Identifying factors affecting schedule and cost performance on building project

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Abstract. The project cost and schedule are two major factors which contribute to the project performance. Therefore, it is important to identify factors that affect project cost and schedule performance, which will, in turn, affect the whole project performance. Previous studies have listed many factors have a large impact on time and cost performance, however the discussion related to the relationship between influencing factors and performance parameters is still limited. This research identified and refined 15 influencing factors through literature review. Those factors were grouped into 3 group factors: resource, environmental and management. Then, further literature review further was conducted to determine the relationships between influencing factors with project time and cost performance. The study focuses on factors influencing project cost and time performance based on the physical progress and actual cost. The result shows that resource group is the most variable influencing physical progress, direct cost and indirect cost. While environment and management group influencing physical progress and indirect cost.

1. Introduction
A country's economy gets significant contribution from the construction industry. However, performance measurements in the construction industry are still lagging behind when compared to other industries such as manufacturing [3, 11]. Consequently, it becomes important to measure in order to make the industry sustainable. The construction performance is affected by three main attributes: time, cost and quality. These three attributes are correlated one and each others [10].

Previous studies claimed that lots factors have a big impact on time and cost outcomes. Time and cost performance in construction project are influenced by some variables such as external conditions, project characteristics, design team characteristics, project team performance, procurement system, contractor characteristics and client characteristics [7]. The project management is needed to coordinate and to synchronize the planned cost and schedule to achieve the project goals.

The character of the project, such as unique, uncertain, long-duration nature, and complex make it difficult to predict time and cost projects [17]. Large number of performance indicators that could be measuring and evaluating project performance that could be related to various dimensions [6]. Earned value management (EVM) is one of project controlling tools which integrate cost and schedule aspects [21]. It approaches provides ideas to performance along with variance indexes which should be used to quantify specific construction achievement and situation. Moreover, that can be used to determine the efficiency and effectiveness of past actions of a project about time and cost [11].

EVM consists of three factors including actual cost (AC), earned value (EV), and planned value (PV). The first factor was actual cost of tasks implemented or WBS share performed based on actual...
physical progress. While EV was the amount of the task implemented or portion of a work breakdown structure and PV was planned budget for performing a task or part of the WBS including details of performance. EVM uses time and cost performance indicator, called as schedule performance index (SPI) and cost performance index (CPI). CPI is derived by dividing EV and AC, while SPI could be determined using the ratio EV to PV.

Several studies on project performance based on EVM have been conducted, including [13] which measure the time, cost and quality of the project but without analyzing the influencing factors. As well as [21] with the gray number method. Another case were done by [3, 4, 7, 12], they identified factors that influence project performance without analyzing the impact of the relationship between influencing factors and performance parameters themselves. Project performance has a complex and dynamic character, so research is needed to identify factors that can affect performance and its relationship with measurements using EVM.

The main objectives of this paper are to identify factors influencing time and cost performance in building projects and to analyze their relationship with SPI and CPI as the indicators of the project performance. The results from this study will offer a preferable understanding of the critical factors and help practitioners implicating building projects to take measures to ensure the attainment of project schedule and cost objectives.

To achieve the objective, this study was done by these subsequent phases. Initially, the factor affecting project time and cost performance was analyzed by an extensive journal reconsider. Then, a further literature review was conducted to determine the relationships between influencing factors with project time and cost performance.

2. Research methods
To fulfill the objectives of this study, that is to identify general factors influencing time and cost performance in the building project. 21 journal articles and research reports were reviewed. Journal articles are more than half of whole paper, and the rest is research reports.

2.1. Study process
The reviewed papers were derived from four main databases: Google Scholar, Scopus, Emerald and Science Direct as listed in figure 1. All journal papers have been revised, than the important substance was summarized through each of them. This substance consist the tittle of the journal, case study, the year of the study, identification of factors contributing to the project performance, data analysis techniques and relationship between factors.

Figure 1. Methodology process
2.2. Journal name

Project performance issues including time and cost indicators have been checked in 13 different journals, and Table 1 determine the classification of the publications based on the origin. As shown in that table, 11 different journals name known had appeared the majority of papers on this topic (52 percent of whole articles). The Engineering, Construction and Architectural Management was the majority with 8 articles, and counted for 38 percent of the whole articles. It was continued by Journal of Facilities Management, with 2 papers.

| Journal Name                                          | Frequency | %  |
|-------------------------------------------------------|-----------|----|
| Engineering, Construction and Architectural Management | 8         | 38 |
| Journal of Facilities Management                      | 2         | 9  |
| Other Journals*                                       | 11        | 52 |
| Total                                                 | 21        | 100|

Note: *Other journals were those which had one frequency also Journal of Civil Engineering and Management, International Journal of Project Management and Journal of Economic and Administrative Sciences, etc.

2.3 Project classify

Figure 2 describe the classification of publication bestow on their case study field: building project, infrastructure project or various construction projects type. Separate the writers who looked for performance factors in the detail industry type, all construction project type was the biggest part of projects, with 62 percent. Building projects was the second reflecting 29 percent, while infrastructure projects the third shown 9 percent of whole projects.

2.4 Publication period

As illustrated in figure 3, publications throughout the last 14 years were classified into five-year periods between 2006 and 2019, and were considered. As illustrated in this illustration, after 2015, there was an upturn in the total of publication papers reported around project performance. With 14 publication papers presented between 2016 and 2019, it shown the biggest number of performance-related researches in all five-year targeted period. Based on this study, there were fewer project-identifying factor studies done before 2010.

![Figure 2. Distribute of journals article in accordance with the type of project](image-url)
2.5 Data processing methods

Some methods were used to assess the data obtained from the questionnaires, severity index (SI), relative important index (RII), regression, T-test, factor analysis, data classification, etc. Figure 4 shows the classification of data processing methods used in identified journal papers. RII and data classification were the first rank among the processing methods with 29 percent, respectively. The third technique was factor analysis. Other methods equal 16 percent of all utilized techniques.

By a deeper review of previous research that were related with identifying factors of construction time and cost performance, 20 possibility affecting factors were found on Table 2.

Show an elaborated empirical study of affecting factors of time and cost performance in the building project done by preceding study. Despite of factors from distinct empirical research are given different names, several of them are identical or overlap. Therefore, factors with few literary journal have combined and then refined them to form the final 15 influencing factors with grouped as follows resource, environmental and management.

Besides the variables found from study literature to get the factors influencing time and cost performance, an analysis is carried out to get the influenced variables. The influenced variables are obtained from the calculation of SPI and CPI equations. Figure 5 explains the steps of identifying variables from the EVM method equation. Where planned value and budget at completion (BAC) obtained from project planning step. So variables that can fickle because influenced by various factors including physical percent complete, direct cost and indirect cost.

![Figure 4](image-url)  
Figure 4. Classification of papers according to data analysis technique
After obtaining the factors influencing project time and cost performance, the process is followed by identifying the relationship between variables based on the journals that have been reviewed and other journals.

3. Result
As aforementioned, earned value analysis is indicated by SPI and CPI. These two indicators are derived from the ratio earned value and planned value as well as actual cost. Earned value indicator is determined by physical progress and the planned budget. Planned budget and planned schedule are considered as fixed variable, which has been given in the beginning of the project. While physical progress and actual cost are very fluctuate. Therefore, this study only focuses on factors influencing project performance from the perspective of physical progress and actual cost.

3.1. Factors influencing physical percent complete (physical progress)
In general, physical progress is influenced mostly by three major factors; they are environment, resource and management. Environment factor includes weather condition, public facilities and site condition.

Meanwhile, resource factor consists of Materials and labor procurement, availability of materials and equipment on site, skills and productivity of labor, financial condition of owner and contractor, consultant experience level, subcontractor experience level and economic environmental.

Material is one of the factors influencing performance productivity. The availability of sufficient material reduces the risk of waiting by workers [23]. According to [3], shortage of labor and strike by the labor force can influence building project performance. Contractors, owners, and consultants need qualified staff to manage the project they are working on. Deficiency of staff causes a huge material is one of the factors influencing performance productivity. The availability of sufficient material reduces the risk of waiting by workers [29]. According to [3], shortage of labor and strike by the labor force can influence building project performance. Contractors, owners, and consultants need qualified staff to manage the project they are working on. Lack of staff causes a huge burden on the staff at work. In practice, reducing staff can increase responsibility, control, cause poor quality work, improve lower construction management causing construction delays [9, 11]. Moreover, the financial difficulties of the owner can result in late payment by the owner and even closing [10, 11, 26].
Table 2. Schedule and cost performance factors

| Variables                                      | Literature                                                                 |
|------------------------------------------------|-----------------------------------------------------------------------------|
| Resources                                      |                                                                             |
| Materials and labor procurement                | [4], [2], [3], [6], [9], [11], [15], [18], [21]                           |
| Availability of materials and equipment on site| [4], [2], [3], [8], [9], [11], [15], [20], [21]                           |
| Skills and productivity of labor               | [3], [6], [8], [9], [12], [13], [15], [18], [21]                         |
| Financial condition of owner and contractor    | [8], [5], [7], [6], [14], [17], [18], [20], [21]                         |
| Consultant experience level                    | [2], [6], [7], [11], [15], [16], [20]                                     |
| Subcontractor experience level                  | [2], [6], [9], [15]                                                       |
| Economic environmental                        | [4], [6], [9], [16], [20]                                                 |
| Contractor technology                          | [11]                                                                       |
| Environmental                                  |                                                                             |
| Weather conditions                             | [8], [3], [5], [6], [8], [9], [11], [13], [19], [21]                     |
| Public facilities                              | [3], [13], [20], [21]                                                     |
| Site condition                                 | [4], [2], [3], [5], [6], [9], [11], [13], [19], [21]                     |
| Management                                     |                                                                             |
| Rework                                         | [6], [9], [13], [17], [21]                                                |
| Related to design                              | [8], [6], [7], [8], [11], [16], [18], [19], [21]                         |
| The presence of supervising consultant staff   | [6], [8], [10], [13], [15], [16], [18]                                    |
| Slow decision making                           | [8], [6], [13], [21]                                                      |
| Related to contract                            | [8], [6], [8], [10], [12], [17]                                           |
| Project Duration                               | [12], [14]                                                                |
| Poor coordination                              | [6]                                                                        |
| Safety                                         | [13], [5]                                                                  |
| Quality                                        | [15], [19]                                                                |

The results of the correlation analysis of time overruns are the same as [3] by the known factors as influencing project performance reveal that economic, financial and political clusters have a matter connection with time overrun. The geographical location of a project, soil conditions and weather conditions are examples of the most general environmental effects. Nevertheless, manager construction work will consider physical effect when planning management strategies for avoid the extremes that can make use of what is available resource to get the project goals on time.

Project completions on time, standard of quality and within the assigned budget are the main goals of construction projects. However, there are several unprecedented circumstances that might affect the project performance. To manage building projects efficiently, the coordination process must be applied as an important one function in project management [4]. The more project entities, the more coordination needed. The poor coordination will lead to ineffective project performance, such as project overrun and late schedule [12]. Therefore, it needs such a coordination meeting to support the coordination process [4].

3.2. Factors influencing direct cost

According to the direct cost definition, resource factor is the most dominant factor influencing direct cost. As construction projects take a long time to complete with their complexity and dynamic nature, they are economically risky [6], and have a long history of cost escalation [23]. Total costs can be classified into direct costs related to performing the work, and indirect costs. Direct costs include material, labor, equipment, and subcontractor costs [24]. They can contribute the direct cost influenced by resources, such as not available of material; apparatus and professional workforce impose lots of barrier to a better achievement [9].

According to [10], Material related factors affecting project performance can be associated with material shortages, transportation, material manufacturing, impairment and material changes and delivery. As mentioned by [22], in some developing countries such as Indonesia, the escalation of material price is able to influence the project schedule as the contractor needs to wait until the price. In factors environmental clusters, economic, financial and unexpected price rise of materials had major impact to building project cost performance [3].
Equipment, especially capital equipment, has characteristics and is different requirements for bulk material procurement. [25] State if procurement of capital apparatus has higher waiting times and bigger unit incur costs, and usually for assembly needs special technology. Lack of apparatus, along with apparatus that is not properly maintained, mainly throughout the construction season, could cause project defeat or lead it to diverge.

3.3. Factors influencing indirect cost
Indirect cost, according [14], two major element of it that defined which determine in detail are construction overheads, management costs. Construction overhead can be defined as the total cost incurred by the contractor at the construction site related to delivery work, but is not included in standard labor costs, materials and of construction equipment. Management costs are incurred to maintain functional units and personnel work that carry out general administrative activities carry out supervisory functions, as well as control, register, report and are related to instructions and other functions related to the organization, management and administration of construction companies.

Similar to physical progress, indirect cost is mostly influenced by management, resource and environment factors. Various factors influencing overhead and management cost. One of the most common factors that causing the final project cost to exceed the initial estimate (overhead) is force majeure. Even though the contractor is usually required to obtain an insurance policy against this, if such an event does occur without this provision it may cause delays and further affect costs [5]. Legal compliance and environmental issues are also considered important in influencing project cost performance [8]. Project managers, in addition to their traditional functions, must set up processes for scanning the environment, identifying potential problems, and trying to build power relationships that can assist in managing the factors underlying successful implementation [3].

Construction work managers and supervisors have to apply a suitable leadership style in project management to minimize pointless cost overruns [3]. Inexperienced stakeholders or have new comers can cause delays and cost overruns [11, 16]. According to [10] in [17] factors related to contractor site management, factors related to design and documentation, factors related to financial management can influence cost overruns.

The distribution of relationship between influencing factors with time and cost performance index is illustrated in figure 6. Most portion of the factors were distributed to resource group, indicating the importance of this group, especially in the procurement and availability of material, labor and equipment. Labor productivity and contractor’s economic condition also have high importance. The resource factor also has a large impact on time and cost performance, indicated by its effect on implemented volume, direct cost and indirect cost. The second place was management group with having five factors, than the third rank was environment group having three factors.

4. Conclusion
This paper presents a literature study on influencing factors of time and cost performance on building projects based on the EVM method. This paper identifies 15 influencing factors associated with project time and cost performance. Then, these factors grouped into 3 cluster, environmental, resource and management. According to finding in this paper, noted that environmental variables can influence implemented volume and indirect cost. Resources variable can influence implemented volume, direct cost and indirect cost, while management variable also can affect implemented volume and indirect cost.

The finding of this study can find out what factors can affect the project's time and cost performance to provide a better understanding of practitioners to take steps to ensure the achievement of the project schedule and cost objectives.
Figure 6. The identified relationship of schedule and cost performance

Acknowledgements
The results of the paper are mainly derived by literature review, so the results still need validation by quantitative research method based on the survey. It is also unknown how big the contribution of each variable influences the project schedule and cost performance index. To validate the findings in next study, then could apply more specific case studies and conduct interviews. So that it can be implemented directly and compared with real conditions on the site.

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