

Examining The Drivers Of Decision-Making: A Methodical Approach For Choices Of Construction Project Delivery Methods

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Abstract

Different approaches exist for obtaining construction projects, including options like design-build (DB), design-bid-build (DBB), construction management at risk (CM-at-risk), and integrated project delivery (IPD), among several alternatives. Selecting the most suitable procurement plan for a specific project requires careful consideration of each approach. In this process, a selection approach and criteria need to be evaluated. This study aims to enhance clarity by synthesizing existing literature on factors influencing project delivery selection and presenting a comprehensive list of these factors. A methodical analysis was conducted, initially identifying many papers, which were narrowed down to 57 relevant to construction projects. Through the examination and consolidation of recurring themes, a definitive list of 11 criteria and 22 sub-criteria was established. The most frequently reported factors, in descending order, included concerns of owner, contractor, cost, time, quality, risks, contracts and claims, laws and regulations, complexity, size, and type. It's important to note that these factors vary from project to project, and the study provides an argument on how they influence the project delivery methods (PDMs) selection. The results of this research provide valuable insights into the impacts associated with different PDMs in the construction industry. This study informs industry professionals, policymakers, and project owners about the implications of their choices.

Keywords: Project delivery methods; Construction projects; PDMs; Industry professionals; Policymakers.

Introduction

The PDM selection in construction represents a crucial phase that significantly influences the success of a project [1; 2; 3]. PDM delineates how various project participants are organized to collaborate in the transformation of the owner's goals and objectives into a completed facility [4]. This choice has a direct impact on construction performance, encompassing aspects such as delivery speed, cost, and quality [5; 6; 7].

PDM can be seen both as a contractual structure and a compensation arrangement through which project owners secure a finished facility tailored to their requirements [8]. Multiple PDMs exist, with the most prevalent approaches including DBB, DB, IPD, CM-at risk, general contractor (GC), and engineering procurement construction (EPC) [9; 10].

The effectiveness of the selected PDM significantly influences the performance of project implementation [7]. Previous research indicates that opting for the most suitable PDM can effectively reduce contract disputes and lower project prices by 10% - 30% [11]. Some studies suggest that the CM and DB methods grant notable advantages in cost and time compared to the DBB approach [12; 13]. However, researchers emphasize that these advantages may not be universally applicable but vary based on the project type [14].

Observations indicate that employing the DB approach may lead to increased initial expenses and a reduced number of competitive bids, particularly in cases where the method is not ideally matched to the project [15]. However, determining the most suitable PDM poses a significant challenge due to the numerous uncertainties that can arise throughout the project's functioning stages [4].

When selecting a PDM, the vital first stages entail defining suitable criteria for selection and assessing their efficacy. The criteria for choosing a PDM remain a significant area of interest in project management studies, influenced by evolving factors and the growing intricacies of projects. As far back in 1985, NEDO outlined (9) criteria for selecting PDMs [16]. Subsequently, researchers have built upon this foundation, introducing numerous modifications and additions to the criteria set.

Although efforts to enhance comprehension of the factors affecting PDM selection have been made, the varied and inconsistent priorities across these different lists have,

paradoxically, complicated the PDM selection process. Hence, it is timely to examine the current knowledge on PDM selection to develop a complete list of criteria and thereby simplify the tools used for PDM selection. This study aims to meticulously review and analyze earlier research in this field, with the goal of defining a coherent set of criteria related to PDM selection.

Literature Review

Primary PDMs

Numerous PDMs are employed in the construction industry, with one such method being the DBB, commonly known "conventional" delivery approach. The DBB method involves three principal stakeholders: owner, designer, and GC. This arrangement makes the owner oversee and manage the designer and the contractor's performances, ensuring compliance with contractual requirements [17; 18]. Whereas the DB method lets the owner enter into a contract with one entity tasked with overseeing the design and construction phases, as outlined by [7]. This approach is preferred when the owner seeks unified accountability and responsibility sources. Notably, the advantage lies in having a singular entity responsible for design and construction, eliminating potential oppositional relationships that may occur in the DBB method, as highlighted by [8].

On the other hand, the format of construction management/general contractor (CM/GC) involves the owner hiring a construction manager who also serves as the GC. The construction manager's role extends beyond traditional contracting, focusing on providing consultation on various aspects of the project's operational and financial dimensions. However, despite this consultative role, there remain two distinct contracts for design and construction that require separate management.

Consequently, the construction manager in the CM/GC format is tasked with offering expertise in architectural services and conducting evaluations related to costs, schedules, materials, and other relevant factors. Additionally, the construction manager guides optimizations and design alternatives, contributing to informed decision-making during the project's lifecycle. Furthermore, the responsibilities of the construction manager encompass controlling and monitoring the construction and ensuring adherence to established benchmarks in terms of costs, time, and other project requirements. This oversight is crucial to guarantee a

maximum price for the project, as emphasized by [8; 18].

The Construction Manager/Project Manager (CM/PM) format lets the owner opt to delegate the project management process, either entirely or in part, to a program management agency or program manager. This program manager may assume the role of the project manager throughout the complete process or act as an owner's representative, providing backing and augmenting expertise of facility management. It's noteworthy that program management tasks can be assigned to either or together the DB entities, as discussed by [8].

The foundation of construction projects traditionally adheres to transformation theory, as proposed by [19], which also serves to explain PDMs. Differences between different PDMs are evident in how work is divided and how responsibilities and risks are assigned throughout the implementation phase. Stakeholders at each stage focus on converting resources to project deliverables for improving the project's overall value, as emphasized by [20; 21].

Conversely, the transformation theory limitations are apparent. In the pursuit of individual transformation excellence, participants often overlook the subsequent activities or the needs of the end customer. Furthermore, transformation theory fails to address the efficient utilization of resources. These deficiencies result in significant information loss, rework, and waste, as noted by [22]. This realization has contributed to the gradual evolution of many delivery methods towards integration as a response to the need for a more cohesive and efficient approach.

PDM Selection

The determination of the PDM is typically made by the owner preceding the project commencement. This decision-making process is intricate and influenced by the uncertainty inherent in both the construction project and the decision-making environment, as highlighted by [23]. Indeed, the selection of PDMs presents a multicriteria decision-making problem, as discussed by [24].

Research on the project delivery systems selection can be mostly categorized into two types, encompassing the selection criteria and the selection approach. On the one hand, studies focusing on the selection approach are dedicated to developing models that facilitate decision-making. These

models often involve the transformation of fuzzy judgments into an innate and user-friendly practical process, as exemplified in the work of these researchers [25; 26; 27].

On the other hand, the research into selection criteria aims to identify, evaluate, and scrutinize the criteria considered in practical decision-making. Scholars such as research work [14; 28] delve into the examination of criteria relevant to the selection of project delivery systems. These two streams of research contribute to a comprehensive understanding of the complexities associated with determining the most suitable PDM for a given construction project.

No universally applicable "one-size that fits all" optimal PDM. The choice of the project delivery system ought to be tailored to the identifiable requirements of the project, the distinctive circumstances and characteristics of the owner, and the effective composition of the project team, as emphasized by the research [29]. When deciding on the PDM, it becomes crucial to identify suitable selection criteria and assess their efficacy. The selection criteria for PDMs were a focal point in the realm of project management, evolving, subdividing, and becoming more concrete in response to the increasing complexity of project development.

These criteria encompass a broad spectrum, including but not limited to financial capacity, management capability, technical excellence, safety measures, personnel qualifications, experience, scope alternatives and offered optional features, data of project completion, and the owner risk. Utilizing a complete list of selection criteria aids in recognizing project features and facilitates the selection of a delivery method more fitting.

While studies have undertaken comparisons of several PDMs, often offering valuable recommendations, these comparisons generally adopt a case comparison methodology. For instance, the study [30] analyzed (291) U.S. highway projects, concluding that different methods outperformed conventional methods. The study [13] extended the work of the Construction Industry Institute (CII) by comparing 212 projects using DBB, CMR, and DB projects, evaluating the schedule performance and cost of these delivery methods. Notably, the completed unit cost of DB, DB exhibited superior schedule performance comparable to DBB and slightly lower than CMR projects.

While these studies offer valuable insights for owner decision-

making, it's important to note that owners cannot unthinkingly apply these conclusions. Instead, they need to identify an appropriate delivery method based on specific factors. The selection of influencing factors from a complete list serves as the foundation for the decision-making process. It is essential for evaluating the chosen PDM performance.

Methodology

A multitude of factors impact the selection of a PDM, and this study aims to pinpoint key indicators through an exhaustive review of the literature. To accomplish this, a methodical process has been utilized to examine and assess the results of previous research regarding the selection criteria of project delivery systems. Before embarking on the formal research, several preparatory steps were undertaken. These included an initial review of the literature, the identification of relevant keywords, and the delineation of research areas.

Considering the varied terminology used to refer to PDMs across different literature sources, the preliminary phase of this study concentrated on identifying these terms. A comprehensive review of prior literature revealed five analogous expressions, including "project delivery method/system" (PDM/S), "project procurement method/system" (PPM/S), and "project contract system" (PCS). Furthermore, acknowledging potential differences in terms of reading "project" and "delivery" across disciplines, a deliberate choice was made to merge the two terms to avoid overly broadening the search scope.

The examination concentrated on abstracts, keywords, and titles extracted from the obtained papers to pinpoint material pertinent to factors impacting the PDMs selection within the construction sector. Papers not directly addressing the criteria for selecting PDMs, such as those focusing on PDM effectiveness, contractor choice, risk allowance, and similar topics, were omitted. A methodical procedure is employed to scrutinize and assess the conclusions of past studies regarding PDM selection factors. The methodology utilized mirrors a parallel approach outlined by [4]. It encompasses a two-stage process, as depicted in Figure 1. Concurrently, a research report from [16] and a conference paper from PMI were integrated into the compilation due to their early introduction of indicators and their practical significance. In total, (57) papers were identified for subsequent analysis.

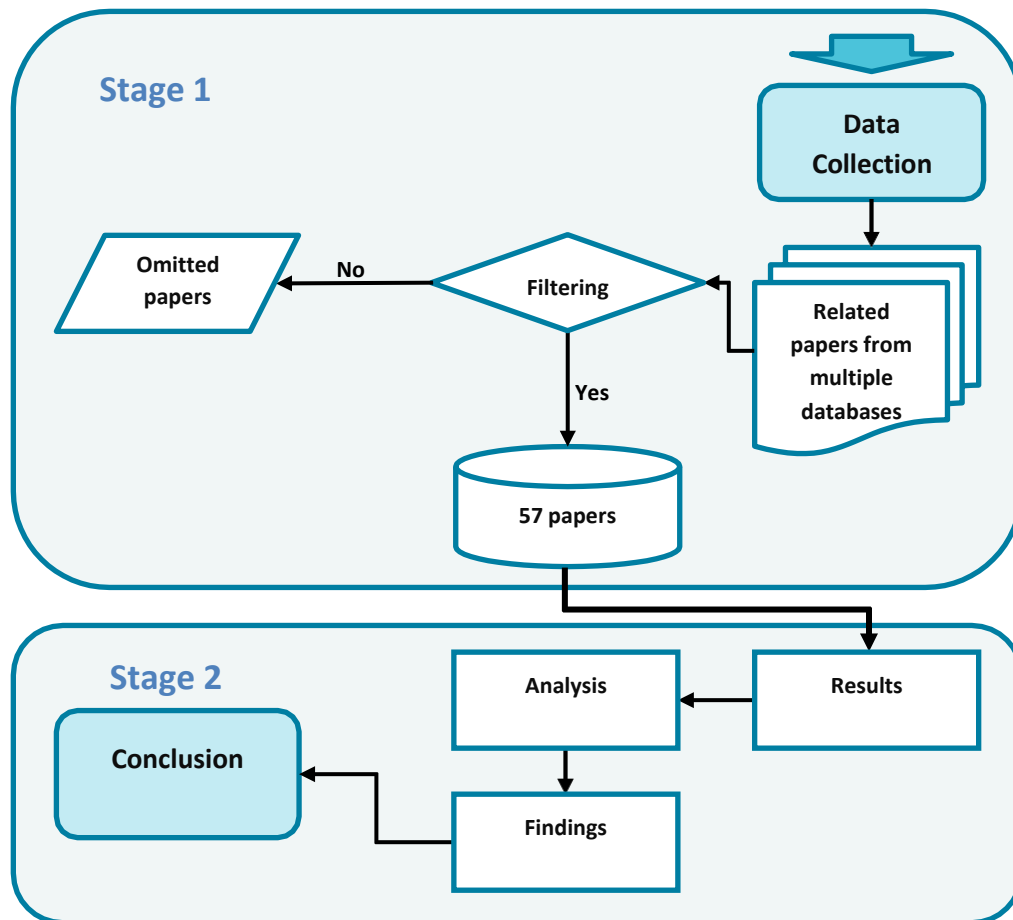


Fig. 1. The two-stage approach utilized by methodology.

Results

Table 1 and Figure 2 display the selection criteria extracted from the chosen studies. These criteria play a crucial role in boosting project success within the context of PDM selection. Through a methodical analysis, these criteria were consolidated into 11 primary criteria and 22 sub-criteria. During this process, items with similar or identical implications were combined into a single-term grade, as recommended by [4]. For instance, various studies used terms like schedule, speed, and milestone to refer to the criteria "time." These were categorized under the same overarching term while preserving any nuanced differences within the sub-criteria. Refer to Table 1 for a detailed overview.

Table 1. The (11) criteria and (22) sub-criteria shaping the PDM selection obtained from (57) publications.

Criteria	Sub-Criteria	Number	Total/Criteria
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Owner	Role and Liability	28	161
	Capability	84	
	Involvement	30	
	Type	14	
	Trust in Other Participants	5	
Contractor	Availability	40	145
	Proficiency and Ability	105	
Cost	Assurance	11	81
	Control	45	
	Necessity/Constraint	25	
Time	Assurance	8	80
	Control of phases	36	
	Necessity/Constraint	36	
Quality	Control	56	64
	Constructability	8	
Risks	Allocation	9	58
	Management	49	
Contracts and Claims	Claims	56	56
Laws and Regulations	Regulations	48	48
Complexity	Complexity	41	41
Size	Size	24	24
Type	Type	17	17

Starting from [16] introduction of nine PDM criteria of selection in 1985, scholars have consistently expanded and augmented this indicator technique, resulting in a continuous upward trajectory in the total number of criteria. Initially, stringent requirements tied to project management systems, such as owner concern, cost, time, quality, and risk, have progressively broadened. They now encompass considerations related to political and government regulations, community participation, and the external environment. This expansion aligns with the growing complexity observed and scale in construction projects.

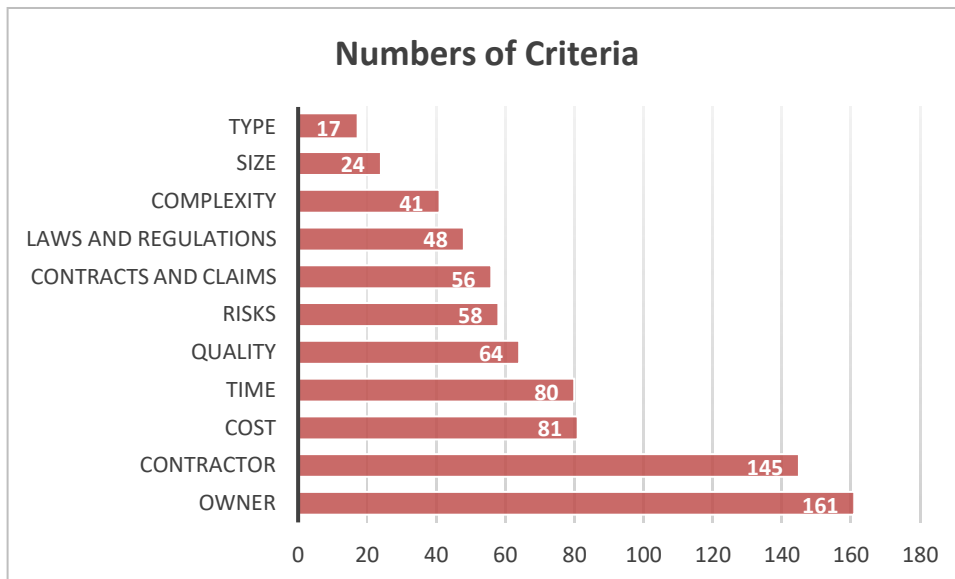


Fig. 2. Numbers of criteria from chosen publications in descending order.

As projects grow in size and complexity, project organizations and members must adapt to more confronting environments. In the case of cross-regional projects, including those spanning borders, internal project members face heightened constraints imposed by local support, cultural factors, and external laws. Owners and contractors are compelled to make trade-offs, relinquishing specific requirements to navigate these limitations when selecting delivery methods. For instance, though the DB method promises a rapid construction period, its limited entities with management rights may prompt local governments to demand increased participation and shares for local initiatives in the organization of project management. This expectation aims to enhance the effectiveness of local enterprises. Consequently, GCs may demand to make negotiations, opting to abort DB in favor of alternative delivery methods.

Figures 3 and 4 depict the progression of research papers concerning selection factors based on the types of projects. Overall, project selection factors continue to dominate, like quantity, comprising 60% with 27 articles. However, researchers increasingly recognize a significant correlation between the project type and the PDM choice. Every project, regardless of the industry, possesses unique characteristics that can influence the selection of the PDM, as highlighted by [31]. There is a growing emphasis on research dedicated to the specific project type selection factors, marking a notable shift that became apparent from 2010 to 2011.

Moving on to Figure 4 discloses the articles categorized by project research types near 2010. Prior to 2010, the selection factors research of general PDM was predominant, constituting 88%. Only 6% delved into water and building facilities. Post-2010, there was a notable increase in research articles, with specific project types gradually claiming a more significant share at 57%, while the general projects proportion decreased to 43%. The study covered seven types of projects, with transportation engineering, containing highways, emerging as the predominant research focus, accounting for 36%. In the following section, the research will display the concerns of the chosen factors.

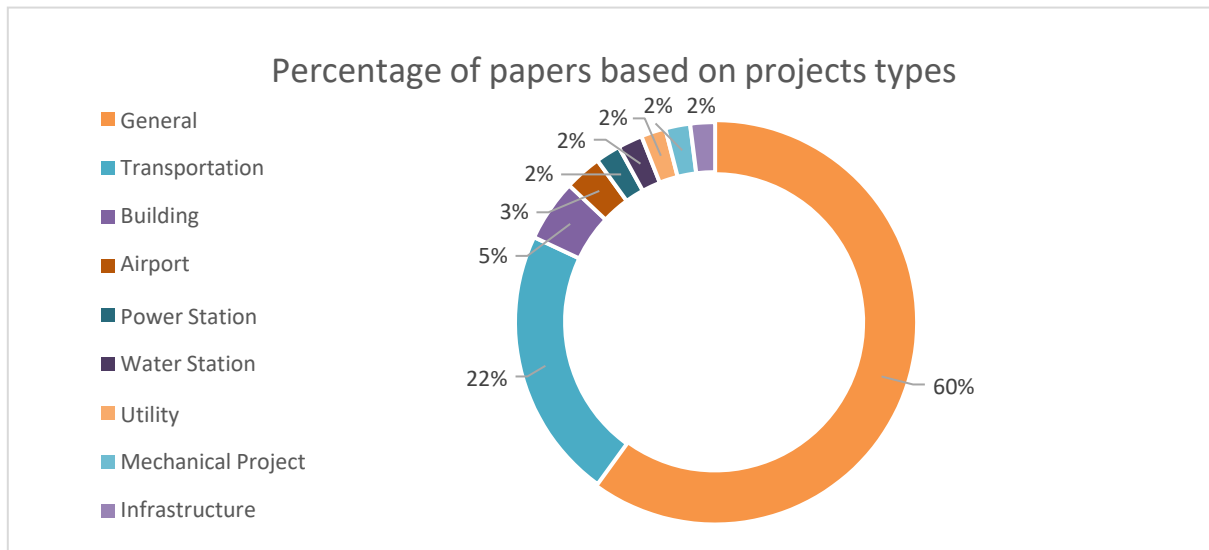


Fig. 3. The percentage of papers based on project types.

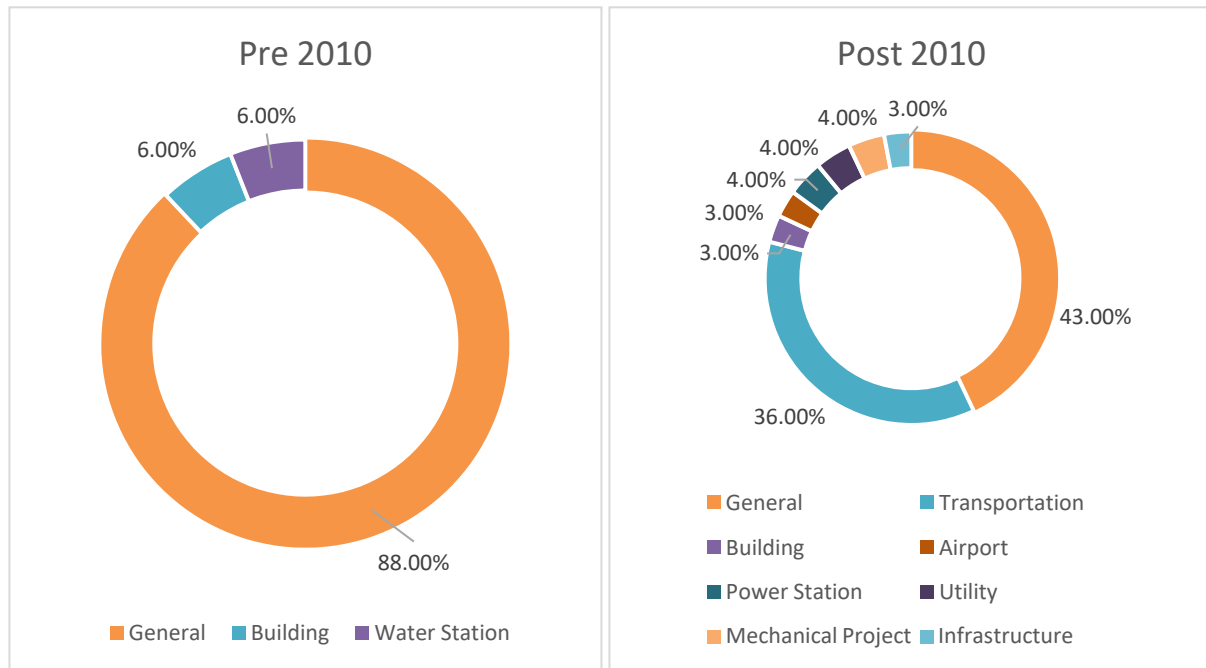


Fig. 4. The percentage of papers pre and post-2010.

Concerns Of The Chozen Factors

Owner

Owner concerns take the lead among all factors, with a total of 161 mentions. These issues encompass various aspects of the owner's role and Liability, as highlighted by [10; 16; 32]. They also include considerations of the owner's capability, as discussed by [33; 34; 35]. Additionally, the owner's willingness to participate, owner's type, owner's risk preference, and the importance of mutual trust have been consistently emphasized in the literature, explored by various researchers such as [4; 14; 25; 36; 37; 38], among others.

The adoption of the DBB method tends to be higher when owners seek a leading role in management and desire more control. Government or owners of the public sector lacking in-depth project control capacity and construction experience may opt for DB or CM methods. Trust plays a crucial role in the owner-contractor relationship, as a lack thereof may necessitate extensive monitoring efforts, costing the owner both money and energy. The owner's adequate experience and technical knowledge are vital considerations, enabling them to assess the behavior of the contractor and communicate effectively. While the owner doesn't need to possess the same capabilities and knowledge as the contractor, a certain level of understanding is necessary. These owner characteristics inevitably influence the relationship with the risk allocation, contractor, and project management contract. It becomes

incumbent upon the owner to define the extent and scope of their authorization, establishing the fundamental contract framework.

Contractor

Contractor concerns emerged as the second-ranking category among all factors, garnering 145 mentions. Some literature highlights competitive contractors as one of the top ten leading factors, as demonstrated by [34; 35]. Issues concerning contractors encompass considerations such as the availability of a suitable and qualified contractor, as discussed by [15; 33; 38], along with assessments of the contractor's proficiency and abilities, as explored by [4; 10].

The availability of contractors necessitates an evaluation of potential contractors in the market and the accessibility of market information. Assessing a contractor's experience and capabilities involves factors such as similar project experience, familiarity with a particular delivery method, proficiency in advanced technology, acquisition of experienced employees, labor productivity, ensuring the stability of the supply chain, and managing construction arrangements such as the adjustment and integration of activity sequences and supervision. The early participation of the contractor in the project is also emphasized for more efficient project implementation. As highlighted in a survey by [39], engaging construction contractors at an early stage through CMR contracts not only enables the establishment of a budget sooner than in DBB but also offers designers immediate cost constructability analysis, and estimates, thereby improving the overall effectiveness of the project.

Project cost

Cost criteria hold the fourth position, with a total of 81 mentions. Similar to time criteria, cost criteria can be segmented into cost assurance, control, and necessity or constraint. While many owners in regular business projects aim for minimal costs [40; 41], some prioritize completion within the budget [38; 42]. The cost considerations encompass direct costs based on resource limitations, waste, design, rework, and delays resulting from poor communication and unsuitable construction management. From a wider perspective, operation, and maintenance costs are also integral to the overall concept of cost.

Selecting an appropriate PDM can mitigate doubt in design and

construction [15] and reduce costs attributed to waste, rework, idle resources, and delays. The owner must start project cost targets or requirements early on, along with anticipating potential cost changes and their magnitude [25; 40]. Simultaneously, precise cost estimation before contract signing [17; 43] is crucial. Identifying profits derived from cost savings and offering incentives to contractors [44], as well as managing the costs of each stage of work [7; 39; 45], are additional considerations.

Different delivery methods employ diverse means and emphases in cost control. The DBB method focuses on controlling cost increases resulting from information loss among different phases. In contrast, DB and CM methods need to manage overlapping management costs. The identification of the most economical option fluctuates depending on the degree of integration between construction and design. In practical terms, value engineering stands out as a valuable technique for cost optimization, benefiting both project owners and contractors [5; 8].

Time

Time continues to be a pivotal factor and goal in most projects, mentioned 80 times using diverse terminology. These criteria encompass aspects such as time, schedule, or pace and can be classified into categories such as time assurance, control of phases, and necessity or constraint. When entering a contract, it is essential for both the owner and contractor to come to a consensus regarding the level of certainty concerning the project's completion date, as emphasized by [32].

Different PDMs possess varying capabilities to expedite project timelines based on organizational relationships and operational modes. It becomes imperative for the project owner to assess and determine which PDM exhibits the most exceptional ability. Achieving on-time completion, as emphasized by [34], or delivering within the planned timeframe, a requirement anticipated by both owners and contractors is a common objective. Owners employ stringent milestones or deadlines to supervise and monitor project delivery speed, as observed in works by [17; 46]. Alternatively, incentive mechanisms, such as those geared towards shortening the time, may be established to ensure on-time completion and minimize delays.

The contractor's tasks are inherently specific and intricate. To

effectively meet the owner's objectives, the chosen delivery method should encompass several key functions. These functions include providing as accurate as possible time estimation during the contract signing phase and incorporating incentive mechanisms to expedite planning, design, pre-construction preparation, construction, and procurement stages [40; 41; 45; 47]. Additionally, the delivery method should aim to minimize interference between stages or achieve overlap between different phases or tasks [45; 46]. A swift feedback mechanism is crucial to adjust subsequent work [45] promptly. The quick agreement among contributing entities serves as an organizational assurance for achieving shorter durations in each phase.

Project Quality

Quality can be understood as the extent to which contractors and designers meet the owner's specifications. References to quality factors appear 64 times throughout the gathered articles. Maintaining extensive control over both aesthetic and physical quality is crucial in this context [8]. Additionally, the owner takes into account factors such as the contractor's reputation, aesthetic sensibilities, and design confidence [32]. Ensuring that project outcomes align with the owner's requirements constitutes a fundamental aspect of any delivery method. However, the strategies and actions undertaken may differ due to organizational disparities among delivery methods.

Within the DBB approach, each phase is distinctly specialized, integrating a quality inspection system for reciprocal oversight among phases, thereby aiming to ensure comprehensive quality under optimal circumstances. However, due to the segmentation of phases, participants may prioritize enhancing the quality of their respective tasks independently, potentially neglecting the owner's quality standards and the interrelated quality aspects among phases.

Quality standards can be classified into quality metrics for each stage [15; 38; 45; 48], the level of task completion within each stage [15; 33], and the feasibility of design execution [48]. Assessing constructability acts as a link between design and construction. By evaluating constructability early on, projects can minimize construction waste, rework, and delays [5; 15; 30; 49].

Risk

References to risk factors appear 58 times throughout the gathered articles, covering different facets of project execution like definition of scope, site conditions, resources, and technology. These risks involve the initial evaluation of project risks, the distribution of risks among contractors and owners, and risk oversight during application. The preliminary risk evaluation should not only address uncertainties arising from the natural environment, resources, and technology [50; 10; 48] but also risks stemming from the discrete nature of tasks and organizational structures determined by the selected delivery method [40; 41; 46; 48].

Suitable delivery methods have the potential to alleviate organizational risks. Greater organizational integration empowers experts to render more precise and holistic assessments regarding technical risks. From a risk standpoint, project delivery entails the dispersion and management of risks between owners and contractors via organizational structures and task allocation. In theory, certain delivery methods facilitate the transfer of all risks to an organization. A meticulously crafted construction contract can delegate nearly all customary risks to a singular contractor entity [32; 37; 39].

Risk management can be executed by identifying potential changes in construction [46], minimizing risk factors [44], and shifting risks to further risk-capable contributors across contracts [40; 41].

Contracts and Claims

Concerns related to contracts and disputes have been mentioned a total of 56 times. While distinct from the project's physical characteristics and the attributes of owners and contractors, these issues are intricately linked to them. The quantity and scale of contracts vary across different delivery methods [36; 41]. In a single contract, numerous activities transition from external contracts in the internal workflow, notably diminishing risks and the likelihood of disputes [15]. Conversely, multiple contracts are susceptible to creating either overlaps or gaps among them, potentially leading to disputes among stakeholders.

However, it's crucial to note that a PDM with fewer contracts isn't inherently superior to one with a more significant number of contracts. From the owner's perspective, a greater number of sub-projects implies a more comprehensive understanding of the project and a more clearly defined scope of work. For

contractors, strict control over quality can be achieved due to constraints in upstream and downstream workflows. The occurrence of disputes hinges more on the clarity and completeness of the contract and its scope [51].

While contracts may seem like a consequence of selecting the PDM, owners should proactively anticipate the contract type [51], evaluate their management capabilities, and subsequently make informed decisions.

Laws and Regulations

Discussions pertaining to legal and regulatory matters are collectively mentioned 48 times, while political impacts are cited ten times in earlier papers. Throughout nearly all phases of PM, the influences stemming from regulations, laws, and policies consistently emerge as the most substantial external constraints. The recognition of PDMs is either constrained, supported, or facilitated by the political and legal framework of the country in which the project is located. For instance, projects in the United States must comply with federal, local, and state laws [14; 39]. Laws and regulations play a crucial role in shaping the legitimacy of PDMs, subsequently influencing the emergence of project risks.

These regulations and laws include not only directives concerning the suitability of delivery methods but also environmental restrictions [15], labor regulations [14; 39], and employment standards [48]. Policy factors represent another vital consideration that owners and contractors must factor in [10; 52]. Typically, most investors or ultimate beneficiaries of construction projects utilizing delivery methods have ties to governmental entities. The government conveys its risk tolerance and disposition by crafting policies that have the potential to impact the actions of project participants.

Complexity

The concept of "complexity" refers to whether the owner has particular needs that call for innovation and a unique construction approach [16; 32; 43], mentioned 41 times. "Project complexity" is chiefly evident in its organizational and technical complexities [10; 53]. Technical complexities require a greater number of professionals and more intricate organizational frameworks. Complex projects also necessitate detailed contracts to organise the efforts of participants.

The intricacy of a project influences the willingness of both contractors and owners, subsequently impacting the selection

of delivery methods. Owners overseeing straightforward projects typically lean towards DBB to enhance monitoring at each project stage. In contrast, owners of intricate projects may prefer CM or DB, authorizing contractors with enhanced capabilities to navigate the construction process. Conversely, if contractors possess complete capabilities, they are more inclined to commence complex projects throughout DB or CM. Conversely, contractors may prefer focusing on specific professional tasks in DBB. Project complexity also diminishes effective communication among participants of the project, raises the difficulty of adapting to changes, and introduces additional challenges to the PDM. More intricate projects are susceptible to unforeseen changes, necessitating the establishment of structured PDMs and contract systems at the project's outset to mitigate the alterations' risks.

Size

The size of a project, while not a predominant factor in the selection process, can still carry significance [8]. References to size factors appear 24 times throughout the gathered articles. The size of the project can be gauged by the subproject number or work bundles within the project, their magnitude [33], or even their estimated value [42]. A substantial project scale implies the need for more protocols to regulate the work of diverse professionals and teams, increased resources, and more structured means for project management [4; 43].

The DBB approach might not be appropriate for extensive or mega-scale projects because of the numerous work packages entailed, which encompass design, bidding, , professional subcontracting, and construction. Managing multiple external agreements among these work packages requires efficient and effective organizational coordination procedures.

Type

Project type is stated 17 times, but in the selection of a PDM, it is frequently considered the initial step [4]. Construction projects encompass various types, such as industrial, infrastructure, buildings, and others [4; 43]. Each type possesses distinct characteristics, leading to substantial variations in technical arrangements and project management methods. The varied characteristics of projects require distinct criteria for choosing delivery methods. According to Chen et al., the concept of "delivery speed" is primarily relevant to building projects, setting them apart from other types of projects. Consequently, there is a lack of comparability across

different project types [4].

Discussion

(22) factors are recognized as impacting the choice of PDM, underscoring the decision-making complexity process. Nevertheless, this compilation acts as a thorough project evaluation or an aiding decision-making instrument for stakeholders. When addressing actual construction endeavors, a more exhaustive selection becomes crucial, considering the interrelationships among these factors. These issues also serve as focal areas for future research.

Factors interface

The factors are interconnected and can have both positive and negative interactions. For instance, as indicated by the findings of [51], the contractor's capability is influenced by factors such as cost and time assurance, quality performance, and risk allocation. Simultaneously, quality performance is impacted by the contractor's proficiency and ability, technological obtainability, innovation, and project complexity. [38] also highlights the potential impact among factors inside projects. This suggests that making decisions about project delivery options must consider established standards and the evolving priorities resulting from the interactions between these standards. Similar to the triangular relationship in traditional project management, excessive emphasis on one aspect can detrimentally affect the corresponding performance of other aspects. For instance, prioritizing quality might lead to increased costs and time requirements. Understanding these interactions broadens the possibilities for effectively stimulating standards-based delivery methods but also increases the complexity of resource allocation, capability, and organizational considerations for all involved parties.

However, much of the research on the of PDM selection often fails to fully address the interaction between factors. While some studies, like those by [5; 8; 17; 41], have employed the Analytic Hierarchy Process (AHP) or its enhanced versions, these approaches may not efficiently analyze the interaction among factors at the same level. Deliberately considering standard interactions from a systemic viewpoint could represent a promising avenue for research aimed at achieving the optimal balance.

Factors Statistics

This study arranges factors based on the frequency with which

researchers have focused on them. However, it's important to recognize that the frequency cited by researchers doesn't necessarily indicate the importance of a factor in selecting a PDM. Rather, it reflects the level of attention given to them. Decision-makers, when deciding on the delivery method, should follow these steps regarding these factors: a) establish the priority of factors; b) identify the necessary factors; c) assign weights to each factor; and d) acknowledge the interaction among factors.

For instance, although project type has been mentioned only 17 times, it holds significant priority in determining the delivery method and notably influences the ultimate project performance [34]. Identifying the project type allows the selection of indicators appropriate for the project, enabling the owner to evaluate the importance of each factor. In specific project types, certain standards might be considered crucial, while others may be considered less essential. Complex and large infrastructures might require careful thoughtfulness of contractor capabilities and adaptability to changes in PDMs. Emergency construction projects often face strict time constraints, where political influence becomes less critical once consensus is reached among various departments. Additionally, public and community involvement can play a vital role.

For most traditional construction projects, factors ranked highly in statistical results become priorities for PDM selection. Conversely, some statistically significant factors may have little impact on PDM for usual commercial projects and are typically disregarded during construction and decision-making, such as natural catastrophes, culture, and political influence. Nevertheless, with the growing project complexity and the prevalence of projects in exact environments, early criteria primarily acknowledged by a few researchers, like construction sustainability and design sustainability, may gradually gain mainstream recognition. This highlights the need to adjust the selection criteria and weights according to owner/project characteristics, and the external environment.

The PDM selection is complicated, and exact project objectives and conditions are crucial. Evaluating the unique attributes of each project is vital in determining which PDM can deliver the best results [54]. Essentially, owners should identify project requirements, consider the project's specific circumstances, and choose the most appropriate method to achieve

satisfactory outcomes.

Factors Measurement

The measurement of criteria remains a significant area of research. Among the identified 11 criteria and 22 sub-criteria, only a limited number can be effectively measured, with time and cost being notable examples. The mainstream of index factors continues to be characterized by fuzzy and qualitative criteria. In practical scenarios, making precise and immediate choices, particularly within a limited time frame, as is often the case in post-disaster reconstruction, becomes a critical challenge. Effectively reflecting fuzzy criteria in practice remains a pressing issue that requires further attention.

Currently, the identification and evaluation of criteria heavily rely on professional investigation and subjective professional judgment. Previous studies have employed various research methodologies, including the Analytic Hierarchy Process (AHP) [5], the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) [40], and the triangular fuzzy number method. Nevertheless, these approaches still necessitate adjusting the personal preferences of experts, potentially yielding results that do not accurately reflect the factual project and complicating the establishment of correlations between factors. Hence, there is a need to develop a recognition method that minimizes biased judgment to the greatest extent.

The process-based modeling process emerges as a promising approach to addressing this issue. This method entails identifying related factors by mapping out different activities and required functionalities in the planning, construction, design, and other processes associated with different PDMs. By aligning element needs with objective activity function needs, this approach mitigates the influence of subjective judgment.

Project Circumstances

Each project must establish its own set of appropriate selection criteria before determining the most suitable PDM. The diversity of research perspectives plays a pivotal role in broadening the knowledge domain and criteria associated with PDMs. As previously noted, the project classification emerges as a significant selection factor. Considerations for different project types may vary, and while limited studies illuminate the requirements of distinct project types, some exceptions exist: [7; 14; 15; 55] focused on U.S. transportation engineering, and

[42] delved into electric power plants.

Future research needs to continue exploring the project delivery needs of specific kinds of construction projects, including but not limited to bridges, public buildings, water utilities, energy projects, and other categories. Another area deserving attention is unusual construction. In certain extraordinary circumstances, like post-disaster reconstruction, many conditions, and project constraints such as cost and time limitations, owner requirements, and external market situations, significantly diverge from the norm. In such emergencies, the number, significance, and mutual influence of PDM criteria can be notably skewed. Decision-makers must consider changes in needs, giving priority to factors like swift project completion without compromising quality and the adaptability of the project delivery method to address various construction emergencies. Regardless of the situation, it is important to note that the DB method focuses on strengthening the connection between project stages: design and construction [56].

PDM Execution Under Factors Impacts

Analyzing the factors affecting the execution of PDMs contributes to comprehension and decision-making processes. Investigating how these factors influence performance aids decision-makers in determining whether to adopt them and their respective significance. Some existing research concentrates on crucial factors, such as the studies that examined the impact of owner characteristics [35; 37]. Other studies, such as those by [43; 57], delve into project characteristics and the influence of the external environment separately.

However, the influence and mechanisms of certain factors, which may not have traditionally received attention, should also be subject to thorough examination. For example, when undertaking projects, the project execution organization often needs to take community opinions into account. In highly integrated PDMs, project professional departments can effectively share these opinions, reducing information transmission discrepancies and delays and ultimately enhancing project efficiency. Nonetheless, the effective dissemination of this information to various professional departments and the adaptation of project organizational behaviors have not been extensively discussed. A comprehensive exploration of the factors influencing PDMs

and their mechanisms will enable a better understanding of the subtleties in PDM decisions.

For the decision-making issue, some research found that successful approaches in this part could decrease delays in the decision-making process and prevent conflicts and disputes in projects [58]. Generally, Construction management is currently focused on increasing productivity and optimizing structure costs [59], which indicates the significance of quality-related management to operating construction projects that are discussed in this research. Eventually, previous research studied how to endorse the importance of Building Performance Simulation in the pre-design phase along with the challenges faced during its adaptation to implementation [60], which is related to different PDMs and their capabilities to adopt such simulation approaches to serve the environment.

Conclusion

It is not proven that a single Project Delivery System universally suits all project types [33; 39]. Likewise, there is not a one-size-fits-all best PDM; instead, there exists the most suitable PDM. The choice of appropriate PDMs directly impacts the resource allocation and organizational arrangements for contractors and owners, subsequently influencing project positive accomplishment. Hence, careful selection of the right PDM at the project's start is crucial.

Deciding the PDM selection criteria is a fundamental aspect of PDM selection. Selection factors are not all applicable to all projects, but instituting a comprehensive list of PDMs selection criteria enhances clarity regarding the project's status and optimizes the selection process. This study provides an in-depth review of the factors influencing the PDMs selection. Concluding a comprehensive literature review, a set of general factors is summarized, including the concerns of cost, time, quality, and risk, besides the owner and contractor concerns, external market factors, and resource availability, along with corresponding sub-criteria. Future research can concentrate on customizing and reinforcing common criteria for specific environments and projects. Additionally, further investigation into measuring criteria is necessary. Revealing the criteria influencing PDM selection in various project types and scenarios will facilitate the optimization of PDM selection, ultimately increasing the PDM positive attainment.

Conflict of Interest

The author declares no conflict of interest.

Author Contribution

This is a singular-author work. Hence, the author conducted all research parts, e.g., data analysis, paper writing, and approving the final version.

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