COST ESTIMATION PERFORMANCE IN THE CONSTRUCTION PROJECTS: A SYSTEMATIC REVIEW AND FUTURE DIRECTIONS

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ABSTRACT – Cost estimation in a construction project is very critical to avoid cost overrun in the project. This paper aims to provide a basis to improve cost estimation performance in construction through a systematic review of previous studies for the last 31 years. The papers identified a total of 238 construction cost estimation papers in 23 journals. Only 33 papers focused on factors influencing the performance of cost estimation. These papers were then analyzed, synthesized, and summarized in terms of the distribution across countries and citation influences. The factors of cost estimation performance were clustered into several themes with most of the factors in control themes. The factors in control themes are clutered based on Organizational Control Theory (OCT). However, control themes provide less conceptual basis and dynamic to explain cost estimation performance and relationship among the factors. Therefore, this study reclassified other factors of cost estimation performance with reference to Contingency Theory (CT) and Task-Technology Fit Theory (TTFT). Hence, a new framework with a relationship among the factors and cost estimation performance was developed. Further development and research of using the CT and TTFT frameworks were also discussed.

INTRODUCTION

The growing importance of construction projects in recent years toward economic and social perspectives has significantly improved cost estimation progress. For several decades, many researchers have explored the knowledge area of project performance. Nevertheless, the construction projects still comprise a high risk to be unsuccessful. The project experience in time overrun is a frequent cause of difficulty in construction projects in developing countries (Aziz, 2013; Mahdi & Soliman, 2021). Malaysia also experiences time overrun in construction projects, with 80% of the project have an unnecessary delay in completion (Shehu et al., 2014). Poor cost estimate performance has caused project failure (Project Management Institute, 2018). Therefore, cost estimation is one of the primary factors in avoiding project failures such as cost and schedule overruns in construction projects.

Furthermore, the problem of inaccurate cost estimation has rarely been explored and investigated by researchers. Thus, it is critical to conduct a systematic review of previously published articles regarding cost estimation in construction projects. It will help researchers to understand the status and research trends of the topic for future research and help practitioners achieve project success.

The majority of cost estimation research discussed various cost estimation methods such as fuzzy expert system, cost estimation under uncertainty, building information modelling (BIM) software programs, structural equation method (SEM), expert's judgment, Monte Carlo simulation, historical data, case-based reasoning (CBR), artificial neural networks (ANNs), parametric, and unit cost (Barakchi et al., 2017).

In recent years, there were probably only three articles reviewed systematically within the area of cost estimation in the construction industry published in academic journals (Barakchi et al., 2017; Membah & Asa, 2015; Tayefeh Hashemi et al., 2020). However, these systematic reviews were conducted based on different research objectives. Membah & Asa (2015) review emphasized factors that contribute to cost underestimation and risks in cost estimation. Barakchi et al. (2017) focused on cost estimation methods. The review from Hashemi et al. (2020) focused on the cost estimation method, especially in machine learning techniques. Most past researchers rarely investigated the research trend of cost estimation in construction projects, especially regarding cost estimation performance factors. Hence, this study is vital due to the low amount of existing research on this perspective.

This systematic review extended the literature search to other related journals and aimed to address the following questions:

1. How did the general research trends on factors that influence the cost estimation of construction projects? (Timespan Overall, Overall Journal Shares, Distribution Across Countries)
2. What were the factors that influenced cost estimation performances in construction projects?
3. What are the future research directions on cost estimation and use based on the results obtained from research questions 1 and 2 above?

This paper's remaining parts begin with the “Research Methodology” section, which describes the systematic review methodology. In the “Result” section, the findings are included, and the importance of the results are critically discussed. Lastly, the “Conclusion and Recommendations” section describes the conclusion and provides recommendations for future research.

RESEARCH METHODOLOGY

Research questions 1 and 2 have been responded through systematic review processes including summarizing, synthesizing, and interpreting previous literature. The systematic review process is shown in Figure 1 by integrating the review processes proposed by Siddaway et al. (2019) and Lee et al. (2016).

![Figure 1. Steps of the systematic review](image-url)

The systematic review was initiated by framing research questions and checking the previous reviews' similarity with the planned review in Step 1: Scoping (Siddaway et al., 2019). The research questions should have relationships or connections with the research topics to assist the researcher’s tasks by making them more straightforward. Therefore, the tasks can be completed faster and easier (Siddaway et al., 2019). In Step 2: Planning, the individual concepts in the research questions were divided to create search terms purposely to identify the most potential papers. Moreover, different terminologies were included such as synonym and plural forms, to identify all relevant papers.

Additionally, preliminary inclusion and exclusion criteria were formulated and justified to find suitable papers easier (Siddaway et al., 2019). Next, appropriate databases and journals were identified to focus the search on the relevant domain in Step 3: Identification. The preliminary search was performed by using the predefined search terms into selected databases and journals with the findings focus on Title, Keywords, and Abstract. The utilisation of Boolean, wildcard and
truncation symbol while performing the search tasks are advisable to reduce massive time consumption (Siddaway et al., 2019). Nevertheless, not all the search engine of databases has them. Furthermore, the search results were carefully inspected, and additional examinations were performed to ensure the results include important or critical studies. After that, the search results' references were exported to the citation manager and the title and abstract were read to determine whether the papers are related to the research questions in Step 4: Screening (Siddaway et al., 2019). Next, in Step 5 Eligibility, the relevant information from the eligible papers was extracted into tabulation form. It is essential to extract information from the full-text version, which relates to the research questions (Siddaway et al., 2019). In Step 6: Summarizing, the information of the eligible papers were synthesized and summarized according to the characteristic, quality and effect of the papers (Lee et al., 2016). As for the final step, Step 7: Interpreting, the obtained results were interpreted to develop the recommendation from the evidence of the potency and limitation (Lee et al., 2016).

Research question 3 has been responded by synthesizing the factors influencing the accuracy and performance of cost estimation in construction projects and interpreting the topic's research trend. The systematic review's weaknesses and limitations provide the future research direction and research gap of the topic.

RESULT

Scoping

In scoping stage, various vital issues must be well-thought-out. The review's research questions were developed according to the research topic and researcher interests purposely for a clear and comprehensive review (Siddaway et al., 2019). The research or framing questions for this paper are stated below:

1. How did the general research trends on cost estimation of construction projects? (Timespan Overall, Overall Journal Shares, Research Topics)
2. What were the factors that influenced cost estimation performances in construction projects?
3. What are future research directions on cost estimation and use based on the results obtained from research questions 1 and 2 above?

Moreover, other systematic reviews were searched to clarify the similarity of the review. From the search, Barakchi et al. (2017), Hashemi et al. (2020) and Membah & Asa (2015) published systematic reviews in construction projects. However, this systematic review differs from previous reviews (Barakchi et al., 2017; Membah & Asa, 2015; Tayefeh Hashemi et al., 2020) because this review has different objectives and using different databases. While all the reviews have an objective to support and improve cost estimation research, each review explored different approaches. Membah & Asa (2015) focused on factors contributing to cost underestimation and risks in cost estimation. At the same time, Barakchi et al. (2017) and Hashemi et al. (2020) emphasized cost estimation methods. The main objective of this review is to determine the factor of cost estimation accuracy and performance. Membah and Asa (2015) used the Society of Civil Engineers (ASCE), Web of Science (WOS), Science Direct (SD), the Association for Advancement of Cost Engineering (AACE) International, and the Royal Institution of Chartered Surveyors (RICS). Additional databases were the Transportation Research Board (TRB) and Google as searching databases. Meanwhile, Barakchi et al. (2017) used Scopus and Web of Sciences, and Hashemi et al. (2020) utilized Science Direct (SD) and Google Scholar. However, this review performed the search process through Taylor Francis Group, Emerald Insight, Science Direct (SD), Wiley Online Publisher, as well as professional institutions such as the American Society of Civil Engineers (ASCE), the International Project Management Association (IPMA), and Project Management Institute (PMI).

Planning

The planning stage is essential to ensure that all related articles were identified. Based on the research questions “What are the factors that affect the accuracy of cost estimation in construction projects?” the search terms were obtained, and more search terms were developed to ensure all relevant studies were included in the review. The keywords used in the preliminary search were shown as below:

“Cost Estimate”, “Cost Estimates”, “Cost Estimated”, “Cost Estimation”, “Cost Estimating”, “Cost Forecast”, “Cost Forecasts”, “Cost Forecasted”, “Cost Forecasting”, “Cost Predict”, “Cost Predicts”, “Cost Predicted”, “Cost Predicting”, “Cost Escalate”, “Cost Escalation”, “Cost Escalating”, “Cost Underestimate”, “Cost Overestimate”, and “Cost Overrun”.

As the review focuses on the construction projects, the journals and databases' selection emphasize building, built environment, project management, and construction according to each database.

Searching

The extensive and comprehensive literature searching was performed in a searching stage. The systematic review was performed by searching multiple databases such as Science Direct (SD), Taylor Francis Group, Emerald Insight, Wiley Online Publisher, including professional institutions such as American Society of Civil Engineers (ASCE), International Project Management Association (IPMA), and Project Management Institute (PMI). The preliminary search was performed using keywords in the Planning stages within the domain of Title or Keywords or Abstract with no restriction enforced in the date range. A total of 3176 articles were identified after the preliminary search.
The Science Direct database was reviewed, and two journals were selected, specifically Automation of Construction and International Journal of Project Management. In Wiley Online Publisher, only Project Management Journal was selected.

Furthermore, the subject of ‘Building and Construction’ was selected during the process of reviewing Emerald Insight. The selection of the subject is essential to include the papers in construction projects. The journals selected were Built Environment Project and Asset Management, Construction Innovation, Engineering, Construction and Architectural Management, Journal of Engineering, Design and Technology, and Journal of Financial Management of Property and Construction.

For the Taylor Francis Group, several journals were selected under the ‘Build Environment’ subject area to identify the potential papers. The journals in this database, namely as Transportation Planning and Technology, Transport Reviews, Structure and Infrastructure Engineering, Journal of the American Planning Association, Journal of Civil Engineering and Management, International Journal of Construction Management, International Journal of Construction Education and Research, International Journal of Management Science and Engineering Management, Construction Management and Economics, Building Research & Information, and Architectural Science Review.

Under the American Society of Civil Engineering (ASCE), the journal selected were Journal of Management in Engineering, Journal of Infrastructure Systems, Journal of Construction Engineering and Management, and Journal of Computing in Civil Engineering.

As a result, the number of journals involved in this systematic review was 23. From the selected journals, Construction Management and Economics, Journal of Construction Engineering and Management, Construction and Architectural Management, Journal of Management in Engineering, Engineering, International Journal of Project Management, Automation of Construction and Building Research & Information were within the top 10 in the ranking of construction management journals (Wing, 1997). The selection of these journals improved the quality and impact of the result in this review paper.

**Screening**

In the screening stage, the search results from the previous stage have been assessed for prospective papers. This process requires visual examination of all 2344 articles to filter out non-scholarly papers such as “introduction”, “editorial”, “book review”, “discussions and closures”, “letter to the editorial”, “article in press”, and “announcement”. Accordingly, articles that were under these broad categories were filtered and excluded from detailed analysis. However, articles such as “Forum”, “Case studies”, “Features”, and “Scholarly Paper” were maintained. Moreover, the title or abstract of the papers were read to identify articles that have potential. In the screening process, 238 articles were identified to have potential from 23 journals related to cost estimation in the construction industry as shown in Error! Reference source not found..
Table 1. Total articles after searching and screening processes.

| No | Journals | Databases                  | Searching Process | Screening Process |
|----|----------|----------------------------|-------------------|-------------------|
| 1  | Automation of Construction | Science Direct    | 50                | 19                |
| 2  | International Journal of Project Management | Wiley Online Publisher | 96                | 28                |
| 3  | Project Management Journal | Wiley Online Publisher | 48                | 5                 |
| 4  | Built Environment Project and Asset Management | Construction Innovation | 10                | 6                 |
| 5  | Construction and Architectural Management | Emerald Insight    | 15                | 1                 |
| 6  | Engineering, Construction and Architectural Management | Wiley Online Publisher | 20                | 13                |
| 7  | Journal of Engineering, Design and Technology | Science Direct    | 10                | 2                 |
| 8  | Journal of Civil Engineering and Management | Science Direct    | 23                | 11                |
| 9  | Transportation Planning and Technology | Science Direct    | 58                | 3                 |
| 10 | Transport Reviews | Science Direct    | 50                | 2                 |
| 11 | Structure and Infrastructure Engineering | Science Direct    | 39                | 2                 |
| 12 | Journal of the American Planning Association | Science Direct    | 80                | 10                |
| 13 | Journal of Civil Engineering and Management | Science Direct    | 183               | 14                |
| 14 | International Journal of Construction Management | Taylor Francis Group | 44                | 1                 |
| 15 | International Journal of Construction Education and Research | Taylor Francis Group | 6                | 3                 |
| 16 | International Journal of Management Science and Engineering Management | Science Direct    | 368               | 32                |
| 17 | Construction Management and Economics | Science Direct    | 59                | 4                 |
| 18 | Building Research & Information | Science Direct    | 29                | 2                 |
| 19 | Architectural Science Review | Science Direct    | 265               | 12                |
| 20 | Journal of Management in Engineering | America Society of Civil Engineering (ASCE) | 80                | 4                 |
| 21 | Journal of Infrastructure Systems | Science Direct    | 671               | 56                |
| 22 | Journal of Construction Engineering and Management | Science Direct    | 116               | 7                 |
| 23 | Journal of Computing in Civil Engineering | Science Direct    | 2344              | 238               |

Eligibility

In this step, the screening process articles were subjected to a further eligibility process to assess the quality. This process requires a visual examination of all 238 articles to achieve significant articles related to this research topic. After the eligibility process, the numbers of articles were reduced to 33, with details shown in Error! Reference source not found..
Table 2. Total articles after screening and eligibility process

| No | Journals                                      | Databases                     | Screeni | Eligibilit |
|----|----------------------------------------------|--------------------------------|---------|------------|
|    |                                              |                                | Process| y Process  |
| 1  | Automation of Construction                   | Science Direct                 | 19      | 0          |
| 2  | International Journal of Project Management  |                                  | 28      | 4          |
| 3  | Project Management Journal                   | Wiley Online Publisher         | 5       | 0          |
| 4  | Built Environment Project and Asset Management|                                 | 6       | 2          |
| 5  | Construction Innovation                      |                                | 1       | 0          |
| 6  | Engineering, Construction and Architectural Management | Emerald Insight                 | 13      | 3          |
| 7  | Journal of Engineering, Design and Technology |                                | 2       | 1          |
| 8  | Journal of Financial Management of Property and Construction Transportation Planning and Technology |                                | 11      | 4          |
| 9  | Transport Reviews                            |                                | 1       | 0          |
| 10 | Structure and Infrastructure Engineering     |                                | 3       | 0          |
| 11 | Journal of the American Planning Association |                                | 2       | 0          |
| 12 | Journal of Civil Engineering and Management  |                                | 2       | 2          |
| 13 | International Journal of Construction Management | Taylor Francis Group            | 10      | 0          |
| 14 | International Journal of Construction Education and Research |                                | 14      | 2          |
| 15 | International Journal of Management Science and Engineering Management Construction Management and Economics | America Society of Civil Engineering (ASCE) | 32      | 10         |
| 16 | Building Research & Information              |                                | 4       | 0          |
| 17 | Architectural Science Review                 |                                | 2       | 0          |
| 18 | Journal of Management in Engineering         |                                | 12      | 1          |
| 19 | Journal of Infrastructure Systems            |                                | 4       | 0          |
| 20 | Journal of Construction Engineering and Management |                                | 56      | 3          |
| 21 | Journal of Computing in Civil Engineering    |                                | 7       | 0          |
| 22 |                                            |                                | 238     | 33         |

Summarizing

The summarising step focuses on analyzing and synthesizing the papers selected in the eligibility stage to derive a theoretical explanation of the factors that influence cost estimation performance. The analysis process was qualitative and was interpreted attentively. The shortlisted articles were carefully organized and classified into the research focus and theme appropriately. The synthesized theme was cost estimation performance, practices of cost estimation performance, and cost estimation methods used to improve cost estimation performance. The summary and trend of the 33 shortlisted articles were further discussed in the form of Overall Time Span (Figure 2), Overall Journal Shares (Figure 3), and Distribution across Countries (Figure 4).

Overall time span

The tabulation of the factors of cost estimation performance-related papers was shown in Figure 2. The paper has been published since 1989 with only one article and continued to increase in 1991 (2 papers) and 1994 (3 papers). After that, the number of published papers decreased in 2000, 2001 and 2002. In 2005, the selected papers published were found to
be the highest with five papers, and the related papers started to decrease in 2006 with one paper. From 2006 to 2020, the number of papers fluctuated between one and two papers. The overall trend indicated a constant low of published articles about factors of cost estimation performance after 2005.

**Figure 2.** Tabulation of 33 articles published between 1989-2020

### Overall journal shares

In Figure 3, the 33 papers were categorized according to their journal respectively. Construction Management and Economics published the highest number of papers (10 papers), followed by Journal of Financial Management of Property and Construction (4 papers) and International Journal of Project Management (4 papers). Despite that, the three journals that published the least factors of cost estimation performance-related papers were Journal of Management in Engineering (1 paper), Journal of Engineering, Design and Technology (1 paper) and International Journal of Management Science and Engineering Management (1 paper).

**Figure 3.** The journal shares 33 selected papers
Distribution across countries percentage

The papers about factors of cost estimation performance varied across countries which were shown in Figure 4. The country that has the highest number of the selected papers was U.K. (10 papers, 32%), followed by U.S.A. (4 papers, 13%), and Australia (4 papers, 13%). Countries like Saudi Arabia and Malaysia have the lowest number of articles published which were one paper respectively.

Interpreting

In this stage, the extracted 33 articles related to cost estimation performance were synthesized and categorized in dimensions such as input control, behavior control, output control, project complexity, task characteristic, and technology characteristic. The future research direction on cost estimation performance is determined by using the evidence's strengths and weaknesses.

DISCUSSION

Finding of the systematic review

This paper evaluates construction cost estimation articles published in journals and helps support other construction cost estimation researchers through a classification of cost estimation performance’s factors to new shared dimensions and future research direction on construction cost estimation based on organization control theory (OCT), contingency theory (C.T.) and task-technology fit theory (TTFT).

Firstly, some factors of cost estimation performance were clustered into control dimensions which are input control, behavior control and output control based on OCT. Other factors were clustered into task characteristic and technology characteristic, according to TTFT. Project complexity was the last dimension in which the most factors were clustered. The factors of cost estimation performance were summarized and clustered into shared dimensions which are shown in Table 3.

| Shared Dimensions | Factors | Authors |
|-------------------|---------|---------|
| Input Control     | Project Information | Aibinu & Pasco (2008), Akintoye (2000), Akintoye & Fitzgerald (2000), Al-Harbi et al. (1994), Chan & Park (2005), Doloj (2013), Enshassi et al. (2005), Hatamleh et al. (2018), Jing et al. (2019) |
| Cost Information  |         | Agyekum-Mensah (2018), Aibinu & Pasco (2008), Akinradewo et al. (2020), Akintoye (2000), Akintoye & Fitzgerald (2000), Carr (1989), Chan & Park (2005), Flyvbjerg et |

Table 3: Overall summary of cost estimation performance factors
| Shared Dimensions | Factors | Authors |
|-------------------|---------|---------|
| Team Experience   | Agyekum-Mensah (2018), Akinradewo et al. (2020), Akintoye (2000), Akintoye & Fitzgerald (2000), Al-Harbi et al. (1994), Carr (1989), Chan & Park (2005), Dandan et al. (2019), Dulaimi & Shan (2002), Elhag et al. (2005), Flyvbjerg et al. (2002), Grau et al. (2017), Hatamleh et al. (2018), Islam et al. (2019), Jing et al. (2019), Leung et al. (2005), Lowe & Skitmore (1994), Mahamid (2015), Ogunlana (1991), Trost & Oberlender (2003) |
| Behavior Control  | Estimation Design | Akinradewo et al. (2020), Akintoye (2000), Akintoye & Fitzgerald (2000), Al-Harbi et al. (1994), Elhag et al. (2005), Enshassi et al. (2005), Islam et al. (2019), Morrison (2006), Soutos & Lowe (2011), Uher (1996) |
|                   | Estimation Process | Aibinu & Pasco (2008), Akinradewo et al. (2020), Akintoye (2000), Al-Harbi et al. (1994), Dandan et al. (2019), Grau et al., (2017), Hatamleh et al. (2018), Oberlender & Trost (2001) |
|                   | Resources Integration | Akinradewo et al. (2020), Akinradewo et al. (2020), Akintoye & Fitzgerald (2000), Al-Harbi et al. (1994), Chan & Park (2005), Dulaimi & Shan (2002), Grau et al. (2017), Mahamid (2015) Oberlender & Trost (2001) |
| Output Control    | Review and Acceptance of a review | Aibinu & Pasco (2008), Akinradewo et al. (2020), Akintoye & Fitzgerald (2000), Grau et al. (2017) |
|                   | Benchmarking and Expected accuracy level | Aibinu & Pasco (2008), Akinradewo et al. (2020), Flyvbjerg et al. (2005) |
|                   | Task Characteristic | Variation in Task (magnitude, timing, interference level) | Agyekum-Mensah (2018), Akintoye (2000), Chan & Park (2005), Dandan et al. (2019), Enshassi et al. (2005) |
|                   | Technology Characteristic | Cost estimation methods used | Agyekum-Mensah (2018), Akintoye (2000), Chan & Park (2005) Dandan et al. (2019) |
|                   | Project Complexity | Project Risk & Uncertainty | Agyekum-Mensah (2018), Aibinu & Pasco (2008), Lim et al. (2016), Oberlender & Trost (2001), Sridarran et al. (2017), Tah et al. (1994), Uher (1996) |
|                   | Project Size | Akinradewo et al. (2020), Arif et al. (2015), Jørgensen et al. (2012) Sridarran et al. (2017) |
|                   | The environment of changing policy and regulation | Akintoye & Fitzgerald (2000), Al-Harbi et al. (1994), Doloji (2011), Dulaimi & Shan (2002), Enshassi et al. (2005), Flyvbjerg et al. (2002), Mahamid (2015), Oberlender & Trost (2001), Sridarran et al. (2017) |
|                   | The environment of changing economy | Agyekum-Mensah (2018), Aibinu & Pasco (2008), Akinradewo et al. (2020), Akinradewo et al. (2020), Al-Harbi et al. (1994), Carr (1989), Dandan et al. (2019), Doloji (2011), Dulaimi & Shan (2002), Elhag et al. (2005), Flyvbjerg et al. (2005), Hatamleh et al. (2018), Mahamid (2015), Sridarran et al. (2017) |
According to the systematic review, the factors were clustered into six main themes: input control, behavior control, output control, project complexity, task characteristic, and technology characteristic. Each of the themes is discussed below for a better understanding of the attribute of the themes.

**Input Control**

Input control is defined as the people resource-related factors that influence performance specifically the knowledge, skills, abilities, values, and motives of employees (Snell, 1992). In this paper, input control not only regulates input related factors in the perspective of human but also information into transformation processes. From the systematic review, the input control relates to the experience of estimators, project team and stakeholders, project information such as project scope and specification, and cost information in term of historical data of similar project and material price. These input factors may be gained through mechanisms by selecting the proper people and improving data quality. Previous studies frequently involved input control with motives, skills, abilities, and experience of employees (Snell, 1992). Keltner and Finegold (1996) considered input control as direction setting, selection of criteria for staffs and promotion. Liu and Zhu (2007) involved information special cost and project information in his input control dimension.

**Behavior Control**

Behavior Control is defined when a leader demands certain behaviors, explicit procedures, or rules for the controlee, and the performance of the controlees are monitored and evaluated according to specified behaviors or procedures (Turner & Makhija, 2006). In other words, behavior control focuses on securing proper behavior, which provides the targeted results. After the processes of systematic review, behavior control includes time given in completing estimation, estimation design, estimation processes, and resource integration among stakeholders. Sihag and Rijsdijk (2019) utilized a detailed procedure of techniques as a mechanism of behavior control if it articulates the precise steps to follow to improve individual performance.

**Output Control**

Output Control is referred to performance outputs, standards or goals, and the performance of the controlees are monitored and evaluated according to those outputs or goals (Kirsch et al., 2004). In other words, output control specifies the targeted outputs or objectives, if people with the target will adopt proper behavior to achieve them. After the review processes, output control involves expected estimation accuracy, acceptance of review and benchmarking. Liu and Zhu (2007) considered expected accuracy level, review and acceptance of estimate and benchmarking in his output control dimension.

**Task Characteristic**

Tasks are indicated by the totality of physical and cognitive actions and processes done by individuals in a given environment (Spies et al., 2020). Task characteristic is defined as a feature of entire physical or cognitive actions and processes performed by individuals in a certain environment (Goodhue & Thompson, 1995). Task characteristic theme covers the type of tasks in cost estimation such as repeated task, special requirement task and variation of magnitude,
timing, interference in tasks. In cost estimation, many technologies are used in order to estimate task completion with ease.

**Technology Characteristic**

Technology refers to a tool that is used to perform or assist in performing the given tasks by individuals (Goodhue & Thompson, 1995). The technology characteristics are aligned with task characteristic discussion which have various definition according to the researcher with concern to the surrounding where it utilized and the tasks that required its assistance (Spies et al., 2020). The theme or dimension of technology characteristic involves the characteristic of cost estimation methods that are utilized in completing estimating tasks.

**Project complexity**

Project complexity is defined as a group of problems contain a multitude of possible interrelations which associate with a high consequence in the decision-making process that come out with the outcome (Girmscheid, C., & Brockmann, 2008). From the finding of the systematic review, the project complexity dimension covers many factors of cost estimation performance especially project-related factors such as project risk, project uncertainty, project contingency, and project size. Furthermore, the dimension also consists of external related factors such as political situation, economic condition, market condition, external stakeholder (contractors and consultant), and complexity in contractual related factors. Luo et al. (2017) utilized information complexity, task complexity, technology complexity, organizational complexity, environmental complexity, and goal complexity as factors to project complexity construct. Yang and Cheng (2021) applied project complexity as a moderator for the relationship between relational governance and opportunism and project performance. In this study, the project complexity was influenced by project uncertainty, technical level, and the number of outsourcers and stakeholders.

**Predominately Used Theories**

In this paper, theories such as Organizational Control Theory (OCT), Contingency Theory (CT) and Task-Technology Fit Theory (TTFT) were utilized and adopted in developing a new framework towards cost estimation performance. These theories were used to classify the factors of cost estimation performance and describe the relationships among the factors including the relationship with cost estimation performance.

TTFT indicates that information technology (IT) has a high probability to give a positive impact on individual performance and can be used if the capabilities of the IT have high compatibility with the task given to the user (Goodhue & Thompson, 1995). According to TTFT, individual performance can be predicted by task-technology fit. The fit consists of eight factors which are quality, locatability, authorisation, compatibility, ease of use/training, production timeliness, system reliability, and relationship with users (Goodhue & Thompson, 1995). The fit is formed through a composition of task characteristic and technology characteristic. Task-technology fit measures the degree of compatibility between task and technology characteristics (Farr, 1974). The dynamics of TTFT that affect an individual performance can be systematically mapped as Figure 5.

![Figure 5: Task-Technology Fit Theory](image-url)

Many previous studies utilized TTFT in the information system. The theory is used to predict individual performance based on the compatibility of the information system and the user’s tasks.

Organizational control theory involves exploring the action of a party towards another party that affects their behaviors. It also comprises verbal and physical communication actions to overwhelm others’ resistance and authority (Littlejohn et al., 2012). The dominant model of organizational control theory was developed by Ouchi (1979) through analyzing the prerequisite that governs the application of output and behavior controls. The model is shown in Table 4 with the availability of output measures (output measurability) and knowledge of transformation processes (task programmability) as dimensions (Ouchi, 1979).
Table 4: Choice of organizational control mode

| Output Measurability | Task Programmability | Behavior Control or Output Control | Input Control |
|----------------------|----------------------|------------------------------------|---------------|
| High                 | High                 | Behavior Control                    | Output Control|
|                      | Low                  | Low                                | Input Control |

The model predicts the choice of managers in the control modes. It is possible to determine the suited behavior to achieve the desired outcomes if the involved tasks are well understood. In this condition, behavior control is suitable to use. It is appropriate to utilize output control when the results are measured, observed and controlled easily. When these conditions cannot be applied, input control should be used. Organizational control usually is applied in the context of information systems development (ISD) projects (Henderson & Lee, 1992; Kirsch, 1997) and outsourced ISD projects (Choudhury & Sabherwal, 2003; Kirsch et al., 2002).

A contingency theory is an organizational theory that assumes that there is no best way to organize an organization (Williamson & Chandler, 1964). However, the appropriate action depends on the internal and external situation (Williamson & Chandler, 1964). The basic contingency theory is based on the system approach, which recognized as a famous tool for understanding organization in the 1950s. The main feature of the open system approach is that it refers to the larger environment selected as a context for understanding an organization’s activities (Coates & Hornigren, 1966). The contingency theory was currently developed based on sociological functionalist theories such as the structural approaches to organizational studies (Chenhall, 2003; Reid & Smith, 2000; Woods, 2009). These studies explained that organizational characteristic was contingent on contextual factors such as technology, task environment and organizational size. Contingency theory has been utilized in project management and cost estimation (Howell et al., 2010; Woods, 2009). The general relationship of the theory can be systematically mapped as Figure 6 by adding a moderator effect of project complexity.

Figure 6: Contingency Theory

Future Directions

Based on the systematic review, several research gaps were identified in the factors of cost estimation performance:

1. Most of the factors were clustered based on Organizational Control Theory (OCT) which are input control, behaviour control and output control. However, Akintoye (2000) and Sridarran et al. (2017) concluded that the control factors were not the only primary factors that influence cost estimation performance such as external factors which include project characteristics, external stakeholder, market and economic conditions. The correlations among the factors are fragmented, and the relationship between input control, behaviour control, output control, project complexity, task characteristic, and technology characteristic is unknown and unrecognised. Furthermore, a model is still not developed regarding cost estimation performance.

From the review, various type of tasks and technologies affect the cost estimation performance. The task characteristics and technology characteristics posited by TTFT can be adopted from a cost estimation perspective. As technology refers to a tool that is used to perform or assist in performing the given tasks by individuals (Ammenwerth et al., 2006), technology characteristic in TTFT is adopted to the characteristic of cost estimation methods. Cost estimation methods frequently assist estimators in completing the task of cost estimation. This provides a theoretical base to explain the first research gap by integrating task and technology factors.

Moreover, contingency theory is used to govern the relationship of control factors and cost estimation performance. Previous studies that link relationship control factors and performance have significant and insignificant findings as shown in Table 5.

Contradictions in the findings provide an opportunity to adopt contingency theory to explain the dynamic relationship between the control factors and cost estimation performance. The project complexity is used as a contextual variable in the contingency theory which affects as a moderator in the relationship between control factors and cost estimation performance.
Table 5: Previous studies on control and performance

| Control Mode     | Effect on Performance | Significant | Insignificant |
|------------------|-----------------------|-------------|--------------|
| Input Control    | Yu & To, (2011)       | Bonner et al. (2002) |
| Behavior Control | Henderson and Lee (1992) | Gopal & Gosain, (2010) |
| Output Control   | Tiwana, (2010)        | Henderson & Lee, (1992) |

In conclusion, these theories are appropriate for explaining the second research gap, which the unknown relationships among factors of cost estimation performance and cost estimation performance. The application of the theories is to re-establish and reclassify the existing factors of cost estimation into TTFT, OCT and CT constructs. The integration between TTFT, OCT, and CT provides a better understanding of cost estimation performance in construction projects. The dynamism of the relationships among the factors and the performance variable is systematically mapped in Figure 7.

![Figure 7: The integration between TTFT and CT in explaining cost estimation performance](image)

This study will not only contribute to the knowledge theoretically but also practically. The findings of this study provide a better understanding of the factors that influence cost estimation performance. Therefore, it will improve the performance of estimating cost and leads to less cost and time overrun to occur in the construction projects. Hence, it will provide the best platform for the construction project to be successful.

Furthermore, the model will help the project manager in decision-making regarding what cost estimation methods to utilize in the construction project. The decision is made based on the effectiveness of the method of cost estimation toward the task required in the projects as different cost estimation method has different effects in terms of accuracy, application and ease to understand (Jonny Klakegg et al., 2010).

The study also helps the project manager to specify control modes to utilize in the project teams. As an organization is responsible to provide an appropriate environment for staffs to perform better (Litzky et al., 2006), appropriate control modes applied will provide a better condition for the staffs to perform in high productivity. Thus, this will improve the overall performance of cost estimation. However, the effectiveness of control modes can vary according to the degree of project complexity. This study provides assistance for the project manager to utilize the control modes effectively and efficiently in the high or low complexity of a project.

CONCLUSION

This paper's primary objectives are to synthesize the factors that are affecting cost estimation performance in construction projects and propose future directions regarding cost estimation performance based on the identified factors. The objectives were achieved by performing a systematic review in 11 predefined journals. The search processes of the systematic review were conducted by using predefined keywords in the domain of Title, Article, and Abstract. Then, the selected articles were synthesized according to factors of cost estimation performance. 33 related articles were identified,
which have been published between 1989 and 2020. The overall trend indicated that the importance of cost estimation performance’s factors lacked researchers' attention after 2005.

Through the full-text review of the papers, the cost estimation performance factors were identified and clustered accordingly. The identified factors were clustered into six themes, such as input control, behavior control, output control, project complexity, task characteristic, and technology characteristic. Nevertheless, the relationship among the factors is unknown.

From the systematic literature review, most of the selected control-related factors were classified according to organizational control theory (input, behavior, and output). As the relationship of the factors with cost estimation performance is fragmented, there is a research gap for the relationships to be conceptualized with theoretical constructs.

This study used contingency and task-technology fit theories to respond to the identified research gap. The predefined shared dimensions were re-categorized under input control, behavior control, output control, project complexity, task characteristic, and technology characteristic constructs. The constructs of OCT, CT and TTFT integration provide capabilities to explain the relationship among the factors and towards cost estimation performance.

Despite these theories' capabilities, the application of the theories in knowledge areas of cost estimation performance is novel. Therefore, it contributes to some future direction of the research regarding cost estimation performance. Hence, future research's key objective is to recommend how the OCT, CT and TTFT theories can be utilized to predict and explain cost estimation performance in construction projects.

Furthermore, the TTFT and CT were integrated to predict the cost estimation performance. The integration of these theories provides a better understanding of the relationship's dynamism among the factors.

In conclusion, researchers have yet to investigate a cost estimation performance through these theories. This study provides a better understanding of cost estimation performance and significance for practitioners and academicians. It also offers an opportunity to further research in cost estimation areas by utilizing introduced theories. Thus, it provides a contribution to the research area of cost estimation practically and theoretically.

ACKNOWLEDGEMENT

The author is grateful to the anonymous reviewers of this paper.

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