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CONTENTS-PROCEDURES-HUMAN RELATIONSHIPS TRIAD: RECONCEPTUALIZING LEAN IMPLEMENTATION

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ABSTRACT

Despite widespread Lean Construction adoption, implementation success remains inconsistent. This study investigates reciprocal influences among three project management domains—Contents (specific requirements), Procedures (systematic methodologies), and Human Relationships (interpersonal dynamics)—to explain persistent Lean implementation challenges. Mixed-methods research combining surveys (n=21) and interviews (n=22) with Singapore construction professionals examined cross-domain interactions integrating Lean thinking with traditional project management constraints. Results suggest hierarchical influence patterns: Technical contents appear to exert strong, deterministic influence on procedures, with procedures reciprocally constraining technical design through operational realities. However, critical asymmetry emerges regarding Human Relationships, enabling technical and procedural effectiveness through trust, communication quality, and collaborative norms. Conversely, technical sophistication and procedural rigor demonstrate weak influence on relational development, indicating Contents and Procedures cannot autonomously generate the collaborative culture Lean requires. Interview analysis identified relational dysfunction rather than technical inadequacy as primary implementation failure mode, while communication breakdowns prevented collaborative planning, authentic commitment-making, and honest waste identification despite technically correct tool deployment. This research empirically grounds Human Relationships as an enabling foundation requiring deliberate cultivation, challenging technical determinism in construction management practice. Effective Lean implementation requires establishing collaborative culture before deploying technical tools, necessitating reconceptualized approaches prioritizing relational development alongside technical and procedural refinement.

KEYWORDS

Human relationships, asymmetric influence, relational capabilities, project management, Lean Construction.

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INTRODUCTION

Since Koskela (1992) reconceptualized production theory for construction in a fundamental manner, Lean Construction has made significant headway. Comprehensive toolkits such as Last Planner System (Salama et al., 2021), value stream mapping (Nath et al., 2015), pull planning (Ghanem et al., 2022), and visual management (Tezel & Aziz, 2017a) have developed with the benefit of research evidence of their efficacy (Ballard & Howell, 2002; Sacks et al., 2010). But the success of such implementation has not been consistent. Lean tools are adopted in organizations, yet organizations struggle to sustain the cultural paradigm shift that allows them to adapt, leading them to revert to the old adversarial behavior under pressure despite the technological complexity (Mossman, 2009). Despite a robust regulatory environment in Singapore, successful BIM application, and government Lean commitment from the Building and Construction Authority, the industry is marred with coordination-focused delays and costs, such that the sector experiences persistent coordination-driven delays and cost overruns (Building and Construction Authority 2025). The divergent trajectory from Lean potential to actual performance indicates a basic neglect; current discourse favours tool-centric techniques while undertheorizing systems in place to facilitate their use. The conventional cost-time-quality triangle identifies performance requirements but does not clearly address specific domains of management that need to be integrated. The framework proposed by Wong (2014) provides an alternative via three interdependent dimensions: Contents (specific requirements), Procedures (systematic methodologies), and Human Relationships (interpersonal dynamics). This triad fundamentally differentiates: instead of identifying what projects need to do, it tells managers what to integrate in order to achieve it. This study empirically investigates these domains through the internal influence, relative importance, and implications of Lean in the construction context of Singapore.

THEORETICAL FOUNDATIONS

LEAN CONSTRUCTION AS SOCIO-TECHNICAL SYSTEM

Lean thinking originated from manufacturing contexts characterized by relatively stable workflows, repetitive processes, and single-organizational control (Ono & Bodek, 1988; Womack & Jones, 1996). Construction presents fundamentally different circumstances: temporary multi-organizational coalitions, site-specific constraints, and complex stakeholder ecosystems (Koskela, 2000). These reframe Lean implementation from technical challenge to socio-technical coordination challenge with concurrent transformation optimisation, workflow continuity, and value generation for diverse stakeholders as a necessity (Koskela, 1992). Recent studies increasingly acknowledge Lean's social prerequisites. Ballard (2000)'s Last Planner System adds collaborative planning as social practice, one reliant on trust and psychological safety. These insights are consistent with the findings of empirical work, which shows the influence of the organizational culture on visual management practice (Tezel & Aziz, 2017b); cultural barriers significantly constrain adoption (Johansen & Walter, 2007); leadership commitment is the critical factor in successful implementation (Sarhan & Fox, 2013). These results converge on a fundamental tenet: Lean tools only perform at their best when they are put at the core of functional social architectures (Sacks et al., 2010).

COLLABORATION AND RELATIONAL DYNAMICS

Team collaboration, trust, and communication are widely recognized as critical determinants of construction project performance. Kadefors (2004) demonstrated that formal contractual mechanisms can paradoxically undermine trust, with close monitoring inducing opportunism rather than cooperation. Cheung et al. (2013) provided empirical evidence that communication mediates the trust–performance relationship, while Meng (2012) established that long-term

collaborative arrangements yield measurably better project outcomes than adversarial, transactional ones. In the Lean construction context, Ballard (2000) showed that the Last Planner System depends fundamentally on voluntary, trust-based commitment-making rather than technical compliance, and Franz et al. (2017) demonstrated across 204 projects that team integration and group cohesion significantly mediate the relationship between delivery method and cost, schedule, and quality performance. Despite this evidence, the construction industry retains a deeply adversarial culture (Bresnen & Marshall, 2000) that consistently impedes collaborative working. Critically, Chinowsky et al. (2008) identified a persistent socio-technical gap in the literature: human and relational factors are predominantly studied in isolation from technical/engineering focus.

THE TRIADIC FRAMEWORK

Wong (2014) proposed a framework which comprises three domains providing conceptual scaffolding for socio-technical coupling. Contents reflect project knowledge: drawings, specifications, contractual terms, quality standards. Procedures represent organizational learning: construction methodologies, quality protocols, safety systems, approval workflows. Human Relationships refer to the dynamics between people: communication patterns, trust levels, conflict resolution mechanisms, stakeholder alignments. The theoretical robustness of the triad is its recognition of interdependence in systems. While the contents and procedures are explained in detail in this book, the human relationships and their internal relationships are not discussed.

RESEARCH METHODOLOGY

This study combines quantitative assessment with qualitative exploration (Weyant, 2022). The study utilized a purpose-built questionnaire (n=21) that measured cross-domain interactions among Contents, Procedures, and Human Relationships based on the influence of each domain, utilizing five-point effectiveness scales to measure the effects. 22 construction professionals who participated in semi-structured interviews examined a variety of integration mechanisms that included alignment strategies, change management approaches, conflict resolution dynamics, and communication practices. The demographic and professional characteristics of survey respondents are shown in Figure 1. Engineers are the largest group (n=9, 43%), followed by Project Managers from contractors (n=7, 33%) and clients (n=2, 10%), with Architects (n=2, 10%) and a Project Director from the contractor side (n=1, 5%) also represented. Most respondents had more than 15 years of industry experience (n=13, 62%), while 10% (n=2) had between 10 and 15 years, 24% (n=5) had between 5 and 10 years, and only one respondent had less than a year of experience. Regarding project exposure, 52% (n=11) had worked exclusively in Singapore, while the remaining 48% (n=10) had experience across both Singapore and overseas projects.

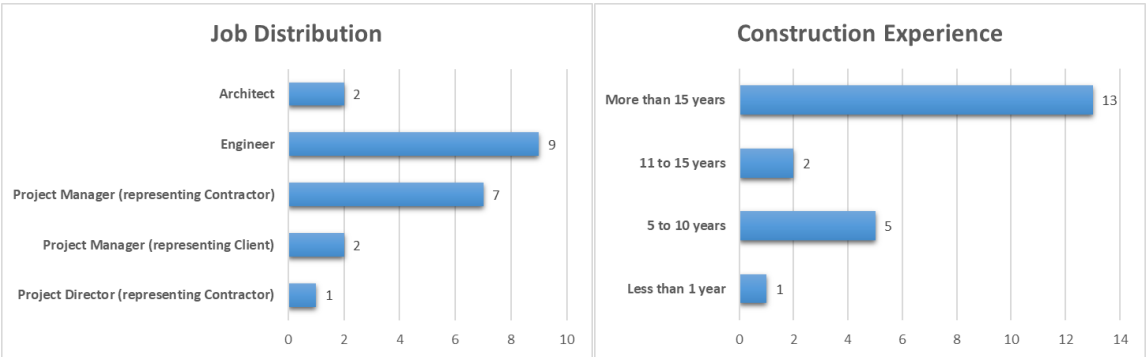

Figure 1: Demographics and professional profile of survey respondents (n=21)

As shown in Table 1, the 22 interviewees were drawn from contractors (n=10, 45%), consultants (n=8, 36%), contractor/specialist firms (n=2, 9%), and client/government bodies (n=2, 9%). The vast majority (n=18, 82%) had previously served at Project Manager level or above, and 91% possessed at least 11 years of industry experience, with nearly half (41%) falling in the 15–20 year range. All interviews were audio recorded with consent, averaged twenty-five minutes in duration, and subsequently transcribed for analysis.

Table 1: Profile of interview participants

Interviewee	Working for	Did the interviewee serve as PM?	Level of Experience
#1	Contractor	Yes	15 to 20 years
#2	Contractor	Yes	11 to 15 years
#3	Contractor	No	5 to 10 years
#4	Contractor	No	5 to 10 years
#5	Contractor	Yes	15 to 20 years
#6	Consultant	Yes	15 to 20 years
#7	Consultant	Yes	15 to 20 years
#8	Contractor	Yes	15 to 20 years
#9	Consultant	Yes	15 to 20 years
#10	Contractor	Yes	11 to 15 years
#11	Consultant	Yes	15 to 20 years
#12	Contractor	Yes	20 to 30 years
#13	Consultant	Yes	>50 years
#14	Contractor/Specialist	Yes	11 to 15 years
#15	Contractor	Yes	11 to 15 years
#16	Contractor	Yes	30 to 50 years
#17	Client/Government	No	11 to 15 years
#18	Contractor/Specialist	Yes	11 to 15 years
#19	Consultant	Yes	11 to 15 years
#20	Consultant	Yes	15 to 20 years
#21	Client/Government	No	20 to 30 years
#22	Consultant	Yes	15 to 20 years

To describe the patterns in this sample, this study adopts quantitative analysis and descriptive statistics (means and standard deviations). Significance testing is not conducted due to the limited sample size. Thus, we interpret means descriptively. Standard deviations in the data indicate varying response variation among respondents in the sample. This research explored general project management, since lean construction concepts must be operationalised within construction domain. By investigating the triadic framework's general dynamics, we identify

the underlying structural conditions that enable or constrain any management philosophy, including lean construction.

RESULTS AND FINDINGS

CROSS-DOMAIN INTERACTIONS

This section examines influences among Contents, Procedures, and Human Relationships. The influence characteristic of the triad distinguishes it against simple linear frameworks. The survey results are summarized in Table 2.

Based on the descriptive survey data, Technical-to-Procedural influences (M = 4.00–4.52) correspond to direct, deterministic relationships—design specifications mechanically constrain construction methods. These influences are immediate, observable, and generally well understood (low SD = 0.60–0.77). Relational-to-Technical influences (M = 3.86–4.19) are enabling, probabilistic—trust and communication create a conducive environment for technical optimization. These are diffuse, delayed, and organizationally contingent (SD up to 0.96).

THE NATURE OF TECHNICAL-PROCEDURAL COUPLING

Technical contents have direct and deterministic influence over procedures. Structural requirements dictate safety protocols, MEP system integration requires coordination procedures, and complex geometries need complicated formwork systems—these design specifications limit ways of constructing. The strongest ratings (means 4.00-4.52) and remarkable consensus (standard deviations 0.60-0.77) in these relationships indicate they represent universal observable phenomena. The influence operates almost mechanically: when technical contents specify certain performance requirements, procedural responses become nearly inevitable. Construction sequencing decisions are driven by design complexity (M=4.38), safety procedures are enforced based on structural requirements (M=4.52, SD=0.60), and MEP system integration requires formalised coordination protocols (M=4.14). The lowest variability in this direction is observed precisely for structural-safety and MEP-coordination relationships (SD=0.60 and SD=0.65, respectively), underscoring how these are widely recognized, universal challenges across project contexts.

The mechanisms also shape technical content in the reverse direction, though less directly. Execution realities impose meaningful constraints on design freedom—safety regulations drive design adaptations, schedule pressures promote modular solutions, and site logistics limit constructability. This reverse influence earned substantial ratings, with means ranging from 3.81 to 4.25. The strongest of these is the influence of safety requirements on design adaptations (M=4.25), which reflects the growing uptake of prevention-through-design principles, where procedural safety imperatives actively reshape technical solutions. Together, these bidirectional technical-procedural relationships constitute construction's mechanical substrate—the deterministic foundation on which projects are built.

Table 2: Cross-domain interactions among contents, procedures, and human relationships

How Contents Influence Procedures		
Mechanism	Mean	SD
Design complexity's influence on construction sequencing	4.38	0.74
Material specifications' effect on quality control procedures	4.00	0.77
MEP systems' impact on coordination procedures	4.14	0.65
Structural requirements' influence on safety procedures	4.52	0.60
Architectural features' effect on resource allocation	4.05	0.67
How Procedures Influence Contents		
Mechanism	Mean	SD
Site logistics procedures' influence on design modifications	3.81	0.93
Quality control processes' effect on material specifications	3.95	0.74
Schedule management procedures' impact on technical solutions	4.10	0.62
Safety requirements' influence on design adaptations	4.25	0.72
Resource availability procedures' effect on technical decisions	3.84	0.76
How Human Relationships Influence Contents		
Mechanism	Mean	SD
Knowledge sharing across teams	3.95	0.80
Open communication channels for early problem identification	4.19	0.75
Stakeholder trust enabling innovation	3.86	0.96
How Technical Contents Impact Human Relations		
Mechanism	Mean	SD
Technical knowledge's effect on trust and mentoring	4.10	0.72
Understanding technical complexities' effect on communication with specialists	4.15	0.81
How Human Relationships Influence Procedures		
Mechanism	Mean	SD
Team communication styles affecting operating procedures	4.14	0.73
Cultural diversity's effect on work procedures	3.57	1.12
How Procedures Impact Human Relations		
Mechanism	Mean	SD
Procedure complexity's effect on team stress	3.81	0.68
Quality/safety control procedures' effect on working relationships	4.00	0.77
Change management procedures' impact on team spirit	3.90	0.79

THE ENABLING FUNCTION OF HUMAN RELATIONSHIPS

Human relationships registered comparatively moderate influence across all measured mechanisms (means 3.57–4.19), with considerably greater variability in responses (standard deviations 0.73–1.12) than those observed in the technical-procedural domain. Unlike the near-mechanical consistency of technical-procedural relationships, the effects of human dynamics on both contents and procedures were uneven across organizations, suggesting that their impact is neither automatic nor uniform. This pattern points to a fundamentally different mode of operation—one that is enabling rather than determining. Relationships do not generate technical or procedural solutions directly; rather, they create the organizational conditions under which such optimisation may or may not occur. Open communication channels for early problem identification received the strongest rating in this domain (M=4.19, SD=0.75), suggesting broad recognition of communication's role in surfacing issues before they escalate.

Interview evidence sheds light on the mechanisms that underpin this asymmetry. One consultant Project Manager mentioned: "For any project, if you don't have a good framework and cohesive team, you will find that you will not be able to — whether via contract, design or actual site implementation, none can interlink and none can execute." (Interview #11) Another project director said: "If relationship is not good, will affect progress of work. In construction, teamwork is very important... Relationship is always very important for progress completion — that's why we are managing it very carefully, internally and externally." (Interview #12) He also adds a concrete mechanism linking relationships to technical outcomes: when good relationships exist with consultants, RFI responses that normally take 14 days can come back in 2 to 3 days which indicates a direct procedural acceleration through relational capital. One specialist project manager offered a detailed account of how even digitally enabled projects collapse into blame culture without relational trust: "It becomes the blame game. 'I gave you, but you never used it.' 'I thought I didn't receive it.' That's happening." He contrasts this with how informal relational give-and-take on the ground resolves minor clashes that formal procedures cannot efficiently handle. (Interview #14) This observation supports the asymmetry's essence: technical contents and procedures are necessary but insufficient. Projects require technical proficiency, but the technical investment alone cannot make up for relational shortage. These observations synthesize one basic tenet: that human relationships are foundation not edge. Foundation effects are more indirect, diffuse, and less visible, which may explain both relatively modest survey ratings and the large variation that occurred. However, it is foundation that decides whether superstructure succeeds or fails.

IMPLICATIONS: WHY TECHNICALLY SOUND LEAN IMPLEMENTATIONS FAIL

This asymmetry explains the Lean Construction paradox: organizations operationalize Last Planner System using digital platforms (strong Contents and Procedures), but suffer unreliability of the commitments, adversarial actions, and failures to coordinate (weak Human Relationships). Technical and procedural rigour cannot generate the trust, psychological safety, and collaborative culture that Lean mandates. As Ballard (2000) argues, Last Planner at its core relies on the voluntary process of commitment, through trust, as a social condition that technical tools are incapable of imposing. This pattern was consistently noted by interview respondents. This claim verifies the foundation metaphor because the same technical and procedural systems create drastically different effects depending on the quality of relationship. Value stream mapping shows this dynamic – technically competent facilitators who rely on rigorous processes can bring workshops to market technically but need participants' willingness to speak up about inefficiency truthfully in order to make them effective. Blame-based cultures generate maps covering up waste over methodological accuracy, whereas trust-based cultures produce maps of things that can be acted upon immediately instead.

MEASUREMENT CONSIDERATIONS AND PATTERN INTERPRETATION

In summary, the technical and procedural influences ranked higher as they produce the direct, visual and mechanical relations documented in the project records. For example, drawings specify dimensions, specifications mandate materials, and procedures prescribe sequences. They follow an engineering logic that professionals recognize universally. Relational influences received less vigorous ratings not necessarily because they are genuinely weaker, but because they function through less visible and more diffuse mechanisms. Regarding indirect enabling processes, respondents referred to ways that relationships impact technical outcomes when we asked them to explain relationships: "Open communication results in earlier problem identification," "Trust enables contractors to volunteer value engineering ideas," "Good stakeholder relations influence access to new technical solutions." These influences are real and powerful, but do not follow simple cause-effect logic visible in project documentation. Greater variance in relationship-based mechanisms also indicates that such effects operate contingently. Relational dynamics, in contrast, are highly linked to leadership practices, organizational values, and institutional norms—which explains why organizations respond to these mechanisms uniquely.

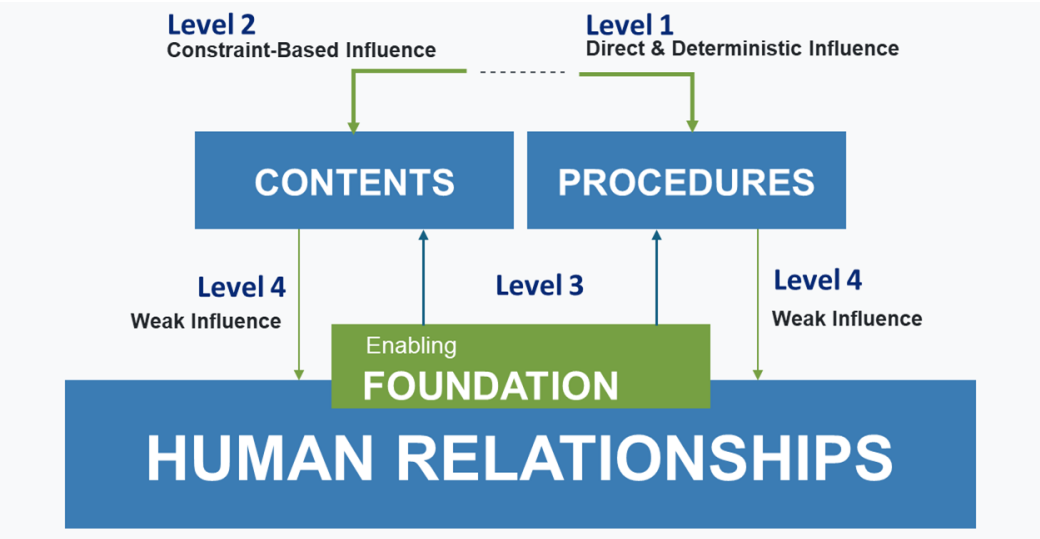

Figure 2: Influencing model: contents, procedures & human relationships

The overall pattern reveals a hierarchical structure of influence mechanisms in Figure 2. The following four-level framework is proposed as an analytically derived construct grounded in descriptive survey means and qualitative interview evidence, rather than as a statistically validated model.

Level 1 - Deterministic (Technical→Procedural): Technical requirements impose procedural necessities through engineering logic. High consensus, immediate visibility.

Level 2 - Constraint-Based (Procedural→Technical): Operational realities constrain design freedom through feasibility boundaries. Moderate consensus, observable through execution conflicts.

Level 3 - Enabling (Relational→Technical/Procedural): Relationships create conditions enabling technical and procedural optimization. Variability in relational mechanisms manifests through observable collaboration behaviors rather than formal project documentation.

Level 4 - Weak (Technical/Procedural→Relational): Technical sophistication and procedural rigor do not automatically generate trust, psychological safety, or collaborative culture.

This structure helps explain why organizations consistently underinvest in relational development, as technical and procedural investments yield tangible and immediately observable results that are easily measurable according to engineering rationale. Following social psychological logic, relational investments lead to delayed, diffuse and difficult-to-quantify effects. But the asymmetry reveals that relational foundation is what determines whether technical and procedural investments prove to be productive in the expected returns. The implications of this for construction digitalization are profound. BIM adoption, scan-to-BIM workflows, AI-driven quality monitoring, and automated compliance systems—all are technical and procedural innovations. Depending on whether relational foundation exists, the outcomes of these innovations will be dramatically different. Organizations with functional relationships will benefit from digital technologies for better cooperation; those where there are more dysfunctional relationships will see digital technology as a new site of conflict. Hence technological approaches to adoption strategies must evaluate organizational relational readiness and adopt culturally appropriate change management practices, not assume universal technical-based solutions.

ENHANCING LEAN CONSTRUCTION THROUGH TRIADIC INTEGRATION

This study does not position lean construction and project management as alternatives. Meanwhile, project management techniques are necessary but insufficient for lean outcomes. Lean principles are most effectively realised when procedural rigour is supported by strong relational dynamics and technically sound deliverables. The triadic framework therefore explains why well-managed projects may still fall short of lean ideals, specifically when Human Relationships are neglected. During Lean implementation, organizations typically invest heavily in Last Planner System training, visual management technologies, and BIM-integrated production control, focusing on the technical and procedure development. However, Last Planner System requires voluntary, trust-based commitment-making; value stream mapping depends on participants' willingness to honestly identify inefficiencies; and pull planning requires stakeholders to prioritize workflow logic over contractual hierarchy. These are relational conditions, not technical ones. Where relational foundations are underdeveloped, technically sound Lean implementations risk becoming performative rituals — teams offer misleading commitments, waste is concealed rather than exposed, and coordination reverts to hierarchical control despite the collaborative intent of the planning scheme.

Conversely, when relational foundations are strong, Lean tools operate markedly more effectively. The influence of Human Relationships on Contents and Procedures, as evidenced in this study, facilitates genuine commitment rather than performative compliance, and psychological safety encourages authentic problem reporting. The same technical and procedural systems therefore yield substantially different outcomes depending on the quality of relational foundation — the relational context defines the practical utility of the technical tools deployed within it.

These findings have direct implications for implementation sequencing. Conventional approaches introduce technical systems first and expect collaboration to follow. The evidence presented here suggests an alternative sequence: establishing trust, psychological safety, and communication protocols before deploying Last Planner or pull planning. Lean tools should not be introduced into adversarial cultures without prior relational development, as a lag exists between relational transformation and effective tool adoption. Organizations with collaborative cultures, by contrast, can deploy tools rapidly and with greater impact. The high variability observed in relationship-driven mechanisms reflects this organizational contingency — relational dynamics are heavily shaped by leadership practices that differ considerably across firms.

At the organizational level, construction companies systematically prioritize Contents and Procedures investment over Human Relationships development. This imbalance compounds implementation challenges, as technical and procedural refinements yield diminishing returns in the presence of relational dysfunction. Project management approaches should be reconceptualised to incorporate explicit assessment of relational capabilities, supported by structured leadership development programmes and relational performance metrics. Educational curricula likewise need to integrate relational competency alongside technical and procedural training, recognizing that successful construction delivery depends on sociotechnical systems that must be intentionally cultivated across all three domains.

LIMITATIONS

The survey (n=21) and interview (n=22) samples remain modest in scale. The findings should therefore be treated as exploratory and descriptive rather than confirmatory, and the hierarchical influence levels and asymmetry characterisation are interpretive constructs rather than statistically validated conclusions. Future research should employ larger, multi-national samples alongside inferential statistics or structural equation modeling to enhance generalisability and formally validate the theoretical model. Beyond survey-based methods, future studies could involve observing behavior and measuring relationship quality, studying communication patterns based on network analysis, or tracking of triadic evolution throughout project lifecycles.

CONCLUSIONS

This study enhances Lean Construction implementation by studying the influences of Contents, Procedures and Human Relationships. The results show essential asymmetry: Contents and Procedures are logically interrelated and constrained related and Human Relationships perform as the foundation to build up the trust and collaborative environment then enhance Contents and Procedures implementation. There seems to be imbalanced organizational investment which favours Contents and Procedures as the top priority. This imbalance results in suboptimal performance potential because technical investments come with fewer returns without relational development. Lean success necessitates an integration approach in which the three domains are held in balance with a particular attention to the domain of Human Relationships given its asymmetrical enabling capacity. Only through balanced and integrated approaches recognizing socio-technical interdependence can construction fully operationalize Lean's transformative potential.

Theoretically, the paper advances socio-technical systems thinking in construction by providing the first empirical investigation of cross-domain influence directionality and intensity within Wong (2014)'s triadic framework, and proposes a four-level hierarchical influence model as a basis for future theoretical development. Practically, the findings reframe Lean implementation strategy by demonstrating that relational capability is a prerequisite for effective tool deployment rather than an emergent outcome. This calls for project management approaches that explicitly assess relational readiness prior to technical and procedural intervention.

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