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Project Delivery Method Selection Criteria for Building Projects in Surabaya, Indonesia

Andi[1]*, Sugianto, S.E.[1], and Lukas, Y.S.[1]
[1] Civil Engineering Department, Faculty of Civil Engineering and Planning, Petra Christian University
Jl. Siwalankerto 121-131, Surabaya 60236, INDONESIA

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Corresponding Author:
Andi
Civil Engineering Department, Faculty of Civil Engineering and Planning, Petra Christian University
Jl. Siwalankerto 121-131, Surabaya 60236, INDONESIA
Email: andi@petra.ac.id

Abstract

Selecting an appropriate Project Delivery Method (PDM) is a crucial decision for owners that significantly influences the success of a construction project. Various criteria, such as the nature of construction projects and the specific characteristics of owners and projects, should be properly considered to make this decision. This paper first assesses and evaluates the key criteria for selecting a PDM for building projects in Surabaya. It then proposes a multi-criteria decision-making model for the selection of three PDMs, namely Single General Contractor, Multiple Primes, and Design and Build. A three-step questionnaire survey was conducted to achieve the objectives. The initial analysis revealed six important selection criteria, which were then modelled and used in the subsequent survey. Using the Analytical Hierarchy Process (AHP) procedures, the second analysis determined the weights of each criterion for the three PDMs. The paper discusses these weights, suggesting the relative strengths of each PDM. Finally, the paper tests the robustness of the model using three building projects in Surabaya.

Introduction

In the construction process, various activities must traverse a lengthy journey from project inception to completion. Along this path, numerous challenges often arise that require immediate resolution. Proper arrangements are necessary to optimally manage project resources, adhere to timelines, and meet the expected quality standards for the facilities being constructed. According to Ervianto [1], achieving a successful construction process involves the active participation of various stakeholders who organize and group activities, ultimately responsible for their execution. These stakeholders include the relationships between owners and contractors, owners and consultants, contractors and consultants, subcontractors and contractors, among others.

The Project Delivery Method (PDM) defines the relationships among the involved parties and outlines when and how they will fulfill their obligations and responsibilities. PDM encompasses a system that regulates the structure, framework, roles, responsibilities, and authority for the parties engaged in the construction process [2]. As El-Sayegh [3] explains, PDM refers to the approach the owner adopts for organizing the project team responsible for both design and construction management. The choice of PDM significantly impacts owner satisfaction and overall project success.

Unfortunately, owners often base their PDM selection on familiarity rather than a comprehensive evaluation of each method's strengths and weaknesses [3,4]. Consequently, inappropriate PDM selection can lead to negative consequences, including conflicts among stakeholders, communication challenges, delays, compromised quality, and increased costs.

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Given these considerations, it is essential to conduct a thorough evaluation and select the project delivery method that best aligns with the overall project needs and objectives. Each PDM has its advantages and disadvantages [5-7], and the right method depends on specific project requirements, the owner's goals, and the skills of the involved parties. Selecting the appropriate PDM necessitates focused and detailed analysis. Importantly, no single method is universally superior; the selection depends on project-specific characteristics and the owner's context.

While extensive literature discusses Project Delivery Method (PDM) selection, there is a notable gap concerning building projects in the Surabaya area. This study aims to address this gap by achieving two primary objectives. First, it will assess and evaluate the criteria used for selecting building project delivery methods in Surabaya. By modeling the selection process as a multicriteria decision problem, it will objectively reveal the relative strengths of each PDM, considering various criteria. The study will validate the proposed PDM selection model using data from several building projects in Surabaya. This validation process will test the robustness of the model and provide practical insights into the most suitable PDM for this specific context.

Literature Review

Once owners decide to embark on a construction project, one critical decision they must make is how best to organize the effort and delegate work to other project participants. This decision not only affects the management of the project but also the number, scope of work, and responsibilities assigned to internal and external organizations involved in the project [6]. Owners should choose a project delivery method alternative that best suits their control objectives and requires a level of their involvement.

There are a variety of alternatives, each demanding different control strategies and different levels of involvement throughout the project life cycle. The owners' choice of PDM plays a key role in determining the success of a project, as it influences how the project will be managed, controlled, and communicated between all parties involved. In this section, the basic understanding of PDM will be discussed, when PDM selection is made, various PDM models that are commonly used, and strategies for deciding or selecting PDM that suits project needs and objectives.

Definition of Project Delivery Method

Project Delivery Method (PDM) refers to the approach or strategy used to organize and manage the construction process from start to finish. PDM covers various aspects of a project, including planning, design, procurement, construction, quality control, and project completion. The primary goal of PDM is to achieve successful project outcomes, which include meeting project objectives in terms of cost, time, quality, and stakeholder satisfaction.

Typically, the decision regarding PDM selection occurs during the early stages of the project life cycle before design and construction commence. This stage is often referred to as the pre-design or early planning phase. The project owner collaborates with the project management team and consultants to make this critical decision.

Types of Project Delivery Method

There is a myriad of alternatives by which an owner may organize and manage a construction project. Each has provided a successful story when properly planned and managed. On the other hand, each has also marked some evidence of failures when exercised by unfamiliar owners with its characteristics, strengths, and weaknesses or when inadequately managed.

Traditional and nontraditional alternatives of PDM are discussed here. The traditional ones refer to those PDMs that separate design and construction packages. The designer prepares a design package, including contract documents. The owner submits the package for bidding and selects the best bidders/contractors to undertake the construction of the project [8]. Two variants for this traditional approach are single general contractor (SGC) and multiple primes. Meanwhile, the most common nontraditional PDMs used are design and build (DB) and Construction Management (CM). The nontraditional approaches tend to bridge the gap between design and construction as found in traditional ones. The following will summarize the alternatives.

Single General Contractor (SGC)

With this approach, a project owner is dealing with two distinct organizations. He/she contracts with an outside engineering and design firm to design the project, and contracts separately with a single general contractor to build the project. Most general contractors will, in turn, subcontract the construction works to smaller specialist contractors (subcontractors).

The products of the design firm (such as drawings and specifications) ideally are completed prior to the bidding of the project, with the hope that the work is well defined, a schedule can be readily determined, and a price quotation can be made by the contractors. However, in actuality, this is seldom the case [6].

Multiple Primes

The traditional contractual nature in this arrangement is similar to that of SGC. However, the owner establishes a competitive bidding cooperative relationship with several special contractors according to the expertise of each special contractor [9]. In a sense, the owner has replaced the general contractor role of subdividing the construction work packages and awarding individual subcontracts. The owner has advantages with the flexibility of awarding each work package on its own merits and avoiding undue dependence on a single contractor. Another advantage is a fast-track condition may exist. This is advantageous in getting the construction works started as early as possible without waiting until all design products are finished.

While this approach may reduce the one-contractor risks inherent in the SGC to a lesser extent, its main disadvantages are extreme demands on the owner for staffing, responsiveness, and organizational strength. The owner or its representative becomes the direct coordinator of all contractors on the site [6].

Design and Build (DB)

According to Carpenter & Bausman [10], design build is an organizational structure that is used if the owner only wants to deal with one company entity: design and construction, starting from planning, implementing, and controlling the entire project. The owner works in a single cooperation agreement/contract with the design build contractor. Some or all the design and construction may be performed by the same entity, or the contractor may subcontract the work to another company.

The nontraditional nature of the Design and Build approach is the integration between design and construction works under one coordination of the contractor. It may improve communication between consultants and contractors during the design and construction stages and may integrate construction knowledge into the design phase [11] to ensure the constructability aspects of the design products.

Selections of PDM Types in this Study

Another nontraditional PDM that similar studies [8,12] mostly mentioned is construction management (CM). Briefly, with this scheme owners hire a CM consultant as their representative to oversee the process of project development. The method is usually used in the case of multiple primes contracts. During construction, the CM coordinates contractors' activities and controls the project. There are two variants of CM approach, i.e., agency CM and CM at risk.

This study, however, did not consider the CM approach. It is because, based on one of the authors' experiences as a CM consultant, a CM consultant can be hired for many different PDM approaches. Owners may hire a CM consultant while using the three PDMs discussed above. To avoid misunderstanding between CM as a PDM and just a profession, the authors decided not to include the CM approach. Thus, three PDMs, i.e., SGC, Multiple Primes, and DB, would be investigated further.

Criteria for Selecting PDM

The study collected nine criteria, which were summarized from several sources [6,8,11,13]. They were owner's involvement, constructability, clarity of scope of work, project complexity, risk allocation, construction cost, payment type, quality, and project duration. Brief definitions of each criterion are in the following sections.

- Involvement of owner: the level owner involvement in maintaining control and exerting influence over project design and execution.
- Constructability: the ease of design to be carried out. With high constructability, the level of difficulty of the construction process will be lower and can save time and costs.

- Scope of Work: the clarity of construction work scope at time of contract award. The readiness and completeness of design products (drawings and specifications) define the clarity the scope of work during the bidding period.
- Project Complexity: the size, type, and complexity of the design. Highly complex buildings may require advanced material and technology to construct.
- Project Risk Allocation: effectiveness in dividing and transferring risk between different project parties.
- Construction cost: achieving the lowest cost is mostly a major concern in project delivery contracts.
- Payment type: a project may be priced as lump sum, unit price, or cost plus.
- Quality: desire to maximize the control of aesthetic and physical quality of the building.
- Project duration: securing the shortest reasonable duration of project completion.

Multicriteria Decision Making

In selecting an appropriate PDM, owners face decision-making problems concerning multiple criteria previously defined. They should be able to recognize and objectively quantify the relative strengths or advantages of each PDM. Furthermore, based on these relative strengths, the owners need to formulate, analyze, and then arrive at a decision of PDM selection. This section will explore methods that can assist owners with these problems.

Liauwnoto [14] summarized five methods that enable the resolution of multicriteria decision-making problems. These include the multiple-attribute utility theory (MAUT), merit point system, simple additive weighting (SAW) method, simple multi-attribute rating technique (SMART), and analytical hierarchy process (AHP). The explanations of each method are beyond the scope of this paper, and readers are suggested to consult related literature for more details.

After considering the characteristics, strengths, and weaknesses of these methods, the current study decided to employ the AHP technique. The Analytical Hierarchy Process (AHP) was developed by Prof. Thomas L. Saaty in the 1970s. AHP is a method that is quite flexible and easy to understand for analyzing and breaking down decision-making problems into its components (criteria, sub-criteria, and alternatives). The AHP methodology can include both subjective factors and objective factors in the decision-making evaluation process [14].

The AHP is a structured decision-making technique used to prioritize and select among multiple alternatives based on a set of criteria and their relative importance. Its basic steps are hierarchy formation, pairwise comparison, consistency check, weight calculation, aggregation and ranking, sensitivity analysis, and decision making. Overall, AHP provides a systematic framework for structuring complex decision problems, eliciting stakeholders' preferences, and deriving rational and transparent decisions based on the relative importance of criteria and alternatives. The computational procedure is thoroughly discussed in Saaty [15].

Method

The study conducted three questionnaire surveys to meet its objectives. The following sections explain these three surveys.

The First Survey

The first survey was designed to identify the most important criteria for PDM selection. As the study would later use the AHP technique and to achieve the desired level of consistency [16], the maximum number of criteria that could be included was only seven. Therefore, the study first filtered the number of criteria.

The filtering process was conducted by combining a questionnaire and direct interviews with several experts who had experience with PDM selections. The experts were shown the nine criteria previously reviewed (owner's involvement, constructability, clarity of scope of work, project complexity, risk allocation, construction cost, payment type, quality, and project duration) and then asked to rate the importance of the criteria for selecting a PDM using a rating scale from 1 (very low importance) to 5 (very high importance). Only those criteria that had a minimum mean value of three were included in further study.

The Second Survey

This survey aimed to obtain the strengths of each PDM with regards to the important criteria revealed from the first survey. The questionnaire reflected the AHP technique [15] and was in the form of a pairwise comparison. The target respondents were owners or their representatives (including consultants) operating in Surabaya, who had experience in PDM selection.

The respondents were asked to compare the importance of one PDM to another regarding a specific selection criterion, with scale values of 1 (indicating the two PDMs would have the same importance) to 9 (indicating one PDM would be nine times more important than the other one). Since there were three PDMs under study, the number of questions would be three times the number of criteria. The analyses of the relative strengths (weights) would follow the AHP procedures and apply a maximum consistency ratio value of 0.1 to ensure that the calculated weights would be consistent [15].

The Case Studies

The final survey would apply and validate the results (weights) of the second survey. The researchers would look for several ongoing or just recently completed building projects. Here the targeted respondents would be people in high positions who were involved and understood the project well. The survey would ask the degree of importance of each criterion placed by the owners in the project.

Following the AHP, the questionnaire would use a pairwise comparison technique, in which the respondents would rate the importance of a criterion compared to other criteria, using scale values of 1 (indicating the two criteria would have the same importance) to 9 (indicating one criterion would be nine times more important than the other one). The subsequent analyses would perform AHP procedures that would combine the results in the second and case-studies surveys. The ultimate deliverable would be a suggestion of the most suitable PDM for each project. The model's decision would be compared to the actual PDM applied in the project for the purpose of validation.

Results and Discussion

Important Selection Criteria

Four construction experts participated in this survey, including one director of a consultant company, one project manager of a construction management company, and two members of an owners' team (a project manager and a tender staff). All participants had more than 25 years of experience and were well familiar with building projects in Surabaya.

Table 1 exhibits the rating of respondents and the mean values. If the standard deviation value is less than 1.5 and the interquartile range value is less than 2.5, then the criteria are deemed as consensus, meaning that all respondents agree with the importance of these criteria. Six criteria fulfill the importance requirements (i.e., having a mean value more than 3 and a consensus condition); they are owner involvement, constructability, scope of work, risk allocation, construction cost, and project duration. Only these six important criteria were then included in the next stage.

Table 1. Analysis of PDM Selection Criteria

No.	Criteria	Respondent Rating				Mean	Standard Deviation	Interquartile Range
		1	2	3	4			
1	Owner Involvement	5	5	5	4	4.75	0.50	0.50
2	Constructability	5	5	5	5	5.00	0.00	0.00
3	Scope of Work	5	5	5	5	5.00	0.00	0.00
4	Complexity	3	2	3	2	2.50	0.58	1.00
5	Risk Allocation	3	3	4	3	3.25	0.50	0.50
6	Construction Cost	5	4	5	5	4.75	0.50	0.50
7	Payment Type	1	1	2	1	1.25	0.50	0.50
8	Quality	3	2	2	3	2.50	0.58	1.00
9	Project Duration	4	4	5	5	4.50	0.58	1.00

The PDM Selection Model

Figure 1 shows the PDM selection model containing three PDMs and six selection criteria. The next stage of the study was to gauge the relative strengths of the three PDMs considering the six criteria. A questionnaire containing eighteen questions (three PDMs multiplied by six criteria) was surveyed to respondents.

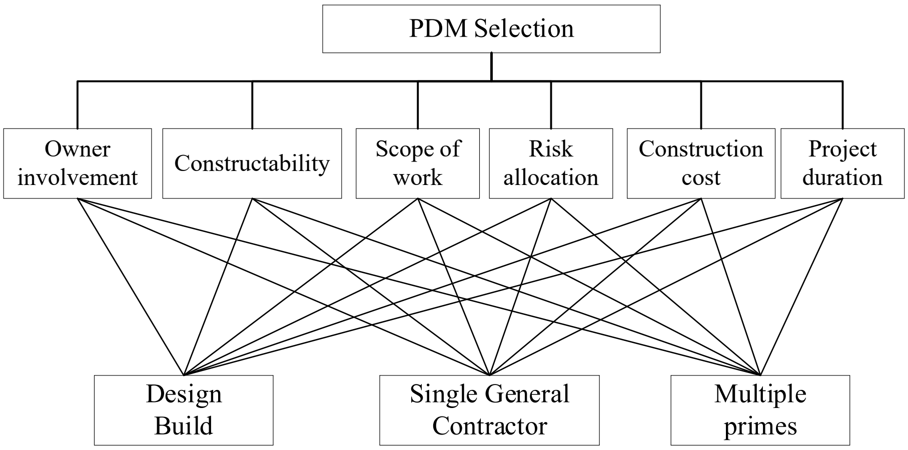

Figure 1. PDM Selection Model

The researchers could gather twenty-one respondents consisting of seven personnel from developers (owners), eleven personnel from CM companies, and three faculties. The data for each respondent were entered into a pairwise comparison matrix and analyzed using the Analytical Hierarchy Process (AHP) technique. Since the data came from many different respondents' opinions, Saaty and Kearns [17] suggested using the geometric mean to average the data to become one matrix for each criterion. The matrix would then undergo a normalization stage. Next, the data would be tested for its level of consistency, by calculating the maximum eigenvalue, consistency index, and consistency ratio for each criterion. Readers are recommended to consult [17] for the detailed formula of each stage. The brief calculations of these procedures are described in the following sections.

Geometric Mean Analyses

The data collected was in the form of pairwise comparisons regarding the importance of a criterion between two PDMs. From the respondents' answers, the study first performed analyses of geometric mean for all criteria. Table 2 is an example of geometric mean analysis for the owner involvement criteria.

Table 2. An Example of Geometric Mean Analysis

Owner Involvement	Design Build	Single General Contractor	Multiple Primes
Design Build	1	2.9324	5.9840
Single General Contractor	0.3410	1	2.9064
Multiple Primes	0.1671	0.3441	1
Total	1.5081	4.2764	9.8904

Normalization and Calculation of Weight

The second step of the analysis was the normalization to calculate the comparison weights of the criteria among the PDMs. The normalization process was carried out by dividing the value of each element by the total value in each column. The results are presented in columns two to four of Table 3, which is an example of normalization calculation for the criteria of owner involvement.

The last column of the table displays the weights representing the importance of the criteria for each PDM. The value of the weight is the average value of the three normalized numbers in columns two to four. For example, the weight of Design Build considering the owner involvement is 0.6513. The total weight for the three PDMs is one.

Table 3. An Example of Normalized Weight Calculation

Owner Involvement	Design Build	Single General Contractor	Multiple Primes	Average Weight
Design Build	0.6631	0.6857	0.6050	0.6513
Single General Contractor	0.2261	0.2338	0.2939	0.2513
Multiple Primes	0.1108	0.0808	0.1011	0.0975

Table 4 summarizes the weights of all criteria held by each PDM. All the calculated weights have a consistency ratio less than 0.1, meaning they are consistent and valid. The values of each criterion indicate the relative strength of one PDM compared to other PDMs. For example, for the owner involvement criteria, DB is relatively having more advantage than SGC and multiple primes, with the weights of 0.6513, 0.2513, and 0.0975, respectively.

Table 4. Comparison of Criteria Weights among PDM

Criteria	Project Delivery Model			Consistency Ratio
	Design Build	Single General Contractor	Multiple Primes	
Owner Involvement	0.6513	0.2513	0.0975	0.0120
Constructability	0.6432	0.2331	0.1237	0.0140
Scope of Work	0.1171	0.2129	0.6700	0.0213
Risk Allocation	0.6288	0.2425	0.1287	0.0111
Construction Cost	0.1129	0.2409	0.6462	0.0191
Project Duration	0.5764	0.1242	0.2994	0.0025

Discussions of the Criteria

The Design and Build (DB) system leads in four criteria: owner involvement, constructability, risk allocation, and project duration. Meanwhile, the Multiple Primes system claims top performance for two criteria: scope of work and construction cost.

In a full DB system, owners theoretically contract with only one entity, the DB contractor [5]. This arrangement is suitable for owners who do not have much time to get involved in the project (with a weight of 0.6513). For building projects in Surabaya, owners typically engage an architect to provide a conceptual design, which is then handed over to the winning DB contractor to detail the design for construction.

With the contractor's early involvement during the design phase, it may enhance the constructability aspects of the design (with a weight of 0.6432), allowing the contractor to incorporate construction knowledge into the design as early as possible. One significant reason for an owner to choose the DB system is that it may shorten the overall project duration (with a weight of 0.5764) due to the overlap between the design and construction stages. In other words, the system enables fast-track construction.

When considering the criteria of risk allocation, owners prefer to use the DB system (with a weight of 0.6288). By employing this system, owners transfer all risks, including design risks such as design errors, and construction risks such as delays, cost overruns, decreased quality, and so on, to the design-build contractor.

Owners tend to favor the Multiple Primes system if construction cost is a consideration (with a weight of 0.6462). By contracting directly with specialist contractors, owners eliminate one layer of profit that would exist if the specialist contractors were working under the general contractor. In a building project, it is unusual for an owner to retain hundreds of specialist contractors to reduce the construction cost. Another reason for this practice is that owners perceive the Multiple Primes system may enhance the clarity of the scope of work for each respective contractor (with a weight of 0.6513).

The Case Studies

Securing willing respondents (projects) for this stage proved to be a challenging task. Eventually, the researchers were able to gain access to three building projects, specifically, two hospitals and one mall project, to validate the weighting results. These projects were under construction at the time of the survey.

Following the AHP mechanism [17], the calculation procedures for each project case were identical to those conducted in the second survey. The paper does not explain the step-by-step calculation to keep it concise. Table 5 presents the summary calculation of weights for each criterion, reflecting the degree of importance placed by the owners on each criterion in each project. All the calculated weights in each project were consistent, with a consistency ratio less than 0.1.

It is clear from Table 5 that construction cost was the dominant factor in the three projects. It has long been recognized that most owners of building projects in Surabaya consider project cost as the most important objective compared to other project objectives such as duration, quality, and safety. The second and third important criteria in Hospital 1 project were project duration and risk allocation (with weights of 0.2395 and 0.1434, respectively), in Hospital 2 project were constructability and project duration (with weights of 0.2268 and 0.1558, respectively), and in the Mall project were scope of work and constructability (with weights of 0.2697 and 0.1452, respectively).

Table 5. Assessment of the Criteria Importance in Each Project

Criteria	Project Cases		
	Hospital 1	Hospital 2	Mall
Owner Involvement	0.0841	0.0526	0.0895
Constructability	0.0469	0.2268	0.1452
Scope of Work	0.0311	0.0346	0.2697
Risk Allocation	0.1434	0.0739	0.0310
Construction Cost	0.4549	0.4562	0.4125
Project Duration	0.2395	0.1558	0.0521
Consistency Ratio	0.0293	0.0352	0.0520

By applying the AHP procedure, the results from the previous surveys and the case studies (Tables 4 and 5, respectively) were multiplied to reach the conclusion of the PDM selection. Table 6 provides a summary of the calculated weights of PDM selection for the three projects. All projects were expected to select the Multiple Primes PDM, as its weights were the highest, i.e., 0.4190, 0.4073, and 0.4935 for the Hospital 1, Hospital 2, and Mall projects, respectively.

Table 6. The Model's PDM Decisions

Project Delivery Method	Project Cases		
	Hospital 1	Hospital 2	Mall
DB	0.3682	0.3720	0.2794
SGC	0.2128	0.2206	0.2271
Multiple Primes	0.4190	0.4073	0.4935
PDM Decision	Multiple Primes	Multiple Primes	Multiple Primes

The actual PDM implemented in the three projects was notably the Multiple Primes. The owners contracted with more than one contractor to execute the work packages, such as foundation, civil, mechanical, electrical, façade, and lift works. These three cases thus validate the proposed PDM selection model for building projects in Surabaya.

Conclusions

There are various options for project delivery methods (PDM) available for owners to select from, each with its own strengths and weaknesses reflected by multiple criteria. Owners should be able to objectively assess the important criteria dedicated to the project, thoroughly analyze them, and ultimately decide on the most appropriate PDM for their project. This study has addressed all these requirements for building projects in the Surabaya area.

The study identified six important criteria that owners mostly consider when selecting a PDM. These are owner involvement, constructability, scope of work, risk allocation, construction cost, and project duration. Based on these six criteria, the study proceeded to develop a selection model for three PDMs (SGC, DB, and Multiple Primes) using the analytical hierarchy process method. The model enhances existing literature [15,16] by providing weights that indicate the relative strengths of one PDM compared to others for each criterion.

For building projects in Surabaya, the Design and Build (DB) system offers the most advantages in four criteria, namely, owner involvement, constructability, risk allocation, and project duration. Meanwhile, the Multiple Primes system performs best in terms of scope of work and construction cost. The model has been validated in three ongoing building projects, where the decisions derived from the model satisfactorily reflected the actual PDM.

Owners in Surabaya may find this model beneficial when considering a new building project. It can assist owners in objectively selecting the appropriate PDM based on the six criteria. Owners only need to perform an identical pairwise criteria assessment in their new project, as explained in the third step (survey).

However, the model does have some limitations. It has only focused on building projects of private owners in Surabaya. The model may not be applicable to other types of projects, such as industrial and infrastructure projects, for public owners, or for other areas. Different types of projects, owners (private versus public), and areas may present different important criteria. Future studies may follow the three steps outlined here to address these research gaps.

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