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From Adoption Factors to Project-Level Conditions: Assessing the Transferability of Blockchain-Enabled Smart Contract Evidence to PPP Infrastructure Projects

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Method Article

Keywords: blockchain-enabled smart contracts, public–private partnerships, infrastructure projects, technology adoption, levels of analysis, construct validity, project-level transferability

Posted Date: November 9th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11354830/v1

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Additional Declarations: No competing interests reported.

Abstract

Background: Blockchain-enabled smart contract (BESC) adoption factors are reported at different analytical levels, but their relevance to adoption does not establish that they can be assessed as conditions of individual public–private partnership (PPP) infrastructure projects.

Methods: This study applied a structured, theory-informed Project-Level Transferability Assessment to 132 harmonised literature-derived factors. Five tests examined construct meaning, analytical level, actor or object, project connection and meaning preservation. Factors were classified as direct transfers, reformulated transfers, contextual influences or withheld.

Results: Of the 132 factors, 38 (28.8%) transferred directly and 58 (43.9%) required reformulation, producing 96 candidate project-level conditions (72.7%). Seventeen factors (12.9%) remained contextual influences and 19 (14.4%) were withheld. Reformulation was especially important for organisational and stakeholder constructs, while wider regulatory and industry conditions generally remained contextual.

Conclusions: The assessment provides a traceable way to move from multi-level adoption evidence towards project-level research without redefining the original constructs. The resulting conditions are candidates for later contextual refinement and empirical investigation; they are not validated indicators of BESC suitability.

1. Introduction

Blockchain-enabled smart contracts (BESCs) are increasingly discussed as a means of improving automation, transparency, traceability and contractual processes in construction and infrastructure delivery [1, 2]. Alongside research examining their applications and potential benefits, a growing body of literature has investigated the conditions that may influence blockchain and smart-contract adoption. These studies have identified technological, organisational, institutional, transactional, governance and stakeholder-related factors that may support or constrain adoption [3, 4].

However, identifying factors that influence technology adoption is different from determining whether those factors can be used to assess an individual infrastructure project. Adoption studies operate at different levels of analysis. Some factors describe technological characteristics, while others concern organisational capabilities, stakeholder perceptions, inter-organisational relationships, industry conditions or the wider institutional environment. A factor may therefore be relevant to BESC adoption without necessarily describing a condition that can be assessed at the level of a specific project.

This distinction becomes important when adoption evidence is intended to support project-level decision-making. Directly converting literature-derived adoption factors into project assessment criteria may change their original meaning, obscure the actor or object to which they apply, or imply a level of project specificity that was not established in the original evidence. For example, an organisational capability cannot automatically be treated as a project characteristic, just as an institutional condition

cannot become a project attribute simply by expressing it in project-level language. A defensible transition from adoption evidence to project-level assessment therefore requires explicit consideration of the level at which each factor was originally defined and the extent to which its meaning can legitimately be connected to an individual project.

This problem emerged from a preceding systematic evidence synthesis of BESC adoption research in construction and infrastructure. The synthesis produced 132 harmonised literature-derived adoption factors after source-level evidence extraction, membership review and construct reconciliation. The resulting factors represent the breadth of conditions reported in the existing evidence base, but the synthesis did not establish that all 132 factors are directly transferable to the level of an individual PPP infrastructure project. Instead, it exposed a further analytical question concerning which factors can legitimately be expressed and assessed at project level and which should remain broader contextual influences.

This study addresses that question through a structured Project-Level Transferability Assessment. Rather than assuming that literature-derived adoption factors are ready-made project assessment criteria, each factor is examined in relation to its original construct meaning, level of analysis, relevant actor or object, connection to an individual PPP infrastructure project and possible basis for assessment. The purpose is to distinguish factors that can be transferred directly, those that require careful reformulation, those that should remain broader contextual influences, and those for which project-level transfer cannot be justified without changing the original construct.

The study therefore provides an analytical bridge between the identification of BESC adoption factors and their subsequent use in project-level research. Its intended output is a traceable set of project-level candidate conditions, supported by explicit transferability decisions and linked to their underlying evidence. These conditions are not treated as empirically validated indicators of BESC adoption suitability. Their contextual relevance and practical meaning within Nigerian PPP infrastructure delivery will be examined in the subsequent stage of the wider research.

1.1 Research Problem

Existing BESC adoption research provides evidence on a wide range of factors that may influence adoption. However, these factors are reported at different levels of analysis and in relation to different actors, objects and contexts. Their identification as adoption factors does not establish that they can be assessed as conditions of an individual PPP infrastructure project.

This creates a methodological problem for research seeking to move from technology-adoption evidence to project-level decision support. Without an explicit transferability assessment, organisational capabilities may be treated as project attributes, institutional conditions may be presented as characteristics of individual projects, stakeholder perceptions may be interpreted as shared project conditions, and technological capabilities may be mistaken for evidence of project suitability. Such

transformations risk changing the meaning of the original constructs and weakening the traceability between project-level assessment and the evidence from which it was derived.

What is therefore required is a systematic procedure for determining whether, and under what conditions, literature-derived BESC adoption factors can legitimately be expressed and assessed at the level of an individual PPP infrastructure project while preserving their substantive meaning and evidence provenance.

1.2 Aim

This study aims to assess the extent to which literature-derived factors influencing the adoption of blockchain-enabled smart contracts can be expressed and assessed as conditions of individual public–private partnership infrastructure projects.

1.3 Research Objectives

1. Determine the original levels of analysis, actors and objects represented by the harmonised literature-derived BESC adoption factors.

2. Assess whether each literature-derived adoption factor can be expressed as a condition of an individual PPP infrastructure project without changing its substantive meaning.

3. Identify the project-specific information required to assess factors that can legitimately be transferred to the project level.

4. Classify the literature-derived factors according to their project-level transferability and establish a traceable set of project-level candidate conditions for subsequent contextual refinement.

1.4 Research Questions

1. At what levels are BESC adoption factors defined and supported in the existing literature?

2. Which factors can be expressed as conditions of an individual PPP infrastructure project without changing their original meaning?

3. What project-specific information would be required to assess each transferable condition?

4. Which factors should remain contextual influences, require further clarification, or be withheld from project-level assessment?

2. Theoretical and Conceptual Foundation

2.1 Levels of Analysis in Technology-Adoption Research

The central methodological problem addressed in this study is partly a levels-of-analysis problem. Technology-adoption evidence is not necessarily produced at a single analytical level. Constructs may describe individuals, organisations, technological systems, inter-organisational relationships, projects, industries or wider institutional environments. A factor can therefore be relevant to BESC adoption without necessarily describing a condition of an individual PPP infrastructure project.

The importance of distinguishing analytical levels is well established in organisational research. Rousseau [5] identified levels of analysis as a central issue in organisational research and distinguished multilevel and cross-level perspectives. Klein et al. [6] subsequently showed that assumptions about the level at which a phenomenon exists influence the specification of theoretical constructs and propositions and should also guide data collection, analysis and interpretation. The level assigned to a construct is therefore not simply a matter of how the researcher chooses to describe it; it forms part of the theoretical meaning of the construct.

Kozlowski and Klein [7] similarly emphasised that multilevel research requires explicit attention to the level at which constructs are conceptualised and to the relationships between phenomena operating at different levels. Their multilevel perspective further supports the need to distinguish the target of assessment from the level and referent of the construct being assessed.

This distinction becomes particularly important when constructs are moved between analytical levels. Chan [8] demonstrated that constructs within the same content domain can exist at different levels while having qualitatively different meanings. He therefore proposed composition models for specifying the functional relationships between constructs across levels of analysis. This is directly relevant to the present study because similarity in terminology does not, by itself, establish equivalence across levels. An organisational adoption factor cannot automatically be treated as a project-level condition merely because a project-referenced version of the factor can be worded.

Morgeson and Hofmann [9] further showed that collective constructs require explicit consideration of their structure and function when developing multilevel theory. Their work reinforces the need to establish how a construct exists and operates at a particular level rather than assuming that constructs can be transferred unchanged between individual and collective levels. Together, these studies show that movement across analytical levels requires theoretical justification and attention to the meaning and referent of the construct [5, 6, 7, 8, 9].

Accordingly, the present study distinguishes between the target of the assessment and the actor or object represented by the construct. The target is an individual PPP infrastructure project, but this does not mean that every factor must become an intrinsic attribute of that project. For example, an organisational condition may be assessed for an organisation participating in a particular PPP project while remaining an organisational condition. Similarly, a regulatory or institutional condition may shape the environment surrounding a particular project without becoming a characteristic of the project itself.

This distinction provides an important theoretical basis for the Project-Level Transferability Assessment. Before a literature-derived factor is expressed at project level, the analysis must establish its original level, identify the actor or object to which it refers, and determine whether a defensible relationship with an individual PPP project can be established without changing the construct. Project-level transfer is therefore treated as a cross-level analytical problem rather than a simple exercise in rewording adoption factors.

2.2 Technology-Organisation-Environment Framework and the Location of Adoption Conditions

The Technology-Organisation-Environment (TOE) framework provides a second theoretical anchor. TOE explains organisational technology adoption through three broad contexts: technological, organisational and environmental [10, 11]. The technological context concerns technologies relevant to the organisation; the organisational context concerns organisational characteristics and resources; and the environmental context concerns the wider setting in which the organisation operates, including industry, competition and regulation.

This structure is important for the present study because it demonstrates that adoption influences are located in different contexts even when they contribute to the same adoption decision. Organisational resources, managerial support and organisational readiness remain organisational conditions. Regulatory arrangements, governmental support and competitive pressure remain environmental conditions. Technological characteristics concern the technology or technological system. Their common relevance to adoption does not make them analytically equivalent.

The TOE framework therefore supports the need to retain the original location of a factor when considering its relationship with an individual PPP project. It does not, by itself, provide a procedure for converting organisational or environmental adoption factors into project-level assessment conditions. The transferability procedure developed in this study addresses that methodological step while preserving the distinctions recognised by TOE.

2.3 Construct Meaning and Cross-Level Transfer

Project-level transfer raises a construct-validity problem. Constructs represent theoretically defined concepts, and their validity depends on maintaining a defensible relationship between the intended concept and the way it is interpreted or represented in research [12, 13, 14]. When a construct is adapted to another context or analytical level, its new expression should therefore continue to represent the same substantive concept. A reformulation that materially changes the actor, object, mechanism or meaning may no longer represent the original construct.

This principle provides the basis for the meaning-preservation test used in the present study. Before a literature-derived adoption factor can be expressed at project level, its original meaning must first be established with sufficient clarity. The actor or object to which the construct applies must also remain identifiable. This is consistent with the wider measurement literature, where equivalence of construct

meaning is treated as important when measures or constructs are compared or applied across different groups and contexts [15].

Contextualisation is therefore distinguished from conceptual substitution. Adding the word “project” to an organisational, institutional or technological construct does not, by itself, establish project-level transferability. A defensible project-referenced expression must preserve the substantive meaning of the original construct while making its relationship with the individual project explicit. Where such meaning cannot be preserved, the factor should remain a contextual influence or be withheld from project-level assessment rather than being forced into project-level language.

This reasoning is also consistent with research on contextual adaptation. Ambuehl and Inauen [16] argue that when an established measure is moved into a new context, translation and psychometric testing alone are insufficient unless the underlying concept is first shown to be meaningful in that context. The present study applies the same general logic one stage earlier: conceptual transfer is examined before measurement or operationalisation. Project-level measurability is therefore not treated as evidence that project-level transferability has already been established.

2.4 From Adoption Factors to Project-Level Conditions

The preceding systematic evidence synthesis identified and harmonised 132 literature-derived factors associated with BESC adoption. These factors provide the evidence base for the present study, but their inclusion in the harmonised inventory establishes only that they are defensible adoption-related constructs within the reviewed literature. It does not establish that all of them can be assessed as conditions of individual PPP infrastructure projects.

Project-level transferability is therefore defined in this study as the extent to which a literature-derived BESC adoption factor can be connected to and assessed in relation to an individual PPP infrastructure project, with the relevant actor or object explicitly identified, without materially changing the original meaning of the construct.

This definition allows a factor to remain attached to its proper analytical object. For example, an organisational factor can remain an organisational condition while being assessed specifically for the organisation participating in a particular project. The transferability question is not whether the project itself possesses every factor, but whether the factor can be meaningfully and traceably assessed in relation to the project context.

The resulting project-level conditions are therefore evidence-linked candidate conditions. They are not automatically validated measures, predictors of adoption success or indicators of project feasibility.

2.5 Transferability versus Project Suitability

Project-level transferability must be distinguished from project suitability. Transferability asks whether an adoption factor can legitimately be expressed and assessed in relation to an individual project.

Suitability asks whether the resulting evidence supports a judgement that BESC adoption is appropriate or feasible for that project.

The two questions require different evidential steps. Technology-adoption theories and empirical adoption studies identify influences on adoption, but they do not automatically establish project-level suitability thresholds. Treating every adoption factor as a suitability criterion would therefore extend the literature beyond what it has demonstrated.

The present study stops before that extension. A factor that passes the transferability assessment becomes eligible for subsequent project-level investigation. It does not, by passing, become evidence that a project is suitable for BESC adoption. Likewise, a factor retained as a contextual influence may remain important to adoption even though it is not represented as a direct project condition.

This boundary protects the study from converting technological capability into project suitability, organisational readiness into an intrinsic project attribute, or institutional support into a property of the project itself.

2.6 Theory-Informed Analytical Framework for Project-Level Transferability

The Project-Level Transferability Assessment combines the levels-of-analysis principle, TOE's recognition of distinct adoption contexts and construct-meaning preservation into a common analytical procedure. Each of the 132 harmonised factors is assessed using the same sequence:

Harmonised factor → supporting evidence → original construct meaning → original level of analysis → actor/object → project connection → meaning-preservation test → transferability disposition → project-level expression (where justified) → required assessment evidence.

The order of this sequence is deliberate. Required assessment evidence is considered only after transferability has been established. The possibility of measuring a factor is not used retrospectively to justify its transfer to project level.

Five tests guide the decision. First, the meaning test establishes what the factor represents in its supporting evidence. Second, the level test identifies the analytical level at which the construct was originally defined. Third, the actor/object test establishes whose or what condition is represented. Fourth, the project-connection test determines whether the construct can legitimately be related to a specific PPP infrastructure project. Fifth, the meaning-preservation test determines whether that project-referenced expression retains the substantive meaning of the original construct.

The assessment produces four possible dispositions. Direct transfer applies where the original construct is already assessable in relation to an individual project without substantive reformulation. Reformulated transfer applies where a defensible project-referenced expression is possible but the relevant actor, object or project relationship must be made explicit. Contextual influence applies where the factor remains relevant to adoption around a project but fundamentally operates at a broader organisational,

institutional, industry, stakeholder or environmental level and should not be represented as a direct project condition. Withheld from project-level assessment applies where available evidence cannot support a project-level expression without changing the construct or where critical information about its meaning, actor or object remains unresolved.

Verification status is recorded separately from disposition. Source-definition recovery, targeted verification or researcher review may therefore be required without being treated as additional transferability categories. This separation prevents uncertainty in the evidence from being confused with the conceptual outcome of the transferability assessment.

The framework also adopts a stopping rule. Where a critical fact required for a defensible transferability decision cannot be established from the controlled evidence, that information is recorded as unresolved rather than inferred. The procedure therefore favours traceability and construct preservation over forced classification.

2.7 Derivation of the Transferability Criteria

The transferability criteria used in this study were derived by bringing together three complementary bodies of literature: levels-of-analysis research, which addresses the location and referent of constructs; construct-validity and measurement-equivalence research, which emphasises preservation of construct meaning; and **technology-adoption theory**, particularly TOE, which distinguishes technological, organisational and environmental contexts. The criteria therefore represent an analytical synthesis developed for the present study rather than a framework reproduced from any single previous study.

Table 1: Theoretical and Methodological Basis of the Project-Level Transferability Assessment Criteria

Assessment component	Theoretical / methodological basis	Function in the Study
Original construct meaning	Construct validity and conceptual equivalence	Establishes what the source evidence actually represents.
Original level of analysis	Levels-of-analysis principle; TOE contextual structure	Prevents constructs from being silently moved across analytical levels.
Actor or object	Referent and unit-of-analysis consistency	Identifies whose or what condition is being assessed.
Project connection	Cross-level contextualisation	Tests whether the construct can legitimately be related to an individual PPP project.
Meaning-preservation test	Construct validity	Prevents project wording from creating a substantively different construct.
Transferability disposition	Controlled cross-level assessment	Records whether transfer is direct, reformulated, contextual or withheld.
Project-level expression	Contextualised construct representation	States the condition in project-referenced form only where transfer is defensible.
Required assessment evidence	Subsequent operationalisation	Specifies what would need to be known about a project without yet creating questionnaire items.
Verification status	Evidence traceability and uncertainty control	Separates unresolved evidence from the conceptual disposition.

Note. **Developed by the authors' synthesis of the theoretical and methodological principles discussed in this study**

Table 1 does not propose that the cited theories provide an existing project-level transferability model. Rather, it shows how established theoretical and methodological principles are combined to derive the assessment criteria used in this study. The four transferability dispositions are therefore analytical categories developed for the present study. Their purpose is to provide a consistent and traceable basis for determining how literature-derived adoption factors should be treated when moving towards project-level assessment.

2.8 Theoretical Position of the Study

The transferability framework is not presented as a new technology adoption theory. Rather, it is a theory-informed analytical procedure developed to address a specific methodological gap between adoption factor identification and project-level assessment. TOE helps locate adoption conditions within technological, organisational and environmental contexts. Levels-of-analysis principles prevent inappropriate movement of constructs between analytical levels. Construct-validity principles require preservation of substantive meaning during contextualisation.

The wider theoretical lenses of Transaction Cost Economics, Institutional Theory and Bounded Rationality remain relevant when interpreting particular factor families. Transaction Cost Economics can assist interpretation of contractual and transaction-related conditions [17, 18]. Institutional Theory can explain regulatory, normative and wider institutional influences [19, 20]. Bounded rationality draws attention to limits on available information and decision-making capacity [21]. Research on decision support systems also examines user capability and incentives [22]. These perspectives inform later interpretation and decision support; they do not replace the transferability procedure.

The theoretical position of this study is therefore deliberately bounded: the study does not attempt to prove that the 132 factors cause BESC adoption at project level. It determines whether the literature-derived constructs can be represented at project level without losing their original theoretical and evidential meaning. This provides the defensible bridge required before contextual refinement, measurement development and subsequent decision-support modelling.

3. Methodology

3.1 Research Design

The study adopts a structured evidence-mapping and construct-transfer approach. It builds directly on the harmonised evidence base developed in the preceding systematic evidence synthesis rather than conducting a new search for BESC adoption factors.

The preceding synthesis produced 132 harmonised adoption factors through source-level evidence extraction, evidence profiling, membership review and construct reconciliation. These 132 factors form the complete input set for the present study. Each factor is reassessed for project-level transferability while retaining its connection to the evidence from which it was derived.

The analysis is interpretive but controlled by an explicit, theory-informed assessment procedure. Transferability decisions are not made from factor labels alone. The underlying construct meaning, level of analysis, relevant actor or object and source evidence are considered before a project-level expression is accepted.

3.2 Unit and Target of Analysis

The unit entering the assessment is each of the 132 harmonised literature-derived BESC adoption factors.

The target context is an individual PPP infrastructure project. However, the object being assessed may differ across factors. Depending on the original construct, assessment may concern the project itself, a participating organisation, a stakeholder, an inter-organisational relationship, the proposed technological system, the contractual arrangement or the wider institutional environment.

Maintaining this distinction allows factors to be examined in relation to a particular project without incorrectly redefining every factor as a project attribute.

3.3 Evidence Base

The analysis retains the evidence provenance established during the preceding systematic synthesis. For each harmonised factor, the available source records, construct definitions, study identifiers and reconciliation information provide the basis for determining its original meaning and evidential context.

Study frequency is not used as a transferability threshold. A factor represented in several studies is not automatically more transferable than a factor represented in one study. Transferability is determined by whether a defensible connection can be established between the original construct and the assessment of an individual PPP project while preserving construct meaning.

Existing provisional project-transferability notes generated during earlier evidence processing are treated only as working material. They do not constitute final transferability decisions. All final assessments begin from the frozen 132-factor inventory.

3.4 Project-Level Transferability Assessment

Each factor is assessed through a common sequence. First, the original meaning of the factor is established from its supporting evidence. Second, its original level of analysis is identified. Third, the relevant actor or object is specified. Fourth, the relationship between that construct and an individual PPP infrastructure project is examined. Fifth, the analysis determines whether a project-referenced expression can be formulated without materially changing the original construct. A transferability disposition is then assigned. Only after transferability has been established is the information required to assess the resulting condition in a particular project identified.

The analytical sequence is therefore:

Harmonised factor → supporting evidence → original construct meaning → level of analysis → actor/object → project connection → meaning-preservation test → transferability disposition → project-level expression (where justified) → required assessment evidence.

This sequence provides an explicit audit trail between the literature-derived factor and the resulting project-level decision.

3.5 Transferability Decision Criteria

A factor is considered transferable only where its relationship with an individual PPP project can be stated without changing the substantive meaning established in the underlying evidence. The assessment therefore applies five tests: meaning, level of analysis, actor/object, project connection and meaning preservation.

Failure to establish a direct project connection does not automatically make a factor irrelevant; it may remain a contextual influence. Where project-level expression would materially change the construct, the factor is withheld rather than forced into project-level language.

3.6 Transferability Classification

The assessment uses four possible dispositions.

Direct transfer applies where the original construct is already assessable in relation to an individual project without substantive reformulation.

Reformulated transfer applies where a defensible project-referenced expression can be developed, but the relevant actor, object or project relationship must be made explicit. The reformulation must preserve the substantive meaning of the original construct.

Contextual influence applies where the factor remains relevant to BESC adoption for a particular project but fundamentally describes a wider organisational, institutional, industry, stakeholder or environmental condition that should not be represented as a direct project condition.

Withheld from project-level assessment applies where the available evidence does not support a defensible project-level expression without changing the construct, or where important information required to establish its meaning or assessment object remains unresolved.

These dispositions describe transferability rather than factor importance, causal strength or project suitability.

3.7 Identification of Required Assessment Evidence

For factors classified as direct or reformulated transfers, the analysis identifies the information that would be needed to assess the condition in an actual PPP infrastructure project.

This step specifies the type of project-specific evidence required rather than developing questionnaire items or measurement scales. Depending on the construct, such evidence may concern project documentation, contractual arrangements, technological requirements, participating organisations, stakeholder responsibilities or other relevant project circumstances.

The purpose is to establish what would need to be known about a project before the condition could be assessed. The validity and practical measurement of these conditions are reserved for subsequent stages of the wider research.

3.8 Traceability, Verification and Stopping Rule

A structured assessment record is maintained for each factor. The record links the final harmonised factor to its supporting evidence, original construct meaning, level of analysis, actor or object, project

connection, transferability disposition, proposed project-level expression where justified, required assessment evidence and rationale.

Verification status is recorded separately from disposition. Where the available evidence is insufficient to establish a critical element of the assessment, the missing information is recorded rather than inferred. Such cases may be flagged for source-definition recovery, targeted verification or researcher review.

The stopping rule requires the assessment to stop where a critical fact needed for a defensible decision cannot be established from the controlled evidence. This preserves the evidence trail and prevents completion pressure from producing unsupported project-level conditions.

3.9 Boundary of the Method

The study assesses project-level transferability rather than BESC adoption suitability. It does not rank the 132 factors, determine their relative importance, develop or validate questionnaire items, conduct exploratory factor analysis, establish Nigerian contextual relevance, classify individual PPP projects, or validate a final decision-support framework.

Its methodological endpoint is a traceable set of literature-derived conditions that can defensibly proceed to subsequent contextual refinement and empirical investigation, together with a documented record of factors that remain contextual or cannot presently be transferred to project-level assessment.

4. Results

4.1 Overall Project-Level Transferability

The Project-Level Transferability Assessment accounted for all 132 harmonised literature-derived factors. Thirty-eight factors (28.8%) were classified as direct transfers and 58 (43.9%) as reformulated transfers. Together, these 96 factors (72.7%) formed the transferable set: they could be expressed and assessed in relation to an individual PPP infrastructure project while retaining the substantive meaning of the underlying construct. The remaining 36 factors (27.3%) were not represented as project-level conditions. Seventeen (12.9%) were retained as contextual influences and 19 (14.4%) were withheld from project-level assessment.

Table 2
Project-Level Transferability Disposition of the 132 Harmonised Factors

Disposition	Number of factors	Share of 132
Direct transfer	38	28.8%
Reformulated transfer	58	43.9%
Contextual influence	17	12.9%
Withheld from project-level assessment	19	14.4%
Total	132	100.0%

Note. The dispositions describe project-level transferability. They do not represent factor importance, causal strength or project suitability.

The distinction between direct and reformulated transfer was maintained throughout the assessment. Direct transfer was assigned where the original construct was already assessable in relation to an individual project without substantive reformulation. Reformulated transfer was assigned where the construct remained transferable but its actor, object or relationship with the project had to be made explicit. The reformulation therefore clarified the assessment referent rather than replacing the original construct.

4.2 Project-Level Candidate Conditions and Required Assessment Evidence

For each of the 96 transferable factors, the assessment produced a project-level expression, identified the relevant actor or object and specified the project-specific information required for assessment. The resulting expressions were not limited to intrinsic project characteristics. Depending on the original construct, they concerned the proposed technological system, project data, contractual and governance arrangements, participating organisations, stakeholders, inter-organisational relationships or the intended project use case.

The required assessment evidence also varied with the construct. Technology- and system-related conditions generally required information on the proposed architecture, interfaces, data flows, access arrangements, security controls or technical capacity. Contract- and governance-related conditions required information on contractual provisions, workflow rules, decision rights, participation arrangements, variation procedures or transaction requirements. Organisational and stakeholder conditions required information about participating organisations, relevant roles, available resources, competence, perceptions, responsibilities or implementation arrangements. This step identified what would need to be known about an actual project; it did not create questionnaire items, scales or suitability thresholds.

Two reformulated-transfer records retained separate verification qualifications. ID-HCF-0240 (BESC awareness) requires targeted verification of the source-defined actor before its project-level assessment

can be finalised. ID-HCF-0042 (contract relationality) requires recovery of the source definition and indicators before its final project-referenced expression can be confirmed. Their verification status was therefore kept separate from their transferability disposition.

4.3 Contextual Influences and Withheld Factors

Seventeen factors were retained as contextual influences. These factors remained relevant to BESC adoption around an individual PPP project but operated principally in the wider institutional, regulatory, industry, market or professional environment. They included conditions such as competitive pressure, government or regulatory mechanisms, legal-framework adequacy, prevailing industry norms and practices, regulatory clarity and sector-specific digital policy. Recasting these conditions as intrinsic project attributes would have changed their analytical level or referent.

Nineteen factors were withheld from project-level assessment. Withholding did not indicate that the factors were unimportant. It indicated that the controlled evidence did not support a defensible project-level expression without changing the construct, supplying an unsupported actor or object, or generalising beyond the source-supported meaning. This occurred where the assessment object remained insufficiently bounded, where a broad harmonised label covered a more specific source expression, or where transfer risked converting a technological capability or source-specific proposition into a project-suitability criterion.

4.4 Cross-Factor Analytical-Object Patterns

For cross-factor synthesis, the controlled actor/object field was grouped into eight derived analytical-object categories. These categories were used to summarise the structure of the 132-factor register. They are synthesis categories developed from the controlled assessment record and are not treated as source-authored original levels of analysis.

Table 3
Transferability Disposition by Derived Analytical-Object Category

Derived analytical-object category	Direct	Reformulated	Contextual	Withheld	Total
Technology / system / data	14	16	0	6	36
Contract / governance / transaction / process	19	5	0	2	26
Organisation / management / workforce	0	14	0	0	14
Stakeholder / user / actor	4	15	0	1	20
Inter-organisational / relationship	1	3	0	0	4
Project / use case	0	1	0	1	2
External environment	0	2	17	1	20
Unresolved / insufficiently bounded	0	2	0	8	10
Total	38	58	17	19	132

Note. Categories were derived for cross-factor synthesis from the controlled actor/object field. They are not presented as source-authored levels of analysis.

Direct transfer was concentrated in conditions attached to project-operational objects. Thirty-three of the 38 direct transfers (86.8%) concerned either technology/system/data or contract/governance/transaction/process conditions. These constructs generally had sufficiently bounded objects and could be connected to an individual project without changing their substantive meaning.

Reformulated transfer was distributed more widely across actor and organisational objects. Forty-five of the 58 reformulated transfers (77.6%) concerned technology/system/data, stakeholders/users/actors, or organisations/management/workforce. In these cases, project-level assessment generally required the relevant organisation, stakeholder, user or technological object to be stated explicitly rather than treating the construct as an attribute of the project itself.

All 17 contextual influences fell within the derived external-environment category. This maintained the distinction between conditions that can be assessed in relation to an individual project and wider conditions that surround the project. By contrast, eight of the 19 withheld factors (42.1%) fell within the unresolved or insufficiently bounded category, showing that unclear construct meaning, actor or assessment object was a recurring reason for withholding project-level expression.

4.5 Evidence Breadth and Transferability

Study-support frequency varied across all four dispositions. Among direct transfers, 28 of 38 factors were represented by one study. Among reformulated transfers, 39 of 58 were represented by one study. Thirteen of the 17 contextual influences and 15 of the 19 withheld factors were also single-study factors. Multi-study representation therefore occurred in every disposition and did not determine the transferability outcome.

Table 4
Evidence-Support Breadth by Transferability Disposition

Disposition	1 study	2 studies	3–4 studies	5 + studies	Total
Direct transfer	28	5	3	2	38
Reformulated transfer	39	7	5	7	58
Contextual influence	13	2	2	0	17
Withheld	15	1	0	3	19

Note. Support frequency is interpreted only as descriptive evidence breadth. It is not evidence of importance, effect magnitude, validity, priority, transferability or project suitability.

This result is consistent with the assessment rule established in the methodology: transferability depended on construct meaning, level of analysis, actor or object, project connection and meaning preservation rather than the number of studies in which a factor appeared.

4.6 Resulting Evidence Set for Subsequent Project-Level Research

The assessment produced two linked outputs. The first is a set of 96 literature-derived candidate conditions that can proceed to subsequent project-level contextual refinement and empirical investigation. The second is a documented set of 36 non-transferable factors comprising 17 contextual influences and 19 withheld factors. Retaining both groups preserves the complete evidence trail and prevents the 96 project-level candidate conditions from being interpreted as a complete statement of every influence on BESC adoption.

The 96 conditions remain candidate project-level conditions. Their inclusion establishes that the literature-derived construct can be assessed in relation to an individual PPP infrastructure project without unacceptable loss of meaning. It does not establish empirical importance, Nigerian contextual relevance or BESC suitability for any particular project.

5. Discussion

5.1 From Adoption Factors to Project-Level Conditions

The main finding of this study is that literature-derived adoption factors cannot be moved to project level by simple rewording. Although 96 of the 132 harmonised factors were transferable, only 38 could be transferred directly. The remaining 58 transferable factors required reformulation so that the relevant actor, object or relationship with the project was made explicit. A further 36 factors could not be represented as project-level conditions without either changing their analytical level or extending the available evidence.

This finding supports the levels-of-analysis argument developed in Section 2. Constructs retain meaning partly through their referent and analytical location [5, 6, 7, 8, 9]. Accordingly, project-level assessment does not require every adoption factor to become an intrinsic project attribute. An organisational condition may remain organisational while being assessed for an organisation participating in a particular project, and a stakeholder condition may remain attached to the relevant stakeholder while being examined in relation to that project. The important requirement is that the project connection is explicit and the original construct meaning is preserved.

The results therefore distinguish project-level transfer from conceptual substitution. The 96 transferable factors are not a renamed version of the original 132-factor inventory. They represent the subset for which a defensible project connection could be established, together with an explicit statement of what or whose condition would be assessed and what project-specific information would be required.

5.2 Why Direct Transfer Concentrated in Technology and Contract-Process Conditions

Direct transfer was concentrated in technology/system/data and contract/governance/transaction/process conditions. Together, these categories accounted for 33 of the 38 direct transfers. This pattern is understandable because such constructs often have an identifiable assessment object that can be examined within the proposed project arrangement. A technological requirement can be related to the proposed system architecture, data environment or technical interface, while a contractual or transaction condition can be related to the project's contractual provisions, workflow, decision rights or transaction structure.

The pattern also helps explain why project-level transferability is not the same as project-level origin. A construct does not need to have been developed originally as a PPP project variable to be directly transferable. What matters is whether its source-supported meaning already identifies an object that can be examined in relation to the individual project without substantive reinterpretation.

Transaction Cost Economics is useful for interpreting part of this pattern because several transferable conditions concern contractual arrangements, transactions, governance mechanisms and the organisation of exchange [17, 18]. The present study does not test Transaction Cost Economics or infer causal effects from these factors. Rather, the concentration of direct transfers around bounded contractual and transaction objects shows why such constructs can often be connected to project arrangements more readily than broader organisational or institutional conditions.

5.3 Why Organisational and Stakeholder Conditions Commonly Required Reformulation

Reformulated transfer was more common than direct transfer and was particularly evident among organisational, workforce, stakeholder and user-related conditions. These constructs can be highly relevant to an individual PPP project, but their referent is usually not the project itself. For example, organisational resources, management support, workforce competence or stakeholder perceptions belong to identifiable organisations or actors. Treating them as project attributes would collapse the distinction between the target of assessment and the object represented by the construct.

The reformulation procedure resolves this problem by keeping the construct attached to its proper actor or object while making the project relationship explicit. This is consistent with the TOE framework, which distinguishes technological, organisational and environmental contexts rather than treating all adoption influences as equivalent [10, 11]. The results show why that distinction remains important when adoption evidence is taken into project-level research: organisational conditions can be assessed in relation to a project without being redefined as characteristics of the project.

This distinction is also important for later empirical work. If the actor or object is not retained, a future questionnaire or assessment instrument could ask respondents to judge a 'project condition' that was originally an organisational or stakeholder construct. The resulting measure might appear operationally convenient while no longer representing the construct supported by the literature. Reformulated transfer therefore provides a controlled bridge to later measurement development rather than a shortcut around construct definition.

5.4 External Conditions Should Remain Contextual

All 17 contextual influences were located in the derived external-environment category. This is one of the clearest patterns in the assessment. Regulatory clarity, legal-framework adequacy, sector-specific digital policy, competitive pressure, industry norms and related conditions may shape the environment in which a PPP project is developed, but they do not become properties of an individual project simply because the project is exposed to them.

This result is consistent with both TOE and Institutional Theory. TOE places regulation, competition and wider industry conditions in the environmental context, while Institutional Theory provides a basis for understanding coercive, normative and wider institutional influences [19, 20]. In the present study these theories support interpretation of where such conditions operate; they do not justify relocating them to project level. Retaining them as contextual influences therefore preserves their analytical role while keeping them visible in the wider adoption environment.

This treatment also avoids a potentially important error in decision-support development. If an external regulatory or industry condition is represented as an intrinsic project characteristic, later analysis may imply that the project can alter or possess a condition that actually exists at sector or institutional level.

Keeping these factors contextual allows them to inform subsequent Nigerian PPP analysis without misrepresenting their level.

5.5 Withholding as a Construct-Preservation Decision

The 19 withheld factors demonstrate the value of allowing the assessment to stop when the evidence does not support a defensible project-level expression. Eight of these factors fell within the unresolved or insufficiently bounded analytical category. Other withheld cases involved source expressions that were narrower than their harmonised labels or technological capabilities that could not be converted into project conditions without adding a suitability judgement.

Withholding should therefore not be interpreted as evidence against the relevance of these factors. It is an evidence-control decision. Construct-validity principles require the representation of a construct to remain connected to its intended meaning [12, 13, 14]. Where the actor, object or substantive boundary cannot be established, producing a more convenient project-level expression would create certainty that the evidence does not provide.

The stopping rule is particularly important in a large evidence base because harmonisation can create labels that are broader than some of the underlying source expressions. A publication-facing factor label is useful for organising evidence, but it does not remove the need to return to the source-supported meaning when the factor is moved into another analytical context. The withheld category preserves that distinction and makes unresolved evidence visible rather than silently resolving it through researcher wording.

The stopping rule is consistent with bounded rationality: decisions must be made with limited information, and missing evidence should remain visible [21]. User capability and incentives also warrant attention in later decision-support work [22]. In the present assessment, limited information is handled by narrowing labels to the source-supported meaning and withholding unsupported transfer rather than filling project-level evidence gaps through inference.

5.6 Evidence Breadth Does Not Determine Transferability

The distribution of study-support frequency provides a further methodological result. Single-study factors occurred in all four dispositions, and multi-study factors also appeared across the transferable, contextual and withheld groups. The number of supporting studies therefore did not determine whether a factor could be transferred to project level.

This distinction is important because evidence breadth and construct transferability answer different questions. Study frequency describes how widely a factor is represented in the controlled literature base. Transferability concerns whether the factor can be connected to an individual project while preserving its meaning, level and referent. A frequently reported factor may still be too broad or externally located for project-level representation, while a single-study factor may have a clear and bounded project connection.

Accordingly, the 96 project-level candidate conditions should not be ranked by the frequency with which they appeared in the preceding synthesis. Their subsequent relevance, importance and empirical structure require separate investigation.

5.7 Implications for the Wider Decision-Support Research

The immediate contribution of the transferability assessment is a controlled reduction in analytical ambiguity rather than a reduction in the number of adoption influences. The original 132-factor evidence base remains intact, but it is now divided according to how the evidence can legitimately be used in project-level research. Ninety-six factors can proceed as candidate project-level conditions, 17 remain contextual influences and 19 remain withheld unless their evidential boundaries can be resolved.

This provides a defensible input for the next stage of the wider research. Contextual refinement can now examine the practical meaning and relevance of the 96 candidate conditions within Nigerian PPP infrastructure delivery without starting from an undifferentiated list of adoption factors. At the same time, the 17 contextual influences can be considered at their proper institutional, regulatory or industry level, while the withheld factors remain visible for targeted verification rather than being lost from the evidence trail.

The resulting structure is also compatible with later decision-support development. Required assessment evidence identifies the kinds of project, organisational, stakeholder, contractual and technological information that would eventually be needed to assess the transferable conditions. However, the present study does not determine measurement scales, thresholds, factor weights or classification rules. Those steps require subsequent contextual and empirical work.

5.8 Methodological Contribution and Limitations

Methodologically, the study provides a transparent procedure for moving from a harmonised technology-adoption evidence base towards project-level assessment without assuming that adoption factors are ready-made project criteria. Its contribution lies in separating the target of assessment from the actor or object represented by the construct and in requiring meaning preservation before operationalisation.

The procedure nevertheless has limitations. The assessment depends on the quality and specificity of the evidence retained from the preceding synthesis. Where source definitions or construct boundaries were weak, the transferability assessment could not create information that was absent from the evidence base. The derived analytical-object categories used for cross-factor synthesis are also researcher-developed synthesis categories rather than categories reported by the original studies. They should therefore be interpreted as an organising device for the present analysis.

Finally, transferability is a conceptual and evidential judgement rather than empirical validation. The 96 candidate conditions have not yet been shown to be important, measurable or suitable for Nigerian PPP projects, and no causal relationship with BESC adoption is claimed. These questions belong to the subsequent contextual refinement, measurement and validation stages of the wider research.

6. Conclusion

This study examined whether literature-derived factors influencing the adoption of blockchain-enabled smart contracts can be expressed and assessed as conditions of individual PPP infrastructure projects without changing their substantive meaning. Starting from the 132 harmonised factors produced by the preceding systematic evidence synthesis, the study applied a structured Project-Level Transferability Assessment based on construct meaning, level of analysis, actor or object, project connection and meaning preservation.

The assessment showed that 96 of the 132 factors were transferable to project-level assessment. Thirty-eight could be transferred directly, while 58 required reformulation to make the relevant actor, object or relationship with the project explicit. Seventeen factors were retained as contextual influences because they operated principally in the wider institutional, regulatory, industry, market or professional environment. Nineteen were withheld because the available evidence did not support a project-level expression without changing the construct, extending the source-supported meaning or resolving information that remained unclear.

These findings show that adoption factors should not be treated automatically as project assessment criteria. Project-level transfer requires more than adding project-referenced wording. The original analytical location and referent of a construct must remain clear. Organisational and stakeholder conditions can be assessed in relation to a particular project while remaining attached to the relevant organisation or stakeholder, and external institutional conditions can remain relevant to the project without becoming project attributes.

The study therefore provides a traceable analytical bridge between evidence synthesis and subsequent project-level research. The 96 transferable factors now form a literature-derived set of candidate project-level conditions, each linked to an identified actor or object and to the type of project-specific information required for assessment. The 17 contextual influences and 19 withheld factors remain part of the evidence trail rather than being discarded.

The resulting conditions should not be interpreted as validated measures, indicators of factor importance or evidence that BESC adoption is suitable for a particular PPP project. Their practical relevance, measurement and contextual meaning require further investigation. The next stage of the wider research can therefore begin from a more defensible basis: a controlled set of literature-derived conditions that have first been shown to be conceptually transferable to project-level assessment, together with a documented record of the broader and unresolved factors that should not be forced into that level.

Declarations

Clinical trial number: not applicable.

Funding

This article forms part of Ajalah M Yahaya's doctoral research at Durban University of Technology, South Africa. Ajalah M Yahaya is supported by the 2026 DUT Doctoral Scholarship Scheme.

Data availability

The factor-level assessment register supporting the findings of this study is available from the corresponding author upon reasonable request.

Ethics approval and consent to participate

This study analysed evidence drawn from published research and did not recruit human participants or collect new participant data. Ethics approval and consent to participate were therefore not applicable to this stage of the research.

Competing interests

The authors declare no competing interests.

Author contributions

Ajalah M Yahaya: Conceptualization, methodology, formal analysis, writing – original draft. Iruka C Anugwo: Supervision, writing – review and editing.

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