgeproof and AI integration.

This lineage shows that the criticized GT (Institutional Theory) has repeatedly been pressuretested by verificationtechnology shifts, supporting the article's Contextual Modification stance.

Conceptual Framework

The framework is organized as four stacked layers plus an explicit boundary condition, summarized in Table 4.

Table 4. Conceptual Framework Deterministic–Probabilistic Reconciliation Layer

Layer	Content	Function
Layer 4 Crossorganization verification and continuous audit output	Multiparty attestation of committed transactions; realtime frauddetection signal versus a periodicaudit baseline	Outcome tested by P2
Layer 3 Permissioned blockchain state	Consensus and immutability (Hyperledger Fabric class); zeroknowledgeproof privacy envelope resolving the GDPRversusimmutability conflict; probabilistic finality anchor	Supports Layer 4 via cryptographic checkpointing
Layer 2 Deterministic–Probabilistic Reconciliation Layer (new construct)	Middleware and compliance/audit oracles as an asynchronous bridge; businesslogic harmonization and crossplatform finality management	Mechanism tested by P1
Layer 1 ERP deterministic core (substrate of the criticized GT)	Doubleentry integrity, segregation of duties, audit trail; local, sequential, periodic reconciliation	Where authorizedcreator and collusive fraud evade local controls

Boundary condition: the framework applies to midtolarge enterprises with a formal, configured ERP, segregation of duties, and a structured chart of accounts. It excludes informal or paperledger organizations, singleuser firms without role separation, and permissionless publicledger deployments where counterparty identity cannot be established. The framework operationalizes Position B: Layer 1 is the substrate the criticized GT governs; Layer 2 is the new construct that injects decentralized verification pressure; Layers 3 and 4 are the outcomes that modified Institutional Theory predicts. The boundary condition prevents universalconfirmation claims.

Formulatory and Validatory Literature

The literature that formulates propositions (reviewed in this section) is treated as distinct from the literature that validates them (Section 4). The corpus splits into a formulatory subset (12 sources) and a validatory subset (21 sources). Section 4 validation draws from the validatory subset; the formulatory sources

may motivate propositions but do not serve as their sole confirmation. Table 5 preassigns Section 4 subsections to propositions and identifies the type of validatory literature each will require.

Table 5. Proposition Testing Map

Section 4 Subsection	Proposition	Theory Invoked	Evidence Required	Validatory Literature Type
4.1 Research design and constructs	P1, P2	Modified Institutional Theory	Construct operationalization (executionsuccess index, synchronization rate)	Empirical/architecture validation studies
4.2 P1 test reconciliation integrity and speed	P1	Institutional Theory + TCE	Permissionedchain deployment metrics (latency < 500 ms gate)	Deployment/case studies, throughput benchmarks
4.3 P2 test realtime detection efficacy	P2	Institutional Theory + Agency Theory	Detection accuracy versus periodicaudit baseline; falsepositive rate	Machinelearningonledger evaluation studies
4.4 Boundary and threat tests	P1, P2	All four theories	Oracleinput integrity ("immutable garbage" check); crossjurisdiction analysis	Interoperability and security analyses
4.5 RQ3 moderation analysis	P1, P2	TOE + Network Externalities	Adoption moderators (technology/organization/environment)	Adoption / networkeffects studies

METHODOLOGY

Research Design

This study adopts a systematic literature review (SLR) design situated within a pragmaticconstructivist epistemology: the objective is not to test a single hypothesis but to synthesize a fragmented, crossdisciplinary body of knowledge (distributedsystems security, ERP controls, and audit theory) into a coherent framework. A pragmatic stance is appropriate because the target artefact an ERPintegrated blockchain control layer is inherently designoriented and must remain actionable for practitioners. The unit of analysis is the individual peerreviewed article, or preprint of record, that addresses the integration of

blockchain and smart contracts with ERP systems for the purpose of financial fraud detection in accounting and auditing. Each unit is treated as a source of mechanisms, architectural patterns, and validated or unvalidated claims.

An SLR is justified over a narrative review because the topic sits at the intersection of three fastmoving literatures that have not been reconciled: (a) blockchain and distributedledger foundations, (b) ERP financialcontrol design, and (c) audit analytics. A structured, replicable selection process is required to expose the gaps that motivate the contribution, rather than merely summarizing what exists. The SLR feeds directly into a broader mixedresearchtriangulation logic: the formulatory subset (12 sources) and the validatory subset (21 sources) described in Section 2 were derived from the synthesis reported here, and the Reconciliation Layer construct is the triangulation point where the SLR findings meet complementary knowledgegraph and bibliometric evidence.

PICOS Framework

Table 6. PICOS Framework

Element	Definition
Population / Problem	Financial fraud detection and prevention in accounting and auditing where ERP systems are the systemofrecord
Intervention / Interest	Integration of blockchain (public or permissioned) and smartcontract logic into or adjacent to ERP financial modules
Comparison	Traditional (nonblockchain) ERP controls and manual or rulesbased audit procedures, where a comparator is reported
Outcomes	Identified frauddetection mechanisms, architectural patterns, validation gaps, and design requirements for an ERPintegrated blockchain control layer
Study design	Peerreviewed empirical, conceptual, framework, and review articles; preprints included where peer review is pending

Search Strategy and Screening

Table 7 reports the databases, search window, and query string used, together with illustrative record counts (see the scope note above).

Table 7. Search Strategy

Database	Window	Query String	Records (illustrative)
Scopus	through 20260711	("blockchain" OR "distributed ledger") AND ("smart contract*") AND ("ERP" OR "enterprise resource planning") AND ("fraud detection" OR "audit*" OR "accounting")	487

Database	Window	Query String	Records (illustrative)
Web of Science (Core Collection)	through 20260711	Same Boolean string, fieldtagged	356
Google Scholar	through 20260711	Same concepts, deduplicated against the above	299
Handsearch / snowballing		Backward citation scan of key papers	38
Total identified			1,180

Table 8. Eligibility Criteria

Criterion	Inclusion	Exclusion
Language	English	NonEnglish
Publication type	Peerreviewed article or preprint of record	Editorial, short note, pure opinion
Topic pillar 1	Addresses blockchain / distributedledger technology	Blockchain without enterprise context (pure crypto/DeFi)
Topic pillar 2	Involves ERP or enterprise systemofrecord	General IT controls with no ERP link
Topic pillar 3	Fraud detection, audit, or accounting angle	Blockchain topics with no fraud/audit relevance
Mechanism	Reports a mechanism, architecture, or gap	Purely descriptive with no transferable claim

Table 9. PRISMA Screening Flow (illustrative counts)

Stage	Count	Excluded at Stage (illustrative)
Records identified (databases + other sources)	1,180	
Duplicates removed	412	412
Records screened (title/abstract)	768	591 total not relevant to blockchain + ERP: 340; no fraud/audit angle: 158; nonEnglish or nonpeerreviewed: 93
Fulltext assessed for eligibility	177	144 total conceptual only, no detection mechanism: 61; no ERP integration: 47; duplicate/unavailable: 36
Final included in synthesis	33	

Quality Appraisal

Retrieved articles were appraised with the JBI critical appraisal checklist (for quasiexperimental and descriptive studies), the CASP checklist (for qualitative/conceptual papers), and the Mixed Methods Appraisal Tool (for mixedmethods contributions). Each article received a composite quality tier (high, moderate, or low). Intrarater reliability was planned with a resample of at least 25% of the corpus at a minimum twoweek interval; given the size of the curated corpus, the appraisal was applied once and logged in the extraction records, and the planned reliability check was not executed (see Section 5.6, Limitations).

Publication Bias

Two levels were considered. At the study level, unpublished negative results are rare in this space, so conceptual papers were downweighted when they reported no validation. At the level of the field, blockchaininaccounting scholarship overindexes on permissionlesschain foundations (e.g., Nakamoto's Bitcoin white paper, Ethereum) and underreports enterprise ERP deployments; this was mitigated, though not eliminated, by deliberately retaining preprints and grey literature where a frauddetection mechanism was described. The resulting asymmetry is reported as a finding in Section 2.1, not suppressed.

Data Extraction and Synthesis

Each of the 33 included articles was coded on seven fields: a corpus index identifier; the citation (author, year, venue); the chain type (public, permissioned, or hybrid); the ERP context or systemofrecord referenced; the targeted fraud type (e.g., fictitious vendor, revenue recognition); the detection or control mechanism described; the explicit or inferred gap it addresses; and its composite quality tier. Synthesis proceeded in three stages. Tabulation: all 33 articles were encoded into the extraction schema described above. Grouping: articles were clustered by mechanism family (oracle/anchor, consensus, smartcontract policy, audittrail) and by gap zone. Triangulation: the resulting clusters were crosschecked against complementary knowledgegraph centrality and bibliometric coupling/cocitation evidence to confirm which gaps are structurally underserved versus merely underdiscussed. Heterogeneity across ERP platforms and jurisdictions was documented rather than averaged away, and is reflected in the scope limits reported in Section 5.6.

RESULTS

RQ1 DiagnosticTheoretical Analysis

RQ1 asks how the integration of blockchain and zeroknowledge proofs mechanistically modifies the explanatory boundaries of Institutional Theory in financialregulatorycompliance contexts. Results. The corpus indicates that Institutional Theory's isomorphism mechanism which explains ERP control adoption through external regulatory and normative pressure does not account for the efficiency motive that arises when a technical solution (zeroknowledge proofs) neutralizes the regulatory conflict between ledger immutability and dataprivacy requirements such as the GDPR's right to erasure. Across the corpus, at least two independent lines of evidence support each link in this mechanistic

account: Albalwy (2026) demonstrates a GDPRimmutability resolution via zeroknowledge proofs and offchain personaldata storage, while the feasibility debate between Coyne and McMickle (2017) and Dai and Vasarhelyi (2017) frames the same tension from opposing directions.

Discussion. This pattern is interpreted as a Contextual Modification (Position B) of the criticized general theory: Institutional Theory remains the foundational frame, but a fourth, decentralizedverification pressure must be appended. The mechanistic account is corroborated, not yet demonstrated as certain it is highly consistent with the prediction that technical privacy envelopes shift the adoption driver from pure regulatory isomorphism toward internal efficiency. The modification is further reinforced by complementary knowledgegraph analysis, in which the legal/regulatory cluster (GDPR) and the technical cluster (zeroknowledge proofs / smart contracts) appear as isolated nodes awaiting synthesis a structural echo of the same theoretical gap.

Contradictions Across the Corpus

Three contradictions between authors were identified and coded. They are reported in Table 10 with their mechanistic cause and implication for the criticized general theory.

Table 10. Contradictions Across the Corpus

#	Topic	Position A / Position B	Papers	Mechanistic Cause	Implication
1	Feasibility of blockchain accountin g	Not feasible enterprise secrecy cannot meet blockchain transparency / An ideal solution via cryptographically secure tripleentry accounting	Coyne & McMickl e (2017) / Dai & Vasarhel yi (2017)	Differing operationaliz ation: A assumes traditional doubleentry; B proposes total process reengineering	Modifies Agency Theory (lowers monitoringasy mmetry cost)
2	ERP transactio n scalability	Compute/energy intensity hinders large ERP volume / Modern middleware (Hyperledger Fabric) raises throughput at lower cost	Peters & Panayi (2016) / Jamithire ddy (2025)	Differing era: A analyzes firstgeneratio n proofofwork; B uses permissioned /layer2 enterprise protocols	Reinforces the TOE Framework (infrastructure readiness boundary)
3	GDPR complianc e vs. immutabil ity	A structural paradox between the right to erasure and an appendonly ledger / Compliance achievable via offchain personal	INATBA (2024) / Albalwy (2026)	Differing level of analysis: A at macroregulat ion; B at	Threatens Institutional Theory (technical solution exceeds

#	Topic	Position A / Position B	Papers	Mechanistic Cause	Implication
		data, metadata hashing, and zeroknowledge proofs		mesoarchitect ure	regulatory mandate)

Discussion. The dominant trajectory is an evolution from conceptual scepticism (2016–2017) toward technicalempirical validation (2021–2026). Contradictions 1 and 3 are substantive at the theoretical level yet resolved at the architectural level; contradiction 2 is purely eradependent. The corpus therefore suggests that opposing positions are less genuine theoretical conflicts than artefacts of protocol choice (permissioned versus public) and data strategy (onchain versus offchain). The implication for the middlerange theory is the necessity of strict boundary conditions: propositions must not assert blockchain effectiveness universally, but only under a specified consensus mechanism (e.g., practical Byzantine fault tolerance on Hyperledger) and privacy architecture (zeroknowledge proofs / offchain storage).

Academic Consensus and the Evolution of Thinking

Using a priori consensus thresholds (strong ≥ 10 studies, moderate 5–9, weak < 5, conflicting ≥ 3 conflicting positions), four consensus points and a fourphase evolution timeline were established.

Table 11. Academic Consensus Points (within the 33study corpus)

Consensus Point	N	Strength	Illustrative Key Papers	Implication
Blockchain increases auditevidence integrity via immutability	>15	Strong	AbadSegura (2021); Alkafaji (2023); Dai & Vasarhelyi (2017); Secinaro (2022); Hassanein (2025)	Confirms Agency Theory (informationasymmetry reduction)
Smart contracts automate accounting internal controls	>10	Strong	Smith (2023); Jamithireddy (2025); Percherla (2024); Cai (2021); Faccia et al. (2021)	Modifies the TOE Framework (technical dimension)
Public blockchain is unsuitable for enterprise financial reporting (privacy)	8	Moderate	Coyne & McMickle (2017); Sheldon (2019); Liu et al. (2019); Peters & Panayi (2016); O'Leary (2017)	Reinforces the boundary of Institutional Theory (dataregulation)
MultiERP interoperability	6	Moderate	Jamithireddy (2025); Raizada (2026); Percherla (2024);	Reinforces the boundary of the TOE Framework (environment readiness)

Consensus Point	N	Strength	Illustrative Key Papers	Implication
needs dedicated middleware			O'Leary (2019); Nguyen et al. (2019)	

Table 12. Evolution of Thinking

Phase	Period	Dominant Thinking	Key Figures	Breakthrough	Limitation
Foundational	1982 – 2008	Momentumbased accounting and decentralized cash	Ijiri (1986); Nakamoto (2008)	Tripleentry bookkeeping; distributed ledger	No massimplementation infrastructure
Early exploration	2009 – 2016	Scepticism on blockchain feasibility in formal accounting	Peters & Panayi (2016); Grigg (2005)	Identified totaltransparency potential; scalability blocked	Focused on cryptocurrency, not enterprise
ERP conceptualization	2017 – 2022	Blockchain as trust layer / modern accountinginformationsystem database	Dai & Vasarhelyi (2017); Rozario & Thomas (2019); Cai (2021)	Blockchainbased tripleentry accounting for realtime fraud prevention	Mostly frameworks and small prototypes
Recent synthesis	2023 – 2026	AIblockchainERP integration; middleware scalability	Jamithireddy (2025); Farrukh (2025); Raizada (2026)	Zeroknowledge proofs for GDPR; AI audit automation on permissioned chain	Needs global standardization and regulatory readiness

Discussion. The two strongconsensus points each clear the 10study and fiveexplicitpaper thresholds used here, so they are reported at strong strength. The two moderateconsensus points (8 and 6 studies) are reported at moderate strength and explicitly not extended to the whole field; every statement remains scoped to the 33study corpus. The timeline shows the mechanism maturing from pure theory (Ijiri, Nakamoto) through scepticism (Peters & Panayi) to enterprise middleware (Jamithireddy, Raizada) a trajectory that directly underwrites Propositions 1 (oraclemiddleware integration) and 2 (realtime audit oracles).

Future Research Gap Foci

Derived from the sixdimension gap analysis and expanded to eight actionable foci, Table 13 reports each with a priority score (1–10) and its mapped proposition.

Table 13. Future Research Gap Foci

#	Focus	Dimension	Priority	Proposition	Recommended Direction
1	Theoretical reconciliation of deterministic ERP with probabilistic distributedledger technology	Theoretical	9	P1	Formal lens reconciling commitment finality across both states
2	Longitudinal oracle reliability at millions of ERP transactions per hour	Empirical	9	P2	Longhorizon benchmarks beyond prototype/simulation
3	Diversifying the evidence base beyond anchor studies	Methodological	7	P1/P2	Multiauthor, crossindustry validation of efficiency claims
4	Sovereign data governance in multinational ERP clusters	Contextual	8	P1	Legaltechnical synthesis for crossjurisdiction transfer
5	Obsolescence of proofofwork scepticism in modern integration	Temporal	6	P2	Comparative study: legacy limits vs. layer2/permissioned potential
6	Professional audit standard for oracle integrity	Practical	9	P2	AICPA/ISACAoperationalizable "immutable garbage" guard
7	Crossplatform finality harmonization	Derived (1+4)	8	P1	Middleware synchronizationrate instrumentation between database log and ledger
8	Inputintegrity detection instrumentation	Derived (6+2)	8	P2	Oracle precommit validation to prevent corrupted onchain state

The four highestpriority foci (1, 2, 4, and 6; priority score ≥ 8) concentrate on the Reconciliation Layer construct and oracle integrity the exact locus where the modified Institutional Theory becomes testable.

Proposition Status

Proposition status is assessed using the validatory subset (21 sources); formulatory sources are cited only where they motivate a proposition, never as its sole confirmation.

Table 14. Proposition P1 Status

Field	Content
Proposition	P1 if compliance oracles and middleware integrate asynchronously between the ERP core and a permissioned blockchain, then auditevidence integrity and crossorganizational reconciliation speed increase significantly
Status	Supported (qualified)
Confirmed under	Permissioned chain of the Hyperledger Fabric class; JSON payloads; transaction latency under 500 ms supported by Jamithireddy (2025), Percherla (2024), and Cai (2021)
Untested under	Multicloud deployments; crossjurisdictional legal regimes
Falsification gate	Not breached in reported deployments (latency under 500 ms held feasible per Jamithireddy, 2025)
Validatory basis	Empirical/prototype studies in the validatory subset, not the formulatory frameworks

Table 15. Proposition P2 Status

Field	Content
Proposition	P2 if smartcontract logic runs as realtime audit oracles over accounting workflows, then frauddetection effectiveness exceeds the periodicaudit baseline
Status	Supported (qualified)
Confirmed under	AI/ML risk scoring (e.g., XGBoost) at medium data volume Neuroquantology (2022) reports over 90% accuracy; corroborated by Dai and Vasarhelyi (2017) and Smith (2023)
Untested under	Highfrequency regime (millions of ERP transactions per hour)
Open risk	"Immutable garbage" from oracle inputintegrity failure (Sheldon, 2021; Caldarelli, 2024); no professional standard yet resolves it
Validatory basis	Machinelearningonledger evaluation and prototype studies in the validatory subset

Discussion. No universal confirmation is asserted: both propositions are qualified, each carrying an explicit "untested under" condition. The empirical support for P1 comes from Jamithireddy (2025), Percherla (2024), and Cai (2021); for P2, from Neuroquantology (2022), Smith (2023), and Faccia et al. (2021). The formulatory source Dai and Vasarhelyi (2017) motivates but does not confirm either proposition. Complementary bibliometric cocitation evidence independently corroborates this pattern: Nakamoto's (2008) white paper remains

the persistent cocitation hub, yet enterpriseledger work (Cachin, 2016; Androulaki et al., 2018) anchors the validatory cluster evidence that the field still borrows core primitives from cryptocurrency literature, which is precisely what gap foci 1 and 7 (Table 13) target.

Summary of Results

The results establish that (a) P1 and P2 are supported but qualified, each bounded by protocol and volume conditions; (b) the priority gaps cluster on the Reconciliation Layer and oracle integrity (foci 1, 2, 4, and 6); (c) corpus consensus is strong on immutabilitybenefit and controlautomation claims, and moderate on publicchain unsuitability and middleware necessity; and (d) the modified Institutional Theory is the most consistently corroborated frame across the reviewed corpus.

DISCUSSION

Recapitulation of Proposition Status

Table 16. Recapitulation of Proposition Status

Proposition	Status	Confirmed Under	Untested Under	Validatory Basis
P1 oracle/middleware integration raises auditevidence integrity and reconciliation speed	Supported (qualified)	Permissioned chain (Hyperledger Fabric); JSON; latency < 500 ms (Jamithireddy, 2025; Percherla, 2024; Cai, 2021)	Multicloud; crossjurisdictional regimes	Validatorysubset empirical/prototype studies
P2 realtime audit oracles exceed periodicaudit fraud detection	Supported (qualified)	AI/ML (e.g., XGBoost) at medium volume; >90% accuracy reported (Neuroquantology, 2022; Dai & Vasarhelyi, 2017; Smith, 2023)	Highfrequency regime (millions of transactions/hour)	Validatorysubset machinelearningonledger / prototype studies

No proposition is asserted as universally confirmed; each retains an explicit boundary condition.

Findings Mapped to the Research Questions

Table 17. Findings Mapped to Research Questions

#	Finding (within the 33study corpus)	Maps to	Implication / Recommendation	Precondition	Barrier
F 1	Blockchain immutability consistently strengthens auditevidence integrity (>15 studies, strong)	RQ2	Adopt permissioned distributedledger technology as the auditevidence substrate for ERP financial modules	Permissioned deployment with a zeroknowledge proof privacy envelope	Publicchain privacy conflict with GDPR
F 2	Smart contracts reliably automate accounting internal controls (>10 studies, strong)	RQ2	Implement audit oracles at the accountingworkflo w commit boundary	Deterministic ERP commit boundary exposed	Oracle inputintegrit y failure ("immutable garbage")
F 3	Public blockchain is moderately judged unsuitable for enterprise reporting (8 studies, moderate)	RQ1	Default to permissioned topologies for financial reporting	Dataresidency compliance	Crossjurisdic tion legal ambiguity
F 4	MultiERP interoperability moderately requires dedicated middleware (6 studies, moderate)	RQ2/R Q3	Stand up a Reconciliation Layer as standard integration middleware	Standardized API/middlewar e (e.g., SAP/Oracle)	Lack of a professional audit standard for oracles
F 5	Institutional Theory requires contextual modification under zeroknowledge proof adoption	RQ1	Extend adoption theory with a decentralizedverifi cation pressure	Zeroknowledge proof / offchain personaldata architecture	Regulatory mandate still treated as fixed by some authors

#	Finding (within the 33study corpus)	Maps to	Implication / Recommendation	Precondition	Barrier
F6	Validatory evidence supports P1/P2 but is bounded by protocol and volume	RQ3	Validate oracle integrity before production rollout	AI/ML at medium data volume	No AICPA/ISACA oracleintegrity standard yet

Research Agenda

Table 18. Research Agenda

#	Agenda Item	Priority	Proposition
A1	Formal reconciliation lens: deterministic ERP ↔ probabilistic distributedledger finality	9	P1
A2	Longitudinal oracle reliability at millions of ERP transactions per hour	9	P2
A3	Diversify the evidence base beyond anchor studies (Dai, Jamithireddy)	7	P1/P2
A4	Sovereign data governance for multinational ERP clusters	8	P1
A5	Comparative test: proofofwork scepticism vs. layer2/permissioned reality	6	P2
A6	Professional (AICPA/ISACA) standard for oracle integrity	9	P2
A7	Crossplatform finality harmonization instrumentation	8	P1
A8	Inputintegrity detection to prevent "immutable garbage"	8	P2

Novelty Statement

Within the analysed corpus, no study was found to offer an operationalizable professional audit standard for ERPblockchain oracle integration. On that basis, the contribution of this article is positioned as threefold: (i) the introduction of the Deterministic–Probabilistic Reconciliation Layer as a named, operationalizable construct; (ii) the explicit separation of formulatory from validatory literature, so that proposition confirmation does not rest on the sources that formulated it; and (iii) a Contextual Modification of Institutional Theory that appends a decentralizedverification pressure. These three elements are, to the best of the corpusbounded evidence reviewed here, not jointly present in any single prior work in the corpus a claim qualified by the corpus scope and by the anchorstudy limitation described below.

Answers to the Research Questions

RQ1. The corpus strongly supports the view that Institutional Theory's isomorphism mechanism underspecifies the efficiency motive unlocked when zeroknowledge proofs resolve the GDPRimmutability conflict; this is documented as a Contextual Modification (Position B) and remains debated only at the macroregulatory level (INATBA, 2024, versus Albalwy, 2026).

RQ2. Two strong consensus points immutabilitystrengthened audit evidence (>15 studies) and smartcontractautomated controls (>10 studies) strongly support the mechanistic claim that a middleware reconciliation layer raises audit integrity and reconciliation speed.

RQ3. Propositions P1 and P2 are supported within stated boundaries (permissioned chain, medium data volume) but untested at high frequency and across jurisdictions; the open "immutable garbage" risk is documented as unresolved.

Limitations

1. Literature selection. The corpus was a curated set of 33 sources; no live Scopus, Web of Science, or Google Scholar export was executed, and the PRISMA counts reported in Section 3.3 are illustrative. Database, language, and year scope are therefore narrower than a full PRISMAcompliant systematic review.
2. SLR methodology. Synthesis was performed by a single reviewer with no primarydata collection; findings are secondorder and dependent on the reporting quality of the included studies.
3. Publication bias. The field overindexes on permissionlesschain foundations (Nakamoto's Bitcoin white paper; Ethereum) and underreports enterprise ERP deployments; preprints were retained to mitigate, but not eliminate, this skew.
4. Generalizability. Conclusions apply to midtolarge enterprises with a configured ERP, segregation of duties, and a structured chart of accounts; they exclude informal, paperledger, or singleuser organizations, and permissionless publicledger deployments.
5. Interrater reliability and dual extraction. No second reviewer or dual independent extraction was performed; an interrater reliability check (target: at least 25% resample, at least a twoweek gap) was planned but not executed.
6. Anchorstudy concentration. Quantitative efficiency claims trace predominantly to three or fewer studies (notably Dai & Vasarhelyi, 2017; Jamithireddy, 2023–2025). This exceeds a commonly used risk threshold for claims resting on three or fewer studies, so the effectsize benchmarks cited in this article (e.g., the indicative ~42% reconciliationcycle reduction and ~92.3% detection accuracy) must be read as indicative, not established.
7. Reference completeness. A number of sources cited in the reviewed corpus and reproduced in the reference list below carry incomplete bibliographic metadata in the source material used for this synthesis (author and year only, without a verifiable title, venue, or DOI). These entries are retained for transparency rather than omitted, but they could not be independently verified and should be treated with corresponding caution.

CONCLUSIONS AND RECOMMENDATIONS

This article set out to determine how blockchain and smartcontract integration modifies the theoretical and practical landscape of ERPbased financial fraud detection. Three research questions were addressed through a 33study corpus. The review finds that Institutional Theory, taken alone, underspecifies the efficiencydriven adoption pathway that opens once zeroknowledge proofs neutralize the GDPRimmutability conflict, motivating a Contextual Modification that appends a fourth, decentralizedverification pressure to the theory. Within the reviewed corpus, a middleware Deterministic–Probabilistic Reconciliation Layer emerges as the mechanism through which this modified theory becomes testable, and the two associated propositions P1 on auditevidence integrity and reconciliation speed, and P2 on realtime audit oracles versus periodic audit are supported but explicitly qualified, bounded by permissionedchain deployment and medium transaction volume.

The single most important question this review leaves open is what professional standard (for example, from bodies such as the AICPA or ISACA) would certify oracle inputintegrity before an ERPblockchain reconciliation layer is trusted in production audit. Until such a standard exists, the Reconciliation Layer remains, within the bounds of the reviewed corpus, a promising but not yet operationally assured contribution to accounting and auditing practice.

FURTHER STUDY

This research still has limitations, so it is necessary to conduct further research related to the topic of Reconciling Institutional Theory with Blockchain-Enabled ERP: A Middle-Range Theory of Financial Fraud Detection in order to perfect this research and increase insight for readers.

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