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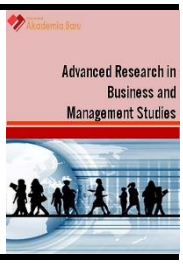

The Impact of Task and Technology Characteristics on Cost Estimation Performance in Construction Projects: A Regression Analysis

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ABSTRACT

Accurate cost estimation is crucial for the success of construction projects worldwide. However, many projects encounter failures due to challenges in this area. Existing research has primarily focused on developing and comparing cost estimation methods, as well as identifying factors and best practices for improving cost estimation performance. Yet, only a limited number of studies have explored deeply into the relationship between these factors and cost estimation performance. This study aims to address this gap by investigating how task characteristics and cost estimation method characteristics affect cost estimation performance from the perspective of cost estimators. Data were collected from cost estimators in construction projects and subsequently analyzed using multiple regression analysis. The results demonstrate that task interdependence and the cost estimation method characteristics significantly impact the cost estimation performance. This study provides novel insights regarding the significance of these method characteristics and sheds light on which task characteristics influence the cost estimation performance. It also provides the importance of fostering a positive organizational culture to mitigate the adverse effects of task interdependence on cost estimation performance. Furthermore, this study recommends further exploration of the interaction between task and cost estimation method characteristics through task-technology fit theory or moderator analysis.

1. Introduction

Effective cost estimation plays a crucial role in determining the success or failure of a project. Unfortunately, many projects worldwide fall short in this area. In fact, despite the growing number of projects, with an estimated 88 million people requiring project management skills by 2027, a staggering 65% of projects fail to meet their requirements, particularly in terms of cost [1]. Numerous previous studies have identified poor cost estimation performance as a leading cause of project failures, especially in construction projects [2,3].

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Cost estimation is a critical element in construction projects as it involves predicting the financial requirements needed to accomplish objectives within a specified timeframe [4]. When cost estimation performance is low, significant discrepancies arise between the estimated and actual costs of project resources. This underperformance not only jeopardizes the project's success but also causes financial damage, particularly for design consultancy firms [5]. Fazil [6] identified several factors affecting cost estimation performance, including the experience and skill levels of estimators, experience in similar projects, the project teams, financial capability, project complexity, project information, task characteristics, cost estimation methods, project size, and external factors. While many previous studies have explored the relationship between these factors and cost estimation performance [4,7], relatively limited research has delved into the details of task characteristics within the context of cost estimation.

Furthermore, cost estimation performance is closely tied to selection of appropriate cost estimation methods. Several factors influence the selection of the most suitable methods for estimating project costs, such as the available level of project information and the project's duration. Numerous methods have been developed, each with their unique characteristics, to predict the estimated total costs of a project. These methods encompass a wide range of approaches, including parametric and machine learning techniques [8]. These methods' characteristics can be classified into key categories, namely usability, applicability, accuracy, and ease of understanding, as identified by Barakchi [8]. Additionally, these characteristics play a significant role in determining the ideal cost estimation method to be used. However, the literature on the influence of cost estimation method characteristics has been limited, especially regarding its impact on cost estimation performance. The rationale behind this lies in the prevailing emphasis within previous literature on assessing the accuracy of individual methods across diverse domains and evaluating the performance of various cost estimation approaches in specific contexts [6].

This study aims to investigate the influence of task characteristics and cost estimation method characteristics on cost estimation performance in construction projects. The findings of the study reveal that task interdependence and cost estimation method characteristics significantly impact the cost estimation performance. The structure of the study begins with a comprehensive literature review on cost estimation performance, task characteristics, and characteristics of cost estimation methods. Subsequently, hypotheses and a research framework are developed based on the research objectives. The study then provides a detailed description of the research methodology, including data collection, measurement of construct items, and respondent demographics. The results section presents descriptive statistics of the constructs and the outcomes of the regression analysis. The study explains the implications of these findings from both theoretical and managerial perspectives. Furthermore, the limitations of the study and suggestions for further research are discussed before concluding the study with final remarks.

2. Literature Review

2.1 Cost Estimation Performance

Cost estimation performance refers to the accuracy and reliability of cost estimation methods in forecasting the actual cost of a project [9]. The assessment of cost estimation performance involves comparing estimated costs with the actual costs of the projects. Good cost estimation performance is indicated by a low variance between the estimated cost and the actual cost of a project, while poor cost estimation performance refers to the opposite [10,11]. Cost estimation performance is also often synonymous with cost estimation accuracy, as many previous studies have explored many cost estimation methods to determine their accuracy [6].

Previous studies in the construction industry have concentrated on developing various cost estimation methods to determine the accuracy level [12-14]. These methods include unit cost, parametric, historical data, expert judgment, case-based reasoning, artificial neural networks, Monte Carlo simulation, fuzzy expert systems, software programs, and building information models [8]. The effectiveness of these methods is crucial for achieving accurate cost estimation performance, and it is important to follow good practices when utilizing them.

Previous research has emphasized the identification of best practices and factors influencing cost estimation accuracy [7,15,16]. However, few studies have investigated the causal relationship between cost estimation performance and these factors. Prior literature has examined cost estimation performance from an individual-level perspective, considering factors such as the stress levels of cost estimators [17], organizational control [18,19], and project risk [20]. This study specifically focuses on the performance of technical aspects of cost estimation at the individual level, particularly within the context of cost estimators in construction projects. While cost estimation performance is influenced by various factors, this study specifically examines task characteristics and technology characteristics, which have been overlooked deeply.

2.2 Task Characteristics

The task characteristics have a direct impact on the accuracy of cost estimation in a project. Previous studies have approached task characteristics from several perspectives such as task interdependence, task equivocality, task exception, task analyzability, task difficulty and task variety [21-23]. Task interdependence explores the degree to which individuals rely on and receive direct support from others to complete a task [24]. Task equivocality refers to the presence of multiple and conflicting interpretations surrounding a task's situation [25]. Task exception quantifies the number of exceptional cases that arise during the course of work [26]. Task analyzability shares similarities with task equivocality, focusing on the complexity and ambiguity involved in analyzing a task [27]. Additionally, task difficulty assesses the level of analyzability and predictability associated with a task, while task variety encompasses the range of diverse tasks that need to be accomplished [28].

This study aims to investigate how task interdependence, task difficulty, and task variety impact the performance of cost estimation. Task interdependence is being explored because cost estimators frequently need to engage in communication and coordination with various stakeholders, both internal and external, to ensure the success of a project [29]. Task difficulty, encompassing aspects such as task equivocality and task analyzability, is being examined as certain cost estimation methods can be challenging to apply, and the construction industry is known for its inherent uncertainty and complexity [8,30]. The study also considers task variety, which shares similarities with task exceptionality, as construction cost estimation involves a broad range of tasks that require diverse skill sets, resources, and approaches to complete a project [31].

Task interdependence is a critical factor that has received significant attention in studies on individual performance [32,33]. On the one hand, Rico [33] suggested that teams utilizing a highly synchronous communication method tend to perform exceptionally well when engaging in tasks with high levels of interdependence. On the other hand, negative interdependence often leads to conflicts among team members, such as competition, resource acquisition, and hindering others' work, which can negatively impact individual performance [32]. It is worth noting that task interdependence can exert both positive and negative influences on individual performance, thereby presenting an excellent opportunity to investigate its effects on cost estimation at the individual level in construction projects. Similarly, previous studies on the relationship between task

variety and individual performance have produced contradictory findings. Zollo [34] demonstrated that task variety positively affects individual performance by facilitating effective knowledge transfer during learning. Nevertheless, Narayanan [35] observed an inverted U-shaped relationship between task variety and individual productivity in offshore software support services. This could be due to an overwhelming amount of task variety that needs to be handled. Moreover, task difficulty in cost estimation is associated with challenges in using estimation methods, project complexity, and resource constraints [6]. Zhao [36] indicated that task difficulty negatively affects the performance of project managers, leading to job dissatisfaction in incomplete green construction projects. Similarly, task variety also has a negative effect on individual performance. Based on arguments on task characteristics, this study hypothesizes as follows:

H_1: Task interdependence is a predictor of cost estimation performance.

H_2: Task difficulty is a predictor of cost estimation performance.

H_3: Task variety is a predictor of cost estimation performance.

2.3 Technology Characteristics

Technology is defined as a tool that assists individuals in performing tasks [37-39]. In the construction industry, technology has significantly improved cost estimation through various tools such as Building Information Modelling (BIM), estimating software, data analytics, machine learning, mobile applications, and drones. These advancements enhance the accuracy, efficiency, and productivity of estimating project costs, thereby aiding decision-making and reducing uncertainties.

Technology is a critical factor in improving individual performance. Several studies have explored the relationship between technology and individual performance, and they have found that technology characteristics positively influence performance [40-42]. This study emphasizes the cost estimation method characteristics, as these methods are common and impactful factors in determining the performance of cost estimation.

Cost estimation methods play a crucial role in assessing the performance of cost estimation in construction projects. These methods consist incorporated technologies such as artificial intelligence, machine learning, deep learning, data analytics, and cloud collaboration [43,44]. Shektar [45] discovered that traditional approaches such as analogy, expert judgment, bottom-up, and top-down are easy to use and understand but lack accuracy and universal applicability. On the other hand, technology-driven approaches like artificial neural networks, fuzzy logic, and constructive cost models are challenging to comprehend and have limited usability, but they offer improved accuracy and applicability. Barakchi [8] identified four key characteristics of cost estimation methods, including usability, applicability, accuracy, and ease of understanding. Therefore, based on this argument, the study proposes the following hypothesis:

H_4: Characteristic of cost estimation methods positively effect on cost estimation performance.

Figure 1 depicts the research model of this study which tests hypotheses that have been proposed regarding the influence of task interdependence, task difficulty and task variety and cost estimation method characteristics on cost estimation performance.

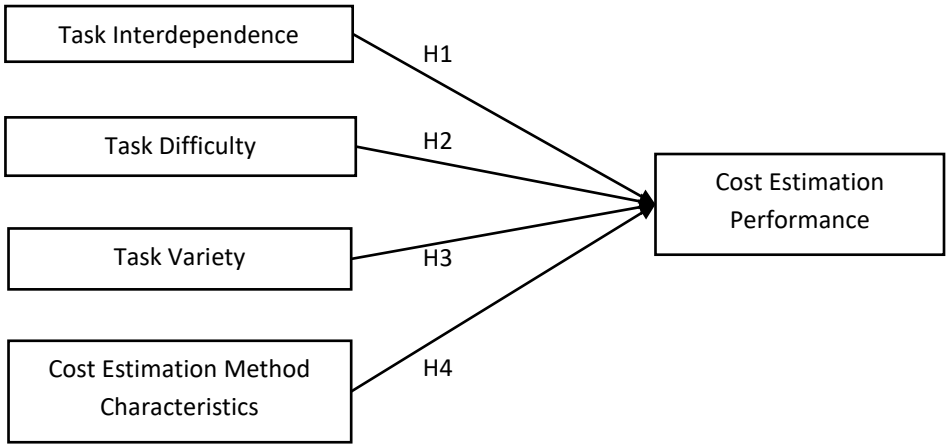

Fig. 1. Research Model

3. Methodology

3.1 Data Collection

In this study, the primary unit of analysis comprised cost estimators actively engaged in estimating costs for construction projects in Malaysia. A 7-point Likert scale was utilized in this paper to evaluate the utilized constructs, with a scale ranging from 'strongly disagree' at one end to 'strongly agree' at the other. The choice of this scale was based on its established effectiveness in accurately capturing the authentic opinions of respondents [46]. The questionnaire within this paper was structured into two sections. The initial section was dedicated to gathering general demographic information, such as gender, age, educational background, job position, work experience, organization type, project type, project details, and similar information. In contrast, the second section focused on the characteristics of tasks and cost estimation methods that influence cost estimation performance within the construction industry. To uphold ethical standards in this study, participants were informed about the survey's content, funding source, research purpose, and the assurance of confidentiality or anonymity before they took part in the actual questionnaire.

The data collection was conducted through paper-based and online surveys over a duration of approximately one month. The questionnaire was disseminated among 350 selected respondents. However, the total number of questionnaires that were collected amounted to only 165, indicating a response rate of 47.1%. Subsequently, during the process of data analysis, it was found that out of the 165 collected questionnaires, only 152 could be considered valid and reliable for analysis. The remaining questionnaires were not included because the respondents lacked any experience in estimating costs, or due to the survey participants provided very similar answers to a series of questions using the same response scale, which could potentially compromise the quality of the data.

3.2 Data Analysis

The collected data were analyzed using SmartPLS 4 software, specifically employing multiple regression analysis. This statistical technique enables the exploration of relationships between multiple independent variables and a dependent variable. Before the analysis, Variance Inflation Factor (VIF) values were computed to assess the presence of collinearity issues among the variables. The structural model was then examined through multiple regression analysis to evaluate

data variance, assess the goodness of fit, and investigate the direct and indirect effects of the independent variables on the dependent variable.

3.3 Measures

To measure the dependent variable, this study adopted five items from Koopmans [47,48], which were originally used to measure task performance. The items assess planning, focus, priority, efficiency, and time management. As for the independent variables, this study adapted task interdependence [49], task difficulty [50] and task variety [51]. Task interdependence consists of 3 items which focus on interrelated level of tasks. Task difficulty was assessed using four items that focus on the time required to complete tasks and any difficulties encountered while performing them. Task variety is measured using three items that focus on different types of tasks. Additionally, this study adopted items from [52] to measure the cost estimation method characteristics, originally measuring system quality. The items assess the ease of use, ease of learning, and effectiveness and efficiency of the results.

4. Results

4.1 Respondent Profiles

Table 1 presents the demographic profiles of the study respondents. The majority of the respondents were male, comprising 52% of the total, while females made up the remaining these respondents 48%. More than half of the respondents were under 30 years old, accounting for 52% of the sample. The proportion of respondents aged between 31 to 40 years old was 30%, while 18% were over 40 years old. The majority of the respondents had achieved a bachelor's degree (86%), with the remainder holding diplomas (4%), master’s degrees (9%) and doctorates (1%). In terms of work experience, most respondents had less than five years of experience (37%), followed by those with six to ten years of experience (25%). 22% of respondents have between 11 and 20 years of experience, while 16% have over 20 years of experience. The respondents were classified into three types of construction firms, with 16%, 63% and 21% being developers, consultants and contractors respectively. Out of all the contractors, 5% belonged to the low-grade contractors (G1, G2 & G3), 8% were categorized as mid-grade contractors (G4 & G5) and 9% were considered high-grade contractors (G6 & G7).

Table 1 also displays information about the types of projects that the respondents were involved in. The majority of the respondents, accounting for 61%, were involved in private projects. Only 10% of respondents performed cost estimations for public-private partnership (PPP) projects, and 29% were involved in public projects. The respondents were involved in various types of projects, with mixed residential and commercial projects being the most common, accounting for 46% of respondents. Residential and infrastructure projects accounted for 20% each while commercial and industrial projects represented the lowest percentage, with 5% and 8% respectively.

Table 1
Demographic profile of respondents

Demographic Information		Frequency	Percentage
Gender	Male	79	52%
	Female	73	48%
Age	Under 20 years old	2	1%
	21-25 years	35	23%
	26-30 years	42	28%
	31-35 years	25	16%
	36-40 years	21	14%
	41-45 years	3	2%
	46-50 years	4	3%
	51-55 years	12	8%
	56 years or above	8	5%
Education	Diploma	6	4%
	Bachelor's Degree	130	86%
	Master's Degree	14	9%
	Doctorate Degree	2	1%
Working Experience	1-5 years	56	37%
	6-10 years	38	25%
	11-15 years	32	21%
	16-20 years	2	1%
	21-25 years	9	6%
	26-30 years	2	1%
	31-35 years	10	7%
	37 years or above	3	2%
Position	Quantity Surveyor	135	89%
	Cost Estimator	2	1%
	Project Manager	6	4%
	Contract Manager	4	3%
	Engineer	3	2%
Company Firm	Client	2	1%
	Developer	25	16%
	Consultant	95	63%
	Contractor	32	21%
Contractor' Grade	Grade 1 (G1)	1	1%
	Grade 2 (G2)	3	2%
	Grade 3 (G3)	3	2%
	Grade 4 (G4)	6	4%
	Grade 5 (G5)	6	4%
	Grade 6 (G6)	6	4%
	Grade 7 (G7)	7	5%
Sector Type	Public	44	29%
	Private	93	61%
	Public Private Partnership (PPP)	15	10%
Project Type	Residential Construction	31	20%
	Infrastructure Construction	31	20%
	Industrial Construction	12	8%
	Commercial Construction	8	5%
	Mixed Residential and Commercial Construction	70	46%

4.2 Collinearity

Collinearity refers to a situation where two predictors or independent variables exhibit a high correlation with each other. According to Daoud [53], the VIF can be used to assess the level of correlation between variables. A VIF value of 1 indicates no correlation between the variables. Variables are considered moderately correlated when the VIF values range between 1 and 5. However, if the VIF exceeds 5, it suggests a high correlation between the variables, indicating collinearity issues.

In this study, the VIF values for each predictor are presented in Table 2. It is important to note that none of the VIF values exceed the threshold for collinearity. Therefore, it can be concluded that there are no collinearity issues in the model.

Table 2
Collinearity using VIF

Constructs	VIF
TAV	1.774
TAI	1.378
TAD	2.066
CEM	1.229

Note: TAI: Task interdependence, TAD: Task difficulty, TAV: Task variety,
CEM: Cost estimation methods characteristic, CEP: Cost estimation performance

4.3 Regression Analysis

Table 3 presents the values of R^2, adjusted R^2, and the F-test for the regression analysis of the research model in this study. R^2 represents the percentage of the dependent variable's variance explained by the independent variables, while adjusted R^2 denotes the improved R^2 value that adjusts when a new predictor is introduced, enhancing the model's predictive power. Thus, it is a suitable measure to assess the goodness of fit of the model. In this study, the predictors, namely task interdependence, task variety, task difficulty, and characteristics of cost estimation methods, account for 34.3% of the variances in cost estimation performance. The adjusted R^2, measuring the model's goodness of fit, is calculated at 32.5%.

Additionally, the F-test of overall significance compares the proposed regression model to a model without any independent variables. The result indicates that our model is a better fit compared to the model without predictors. The F-test value in this study supports the claim that the proposed research model provides a superior fit compared to the model with no independent variables.

Table 3
Overall model of regression analysis

Criteria	Values
R^2	0.343
Adjusted R^2	0.325
F-test	19.166

The results of the multiple regression analysis are summarized in Table 4. The table reveals that out of the four hypotheses tested, only two hypotheses demonstrate significant findings. These hypotheses investigate the association between (1) task interdependence and cost estimation performance (β = -0.171, t = 2.179, p = 0.031), and (2) the characteristics of cost

estimation methods and cost estimation performance (β = 0.599, t = 8.073, p = 0.000). The analysis indicates that an increase in task interdependence is linked to a decrease in cost estimation performance. Furthermore, the results demonstrate a positive relationship between the characteristics of cost estimation methods and cost estimation performance.

Table 4
Regression analysis and hypotheses decision

Hypothesis		Coefficient, β	t-value	p-value	Decision
H_1	TAI → CEP	-0.171	2.179	0.031*	Supported
H_2	TAD → CEP	0.107	1.118	0.266	Not Supported
H_3	TAV → CEP	-0.080	0.900	0.370	Not Supported
H_4	CEM → CEP	0.599	8.073	0.000*	Supported

Note: *p-value < 0.05; TAI: Task interdependence, TAD: Task difficulty, TAV: Task variety, CEM: Cost estimation methods characteristic, CEP: Cost estimation performance.

5. Discussion

5.1 Discussion of Findings

This study examines the impact of cost estimation method characteristics and task characteristics, specifically interdependence, difficulty, and variety levels, on cost estimation performance. The findings revealed significant relationships between the independent and dependent variables.

The findings support H_1, indicating that task interdependence has a negative impact on cost estimation performance. This result aligns with a prior study from De Dreu [54]. However, it is worth noting that there are conflicting findings in the literature 1/10/2024 12:54:00 PM. Task interdependence can be categorized into two types: negative interdependence and positive interdependence. In this study, since task interdependence negatively affects cost estimation performance, it falls under the negative interdependence category. According to Deutsch [32], negative interdependence often leads to conflicts among team members, including competition, resource acquisition, and obstruction of others' work, which can have a detrimental effect on individual performance. Task interdependence also contributes to various types of conflicts, such as relationship conflicts, procedural conflicts, and cognitive conflicts, depending on the characteristics of task interdependence [55]. These conflicts may hinder job performance, particularly in tasks involving high levels of interdependence, such as cost estimation in construction projects.

The positive impact of cost estimation method characteristics on cost estimation performance is supported by the findings of H_4. This aligns with prior research indicating that cost estimation methods characterized by high usability, applicability, accuracy, and ease of understanding enhance employee job performance [45,56]. To improve the performance of cost estimators in construction projects, it is crucial to enhance the usability, applicability, accuracy, and ease of understanding of cost estimation methods. User-friendly interfaces and intuitive workflows simplify the estimation process, enabling estimators to concentrate on data analysis instead of struggling with the complexities of the tool. Ensuring the applicability of the methods enables estimators to align estimated costs with the specific needs and characteristics of the construction project. This alignment improves the accuracy and reliability of the cost estimates, facilitating effective project planning, budgeting, and decision-making. Moreover, employing accurate estimation methods refined through historical data and advanced techniques further enhances reliability. Lastly, ease of understanding empowers estimators to comprehend and communicate the results effectively, validating estimates and making informed adjustments. By incorporating these enhancements, cost

estimators can significantly contribute to better decision-making and budget control in construction projects, ultimately leading to improved project outcomes.

5.2 Theoretical and Practical Implications

The findings of this study have significant theoretical and practical implications. Firstly, it enhances our understanding of how task characteristics, specifically task types, affect cost estimation performance. Previous literature has identified task characteristics as a factor influencing cost estimation performance, focusing primarily on magnitude, timing, and interference level [6]. Therefore, this study provides new insights into the field of cost estimation, particularly in construction projects, by examining task characteristics from different perspectives. Secondly, this study represents one of the pioneering attempts to explore deeply the impact of cost estimation method characteristics on cost estimation performance. While prior studies in cost estimation methods have primarily emphasized improving accuracy through various approaches [8], recent research has increasingly focused on investigating the performance of cost estimation using emerging technologies like artificial intelligence and machine learning [43]. This study addresses the gap in research concerning the effectiveness of method characteristics and their influence on cost estimation performance.

From a practical standpoint, this research holds significant implications for cost estimators and project leaders seeking to enhance their cost estimation performance. Firstly, managers should foster a positive working environment and cultivate a culture of collaboration among cost estimators and external parties such as clients, consultants, contractors, and architects. Given the inherent interdependencies in construction projects, a positive organizational culture can mitigate the negative impact of task interdependencies on cost estimation by reducing narcissism among estimators. Secondly, managers should utilize cost estimation methods that offer high usability, applicability, accuracy, and ease of understanding within their organizations. While it may be challenging to find methods that possess all these characteristics, managers should be able to compromise and select the most suitable methods based on project requirements and organizational objectives. Employing such methods enables cost estimators to enhance their performance in estimating costs effectively. This study contributes both theoretically and practically to the field of cost estimation by shedding light on the influence of task characteristics and cost estimation method characteristics. The insights gained from this research can guide decision-making and improve cost estimation practices in various contexts.

5.3 Limitations and Future Research

This study has several limitations and suggests various future research directions for scholars in the field of cost estimation. Firstly, the data used in the multiple regression analysis is not normally distributed and exhibits a low value of R^2. Consequently, the predictive power of the findings in this study is weak [57]. To enhance the quality of the findings, it is crucial to employ a structural equation model (SEM) to ascertain the influence of independent variables on the dependent variable. SEM proves particularly useful as it can accommodate small sample sizes and non-normally distributed data [58].

Secondly, the variable representing cost estimation methods used in this study reflects the general characteristics of such methods. Consequently, it becomes challenging to determine which methods are effective and efficient in enhancing cost estimation performance. To address this issue, it would be beneficial to treat cost estimation methods as categorical data for future

research. Further investigation can then focus on exploring the unique characteristics of each cost estimation method.

Thirdly, this study solely concentrates on the direct impact of task characteristics and cost estimation method characteristics on cost estimation performance. It is important to understand how each task characteristic interacts with cost estimation methods. Therefore, this study recommends future research that investigates the interaction between task characteristics and cost estimation methods. Additionally, it is suggested that further research adopts the task-technology fit theory to determine the effectiveness of aligning task characteristics and cost estimation method characteristics on cost estimation performance.

4. Conclusions

As the performance of cost estimation is a significant factor that contributes to project success, especially in the construction industry, it is crucial to understand how task characteristics and cost estimation methods impact the performance of cost estimators. Through testing of proposed hypotheses, this study has revealed that task interdependence has a significantly negative impact on cost estimation performance, while cost estimation method characteristics have a significantly positive effect.

Therefore, managers in estimation consulting firms must be aware of the influence of task characteristics and cost estimation method characteristics on cost estimator's performance to improve the overall project performance. This paper suggests that providing job training to cost estimators on how to effectively and efficiently use cost estimation methods can improve their capabilities, especially when using challenging methods with high accuracy. Such training can help achieve the best estimation performance in the industry.

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