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EXPLORING OPPORTUNITIES FOR INTEGRATING TARGET VALUE DELIVERY AND FRONT-END PLANNING IN INDUSTRIAL MEGAPROJECTS

Richardus N. Kasih[1], Iris D. Tommelein[2], Rafael V. Coelho[3], Gregory F. Saragih[4], Wataru Kon[5], Budi Utomo[6], and Gerardus Blesto[7],

ABSTRACT

Industrial megaprojects, characterized by their scale, complexity, and interdependent components, often face significant challenges, including cost overruns, schedule delays, and stakeholder misalignment. This study proposes several opportunities to integrate Target Value Delivery (TVD) and Front-End Planning (FEP) methodologies to address these challenges and enhance project outcomes. Drawing on theoretical insights and case studies, the research explores the complementary strengths of TVD's iterative adaptability and FEP's structured methodology. The proposed integration emphasizes early stakeholder engagement, rigorous scope definition, and iterative planning to mitigate risks, improving cost predictability, and aligning project objectives. This paper contributes to knowledge by providing a comparative analysis of TVD and FEP, identifying integration opportunities, and suggesting practical strategies to overcome adoption barriers. While the list of opportunities is conceptual, it lays the groundwork for empirical validation and adaptation across diverse industrial contexts. This study contributes to advancing Lean Construction principles, offering a pathway to improving the delivery performance of industrial megaprojects.

KEYWORDS

Target Value Delivery, front-end planning, front-end loading, pre-project planning, industrial megaprojects, risk management, value engineering, Project Definition Rating Index.

[1] MS Student, Civil and Envir. Eng. Dept. and Project Production Systems Laboratory (P2SL), University of California, Berkeley, CA, USA, nugrakasih@berkeley.edu, orcid.org/0009-0001-9821-0481

[2] Distinguished Professor, Civil and Envir. Eng. Dept., Director, Project Production Systems Laboratory (P2SL), University of California, Berkeley, CA, USA, tommelein@berkeley.edu, orcid.org/0000-0002-9941-6596

[3] PhD Candidate, Civil and Envir. Eng. Dept. and Project Production Systems Laboratory (P2SL), University of California, Berkeley, CA, USA, rvcoelho@berkeley.edu, orcid.org/0000-0003-3298-3622

[4] MS Student, Civil and Envir. Eng. Dept. and Project Production Systems Laboratory (P2SL), University of California, Berkeley, CA, US, gregory.saragih@berkeley.edu, orcid.org/0009-0001-4698-3722

[5] MS Student, Civil and Envir. Eng. Dept. and Project Production Systems Laboratory (P2SL), University of California, Berkeley, CA, USA, watarukon@berkeley.edu, orcid.org/0009-0009-2254-8089

[6] President, Lean Construction Institute Indonesia (LCII), Jakarta, Indonesia, budiutomo@leanconstruction.id, orcid.org/0009-0001-0913-2494

[7] Consultant, PQI Consultant, Jakarta, Indonesia, gerardusblesto@pqiconsultant.com, orcid.org/0009-0004-8848-2151

INTRODUCTION

Industrial megaprojects serve as key drivers of economic and societal progress, facilitating the development of crucial infrastructure, energy systems, and large-scale manufacturing. Compared to smaller industrial projects, these initiatives stand out for their extensive scale, complex coordination needs, and prolonged execution timelines. They are typically defined as projects exceeding US$1 billion in capital investment, with delivery periods extending beyond 3 to 5 years (Merrow, 2011). These characteristics necessitate substantial capital investment and cross-disciplinary collaboration. Whereas smaller industrial projects tend to operate within more stable environments, megaprojects must navigate dynamic environments with heightened uncertainties, regulatory complexities, and diverse stakeholder interests. These project dynamics frequently lead to cost overruns, misalignment of objectives, and inefficiencies in early-stage decision-making (Merrow, 2011; Morton & Ballard, 2009).

The first author, drawing from his experience implementing Lean Construction and Project Production Management (PPM) on industrial megaprojects in the oil and gas sector in Indonesia, has observed first-hand how refining the early planning phase can enhance project outcomes. Engaging stakeholders early, defining project scope with appropriate precision, and establishing clear alignment from the outset are critical strategies for mitigating risks and improving efficiency in such complex environments.

Despite widespread adoption of Front-End Planning (FEP) in large industrial projects (CII, 1995; Merrow, 2011), persistent challenges—such as cost overruns, stakeholder misalignment, and value loss—continue to emerge (Hansen et al., 2018; Natarajan, 2022). These issues suggest that FEP may lack the flexibility needed to support iterative, stakeholder-driven decisions in complex environments. In contrast, Target Value Delivery (TVD) promotes continuous alignment between value, cost, and design, and has shown success in vertical construction. However, its use in industrial megaprojects remains limited. This paper explores whether FEP's systematic front-end planning processes can be meaningfully integrated with TVD's adaptive and collaborative mechanisms to address recurring delivery problems in high-risk, capital-intensive projects.

FEP is an early-stage process in megaproject development, providing strategic insights to manage risks and optimize resource allocation. It includes feasibility studies, conceptual planning, and detailed scope definition, all of which contribute to improving the accuracy of project forecasts and execution (George et al., 2008). Similarly, TVD, a Lean Construction methodology, emphasizes a cost-driven, iterative design process that aligns stakeholder expectations with financial constraints through collaborative decision-making (Tommelein & Ballard, 2016).

Despite the widespread application of FEP in industrial megaprojects, particularly in oil and gas, evolving industry needs highlight the necessity for further refinement. The incorporation of advanced techniques such as Reference Class Forecasting and Machine Learning has begun to address persistent planning inefficiencies, improving predictive capabilities and risk management (Natarajan, 2022). Longitudinal studies spanning three decades underscore the role of FEP in reducing project variability and enhancing cost and schedule reliability (Hansen et al., 2018). However, challenges related to stakeholder alignment, scope variability, and sustainability integration persist (Shlopak et al., 2014; Hansen et al., 2018). In contrast, whereas TVD has been successfully applied in the building sector, its adoption in industrial megaprojects remains limited, despite its potential to foster collaboration and increase cost certainty (Jacob et al., 2021).

This paper explores how the complementary strengths of FEP and TVD can be integrated to improve outcomes in industrial megaprojects. By analyzing the existing literature, this study seeks to identify synergies between these methodologies and identify conceptual opportunities for structured integration for their combined implementation in complex project environments.

RESEARCH METHOD

RESEARCH GAP AND MOTIVATION

The integration of TVD and FEP is an underexplored topic, particularly within industrial megaprojects where challenges such as cost overruns, delays, and conflicting stakeholder priorities often arise. By merging FEP's structured, strategic planning with TVD's iterative, value-driven design, projects can potentially be executed more efficiently and effectively. This study aims to address gaps in Lean Construction research by fostering stronger collaboration, enhancing decision-making processes, and optimizing value creation through an integrated approach that draws upon the unique strengths of both TVD and FEP.

Although TVD and FEP share some complementary goals, their development in separate domains has limited their integration. TVD emerged from Lean and manufacturing contexts, emphasizing iteration and stakeholder engagement, while FEP was shaped by systems engineering, with a focus on defined planning stages and gate-based approvals (Ballard, 2006; Sherif & Price, 1999). In industrial megaprojects, this divide is reinforced by a preference for standardized delivery processes, rigid contracting models, and hierarchical governance systems, which can inhibit the collaborative flexibility required by TVD (Tillmann & Eckblad, 2023). These contextual and methodological differences help explain why integrated applications remain rare creating a gap that this paper seeks to conceptually explore.

While TVD adoption has been more common in building and infrastructure sectors, industrial megaprojects present a particularly compelling context for testing its integration with FEP. First, these projects already institutionalize FEP practices—such as using FELand Project Definition Rating Index (PDRI) scoring—making them structurally ready for enhancement rather than wholesale methodological change. Second, megaprojects suffer disproportionately from cost overruns and stakeholder misalignment, as documented in decades of empirical research (Merrow, 2011; Hansen et al., 2018). Finally, the scale of capital risk in megaprojects justifies investment in collaborative planning innovations, such as those offered by TVD. Thus, despite limited precedents, industrial megaprojects represent both a high-need and high-value context for exploratory integration of TVD and FEP.

In addition to advocating for the integration of TVD and FEP, this paper also aims to identify practical strategies to address adoption barriers posed by people's resistance to change and the inherent complexities of managing industrial megaprojects. By fostering the integration opportunities between TVD and FEP, this study aims to accelerate the diffusion of Lean Construction methodologies across companies and countries, advocating for their broader use and ensuring their meaningful application across global industrial contexts.

RESEARCH QUESTIONS AND HYPOTHESES

This study addresses its objectives through the following research questions: (1) How can TVD and FEP be integrated to improve cost predictability, stakeholder alignment, and risk management in industrial megaprojects?, (2) What are the challenges faced in integrating TVD and FEP, and how can these be mitigated?, and (3) How does the integration of TVD's iterative adaptability and FEP's structured methodology enhance project outcomes?

The hypothesis for the research questions are: (1) Integrating TVD and FEP improves cost predictability and stakeholder alignment by combining structured early-stage planning with adaptive, iterative practices; (2) The integrated methodologies help to address early-stage risk management and continuous stakeholder engagement; and (3) TVD's focus on real-time cost adjustment combined with FEP's risk-focused planning reduces cost overruns and improves overall efficiency in the delivery of industrial megaprojects.

METHODOLOGY

The research used to develop this paper employed a multi-pronged approach:

1. **Literature Review:** Synthesizing theoretical and empirical works on TVD and FEP to identify their characteristics (principles, methods, and application areas), integration opportunities, and gaps.
2. **Case Study Review:** Examining documented examples of industrial megaprojects or other projects that utilize TVD or FEP, focusing on practical applications and identifying implementation challenges.
3. **Comparative Analysis:** Contrasting the philosophies, processes, and outcomes of TVD and FEP to highlight synergies, conflicts, and opportunities for integration. This process evaluates how each methodology supports the alignment of stakeholders, improves cost estimation accuracy, and mitigates project risks effectively.
4. **Integration Development:** Creating a cohesive framework that blends TVD's adaptable processes with the structured planning inherent to FEP. Initially developed as a conceptual model, in future research this framework will be tested and refined through practical applications in real-world projects, ensuring that its outcomes remain relevant and applicable.

LITERATURE REVIEW

INDUSTRIAL MEGAPROJECTS

Industrial megaprojects come with significant challenges and economic impact. Merrow (2011) defines them as projects requiring capital investments exceeding $1 billion and extensive long-term planning. Their completion can take years, involving continuous coordination through multiple stages of planning and execution. Involving stakeholders such as government agencies, contractors, investors, and local communities, these projects often face conflicting interests that further complicate their management. Their high-risk nature stems from exposure to fluctuating markets, regulatory shifts, and technical uncertainties. Many of these projects operate globally, relying on international cooperation, which can introduce logistical obstacles and cultural differences that further complicate successful delivery (Merrow, 2011).

Industrial megaprojects present challenges that go beyond those encountered in other construction projects. These challenges include risks of cost overruns and schedule delays due to the scale, complexity, and interdependence of their components. For example, industrial megaprojects often demand extensive pre-project planning and the use of advanced risk management techniques to navigate their large-capital investments, intricate supply chain logistics, and integration of cutting-edge technologies (Morton & Ballard, 2009; Merrow, 2011). Unlike projects that do not have these characteristics, megaprojects are susceptible to emergent risks such as geopolitical shifts, macroeconomic fluctuations, and environmental regulations, which can drastically impact timelines and budgets (Merrow, 2011; Hansen et al., 2018). Moreover, stakeholder conflicts in industrial megaprojects are magnified by the diverse range of international partners, contractors, and regulatory bodies involved—all of whom may change in the course of the megaprojects extended delivery time—leading to increased misalignment of objectives (CII, 2019; Natarajan, 2022). These projects also face technological and operational risks, as they often pioneer untested methods or materials that amplify the uncertainty of outcomes (Rachman & Ratnayake, 2016; Natarajan, 2022).

Stakeholder dynamics in industrial megaprojects are uniquely complex due to the involvement of multiple layers of decision-makers, transnational partners, public agencies, and community actors—often operating under conflicting objectives and accountability structures (Merrow, 2011; Natarajan, 2022). These dynamics are likely to lead to fragmented communication, late-stage value conflicts, and misaligned expectations, especially when project definitions are locked early without sustained engagement. While FEP frameworks emphasize early alignment, they often lack mechanisms for continuous negotiation. In contrast, TVD's structured collaboration processes, such as big room planning and iterative cost dialogues, offer a way to re-engage stakeholders throughout the project lifecycle. This makes stakeholder management a particularly promising domain for synergy between the two methodologies.

TARGET VALUE DELIVERY (TVD)

TVD traces its roots to Toyota's target costing approach, adapted to tackle inefficiencies, cost overruns, and misaligned project objectives in the construction industry. Introduced to construction in the early 2000s (e.g., Ballard & Reiser 2004), TVD focuses on aligning design and project delivery with defined value goals to achieve optimal outcomes (Ballard & Reiser, 2006; Tommelein & Ballard, 2016; Ballard, 2023). Its core objective is to deliver projects within established cost targets while maximizing stakeholder value through collaboration and iterative decision-making (Jacob et al., 2021). By integrating cost management, active stakeholder involvement, and real-time feedback, TVD promotes transparency and minimizes waste (Musa et al., 2019).

The six stages of TVD implementation are:

1. **Defining Project Value:** During the early feasibility phase, stakeholders work together to define key value objectives, including cost, quality, and timelines. Collaborative "big room" environments foster open communication among project participants. Innovation Teams, consisting of cross-functional experts, ensure solutions meet client expectations while promoting creative problem-solving.
2. **Developing Initial Concepts:** In the conceptual design phase, teams explore multiple design options with continuous stakeholder input. This iterative process helps ensure that the designs align with value targets and avoid unnecessary waste. Methods such as Set-Based Design allow teams to compare multiple design alternatives before selecting the most viable option (Musa & Pasquire, 2020).
3. **Setting Targets and Budgets:** Cost targets for individual project components are established collaboratively during pre-construction planning. Value Engineering plays a key role in identifying cost-effective solutions without compromising quality. Budgets are then aligned with the project's overarching value objectives (Kim et al., 2023).
4. **Refining and Validating Design:** As the project enters the detailed design stage, tools such as Building Information Modeling (BIM) help validate the design's adherence to cost targets and project goals. Feedback loops and methods such as Choosing By Advantages (CBA) guide decision-making, ensuring that value principles are maintained throughout the design process (Lombardo et al., 2023).
5. **Executing Construction:** Lean Construction techniques, such as pull planning, keep construction activities on track with value objectives. Regular progress reviews help identify and address issues quickly, preventing delays or inefficiencies. Tools such as A3 Problem Solving are used to resolve on-site challenges (Tillmann & Eckblad, 2023).
6. **Evaluating and Improving:** Once construction is complete, post-project evaluations measure performance against the initial objectives. Stakeholder feedback is gathered to identify lessons learned, which are then used to refine and improve future TVD applications (Musa et al., 2019).

Applications of TVD across different construction sectors demonstrate its versatility:

- **St. Olaf College Field House Project:** As one of the earliest examples of TVD in action, this project demonstrated how collaborative workshops and iterative design improvements could effectively balance cost, quality, and stakeholder expectations. By integrating key stakeholders early in the process, the project successfully met its performance targets while maintaining cost control (Ballard & Reiser, 2004).
- **UCSF Healthcare Projects:** TVD facilitated under-budget delivery of complex healthcare facilities while meeting stringent design and regulatory requirements. Big room environments and set-based design optimized workflows and minimized waste (Tillmann & Eckblad, 2023).
- **Infrastructure Projects:** TVD was instrumental in reducing cost overruns in large-scale projects such as water treatment facilities by refining scope definition and aligning stakeholder objectives (Ballard, 2023).

Despite its benefits, TVD faces barriers to widespread adoption. Many organizations resist its collaborative approach, favoring traditional hierarchies (Musa et al., 2019). Delayed involvement of subcontractors and suppliers often results in misaligned goals and project inefficiencies (Oliva et al., 2016). A lack of trust among teams further disrupts collaboration (Ballard & Reiser, 2004), while first-time adopters face steep learning curves and limited awareness of TVD's advantages (Kim et al., 2023). Additionally, maintaining target costs requires intensive monitoring, which can lead to conflicts if poorly managed (Tillmann & Eckblad, 2023).

FRONT-END PLANNING (FEP)

FEP is used to align project goals with organizational strategies, managing risks, and ensuring successful outcomes. By addressing scope, uncertainties, and risks early, FEP helps prevent common issues such as scope creep, cost overruns, and delays. Key benefits include clearer decision-making, efficient resource allocation, stronger stakeholder collaboration, and improved performance in both project schedules and quality (CII, 1995; Hansen et al., 2018).

The implementation of FEP has three phases, known as Front-End Loading (FEL):

1. **FEL 1 (Feasibility):** The first phase focuses on identifying potential project opportunities and ensuring they fit with stakeholder's business goals. During this stage, the project team explores initial ideas, develops early cost and schedule estimates, assesses potential risks, and engages key stakeholders.
2. **FEL 2 (Concept Selection):** This phase refines the project scope and ensures investment readiness. It involves developing detailed cost estimates, addressing environmental and safety concerns, defining execution strategies, and assessing scope maturity using tools such as the Project Definition Rating Index (PDRI).
3. **FEL 3 (Front-End Engineering Design or FEED):** The final phase involves creating detailed execution plans, including advanced design packages, refined cost projections, and risk mitigation strategy. Construction and procurement frameworks are established, and a final gate review is conducted to confirm the project's readiness for execution.

PDRI is a comprehensive tool used to assess the maturity and completeness of a project's scope during the FEP phase. It evaluates 70 key elements across various categories, including scope definition, cost estimation, and risk management. Key scoring thresholds provide insight into project readiness: (1) a score between 0 and 200 indicates a mature, well-defined project scope with minimal execution risks, (2) a score between 200 and 400 suggests areas requiring further refinement, and (3) a score above 400 highlights significant gaps that need to be addressed to mitigate project risks effectively. PDRI is applied throughout FEL phases to address scope gaps, align stakeholders, and guide projects toward successful execution (CII, 2019; Merrow, 2011).

Case studies showing the impact of FEP include:

- **Industrial Megaprojects:** FEP reduced cost overruns by up to 25% and improved schedule performance. For example, an oil and gas megaproject successfully aligned technical designs with execution strategies, improving stakeholder coordination (Merrow, 2011).
- **Pharmaceutical and Petrochemical Projects:** PDRI helped identify scope gaps early, leading to significant cost savings and fewer project delays.
- **Infrastructure Projects:** FEP ensured well-defined scope for complex technical interfaces in sectors such as water treatment, significantly reducing change orders during construction (CII, 2019).

Despite its strengths, FEP faces challenges adapting to complex and evolving project contexts. Its rigidity, time demands, and reliance on complex tools such as PDRI limits its flexibility and usability, particularly when faced with emergent risks or shifting stakeholder priorities. These limitations suggest a need for complementary approaches—such as TVD—that promote greater adaptability and continuous engagement.

INTEGRATION GAPS BETWEEN TVD AND FEP

Both TVD and FEP aim to improve project outcomes, but their approaches differ significantly. TVD adopts an iterative and adaptable process, promoting flexibility in managing emerging challenges during project execution (Jacob et al., 2021). In contrast, FEP follows a more linear, structured approach, which can sometimes limit its ability to accommodate changes in the later stages of project delivery (Sherif & Price, 1999). While FEP excels at identifying and addressing risks early during the planning phase, TVD stands out by dynamically tackling risks as they arise during implementation. Despite the potential benefits of combining these methodologies, research on their integration remains limited particularly in the context of industrial megaprojects, where striking a balance between early-stage rigor and ongoing adaptability is essential for success (Malvik et al., 2021).

This review revealed limited scholarship directly examining TVD-FEP integration. While several studies have explored embedding TVD within project delivery models (e.g., Ballard, 2006; Tillmann & Eckblad, 2023), these have largely focused on building sectors and avoided addressing the complex approval structures of industrial megaprojects. Similarly, while FEP has evolved to include stakeholder alignment and PDRI-based risk assessments (CII, 2019), it has not incorporated mechanisms for continuous scope revision or design-to-cost strategies that are central to TVD (Jacob et al., 2021). Attempts to hybridize Lean methods with structured governance, such as in Best Value Procurement (Malvik et al., 2021), suggest that integrated models can work, but they stop short of unifying the complete TVD and FEP frameworks. Given this situation, our study offers an original synthesis that answers a gap in both theory and application.

COMPARATIVE ANALYSIS OF TVD AND FEP

This section compares TVD and FEP by examining their key philosophies, processes, strengths, and how they might complement each other. TVD focuses on aligning project outcomes with stakeholder-defined goals, treating cost control as a built-in part of the design process rather than a separate task. Drawing from Lean Construction principles, TVD relies on iterative collaboration, where teams continuously refine designs to meet target costs and maximize value (Ballard, 2006; Malvik et al., 2021). In contrast, FEP prioritizes risk management through detailed, up-front planning. It operates on the belief that carefully defining the project scope early on helps to reduce risks and limit uncertainties later in the project. This approach enhances predictability in terms of cost, schedule, and outcomes (Sherif & Price, 1999).

TVD employs a cyclical design methodology, incorporating cost, quality, and scheduling considerations into iterative design loops. Multidisciplinary teams engage in continuous refinement, leveraging real-time feedback to align outcomes with project objectives and cost constraints (Kim et al., 2023; Jacob et al., 2021). In contrast, FEP utilizes a sequential process comprising distinct phases—conceptualization, feasibility, detailed definition, and execution. It is structured around decision gates that incrementally refine the project scope, ensuring clarity and alignment at each stage (CII, 1995; CII, 2019). FEP focuses exclusively on pre-project planning phases, whereas TVD extends its applicability across the entire project lifecycle, emphasizing iterative adjustments during execution and delivery (Ballard, 2006; Tommelein & Ballard, 2016).

ADVANTAGES AND CHALLENGES

Table 1 highlights the advantages and challenges of TVD and FEP.

Table 1: Advantages and Challenges of TVD and FEP

Aspect	TVD Advantage	TVD Challenge	FEP Advantage	FEP Challenge
Stakeholder Alignment	Encourages deep stakeholder collaboration and value integration (Malvik et al., 2021).	Requires significant cultural adaptation and training for effective implementation (Tillmann & Eckblad, 2023).	Facilitates early stakeholder alignment through structured frameworks (Sherif & Price, 1999).	Diminishes stakeholder engagement beyond initial phases and doesn't include specialty contractor (Sherif & Price, 1999).
Adaptability	Exceptional flexibility to accommodate evolving project requirements during execution (Musa et al., 2019).	Susceptible to scope creep without stringent controls (Tillmann & Eckblad, 2023).	Ensures stability through predefined milestones (CII, 1995).	Rigid structure limits responsiveness to unforeseen changes (Sherif & Price, 1999).
Risk Management	Prioritizes mitigation of downstream variability through continuous design-to-value adjustments (Jacob et al., 2021).	Relatively weaker focus on comprehensive early-stage risk assessment (Musa et al., 2019).	Strong emphasis on proactive risk identification and mitigation strategies (Sherif & Price, 1999).	May fail to address emergent risks effectively in later stages (CII, 1995).
Cost Predictability	Achieves superior cost predictability by integrating cost as a design parameter (Ballard, 2006).	Challenged by the need to set accurate initial target costs (Musa et al., 2019).	Provides a clear baseline for budgetary and timeline planning (CII, 2019).	Overdependence on static estimates, limiting adaptability (CII, 2019).

CONCEPTUAL OPPORTUNITIES FOR FEP-TVD ALIGNMENT

Based on the comparative characteristics of TVD and FEP, we identify several conceptual pathways for their potential alignment. Table 2 illustrates how principles from both methodologies might complement each other across early project phases. While these are not intended as prescriptive solutions, they highlight areas where further empirical exploration could be valuable.

Table 2: Key Integration Areas of TVD and FEP

Integration Area	FEP Characteristic	TVD Enhancement
Project Scope Definition	Comprehensive scope clarity through structured FEL, enabling a clear and aligned starting point for project teams to define deliverables, objectives, and boundaries. This clarity helps mitigate early-stage risks by reducing ambiguities and aligning all stakeholders with a shared vision.	TVD enhances this foundation by incorporating real-time feedback loops and dynamic stakeholder input, enabling continuous refinement of scope to address emerging project demands and constraints (Ballard, 2023). This iterative process ensures the project remains adaptable while adhering to predefined objectives.
Risk Management	Systematic risk identification and proactive mitigation strategies (Sherif & Price, 1999), focusing on the early identification and categorization of risks, followed by structured mitigation plans during the planning phase. This approach emphasizes pre-emptive action to address known risks before project execution begins.	Improves project delivery by tackling risks early through collaborative, iterative planning and scenario analysis. This flexible approach helps teams quickly adapt to new challenges or constraints, making it easier to adjust goals while staying aligned with stakeholder expectations (Jacob et al., 2021).
Stakeholder Alignment	Encourages early stakeholder participation to establish a shared understanding of project goals and potential risks from the start, setting a strong foundation during the pre-project planning phase (CII, 1995).	Sustains engagement across the project lifecycle by utilizing dynamic feedback loops, enabling continuous alignment with shifting goals and objectives (Tillmann & Eckblad, 2023).
Value Optimization	Establishes a clear roadmap for project objectives and deliverables. Early value engineering during pre-project planning promotes cost-efficient design choices, minimizing unnecessary expenses and enhancing overall project feasibility.	Applies Lean principles to prioritize client-defined value and to minimize waste, boosting efficiency and delivering better outcomes (Jacob et al., 2021). Concurrent engineering fosters collaboration by merging design and construction activities, while early contractor involvement brings practical insights that enhance planning, reduce rework, and improve constructability (Jacob et al., 2021).
Cost Predictability	Sets baseline cost predictability and budget frameworks through structured methods for estimating and establishing initial budgets based on thorough early-phase analyses. Unlike TVD's iterative cost adjustments, this approach emphasizes creating a stable financial foundation at the project's start to guide future planning (Sherif & Price, 1999).	Iteratively refines cost targets, ensuring continuous alignment with project value and stakeholder priorities (Musa et al., 2019). Additionally, TVD promotes active cost monitoring through collaborative decision-making, integrating real-time cost data with project objectives. This approach ensures that all stakeholders, including contractors and specialty teams, remain aligned with cost-saving strategies, making it particularly effective for industrial megaprojects (Ballard, 2023).

The integration of FEP and TVD offers synergy by leveraging their complementary strengths:

- **Value Engineering and Iterative Design**: FEP's focus on early value engineering during FEL sets cost-effective design principles upfront. TVD builds on this by incorporating iterative design cycles during execution, allowing for ongoing adjustments to meet evolving stakeholder needs.
- **Collaborative Feedback Mechanisms**: TVD introduces iterative feedback loops that enhance FEP's structured planning, enabling teams to adapt to unexpected challenges and maintain alignment throughout the project.

Integrating TVD within the FEP's framework creates a balanced approach that combines structured planning with flexibility. This integration supports proactive risk management, sustained stakeholder engagement, and iterative cost and value optimization, ultimately improving the success and efficiency of complex megaprojects.

CONCLUSION

This study explored conceptual opportunities for integrating TVD and FEP to address all-too-common megaproject challenges such as cost overruns, stakeholder misalignment, and planning inefficiencies. By synthesizing theoretical insights, this paper illustrates how FEP's structured front-end definition can be enhanced through TVD's iterative and collaborative mechanisms. The proposed integration opportunities offer benefits in several key areas: improved cost control through real-time adjustments, reduced waste via early and continuous stakeholder engagement, and greater alignment between evolving project needs and delivery strategies.

However, these opportunities come with practical barriers. Industrial megaprojects often operate under procurement models that prioritize fixed-price contracting over collaborative planning, limiting the adoption of iterative methods such as TVD. Organizational cultures built on hierarchy and risk aversion may resist the workflow changes necessary to sustain continuous engagement. In globally distributed teams, misalignment in stakeholder maturity and trust can further complicate integration efforts.

While promising, the integration model remains conceptual and untested in real-world settings. Its implementation may also raise questions of transferability to smaller industrial projects or other project types. These limitations underscore the need for future research to empirically validate the framework through pilot projects, simulations, and comparative case studies. A design science research approach could guide iterative refinement, supported by evaluation metrics such as cost variance (planned vs. actual), the number and timing of change orders, and stakeholder alignment scores derived from structured feedback or engagement assessments. Further studies could also explore the integration of digital tools, such as machine learning and digital twins, and examine cultural readiness as a precondition for Lean adoption.

Ultimately, this study contributes to the Lean Construction literature by proposing an integrated, value-oriented approach to early project planning. By bridging theoretical and practical domains, the TVD-FEP alignment offers a pathway toward more resilient, efficient, and stakeholder-driven industrial project delivery.

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