Factors affecting construction performance: exploratory factor analysis

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Abstract. The present work attempts to develop a multidimensional performance evaluation framework for a construction company by considering all relevant measures of performance. Based on the previous studies, this study hypothesizes nine key factors, with a total of 57 associated items. The hypothesized factors, with their associated items, are then used to develop questionnaire survey to gather data. The exploratory factor analysis (EFA) was applied to the collected data which gave rise 10 factors with 57 items affecting construction performance. The findings further reveal that the items constituting ten key performance factors (KPIs) namely; 1) Time, 2) Cost, 3) Quality, 4) Safety & Health, 5) Internal Stakeholder, 6) External Stakeholder, 7) Client Satisfaction, 8) Financial Performance, 9) Environment, and 10) Information, Technology & Innovation. The analysis helps to develop multi-dimensional performance evaluation framework for an effective measurement of the construction performance. The 10 key performance factors can be broadly categorized into economic aspect, social aspect, environmental aspect, and technology aspects. It is important to understand a multi-dimension performance evaluation framework by including all key factors affecting the construction performance of a company, so that the management level can effectively plan to implement an effective performance development plan to match with the mission and vision of the company.

1. Introduction

The construction industry influences an economy’s gross domestic product (GDP) more than any other industries [1]. Although the industry plays as an important role in country development, there are several problems while trying to improve its performance. This is due to the nature of the work, such as high fragmentation, instability, low productivity, poor quality control, and lack of standards [2]. A number of research studies have been conducted to evaluate and improve performance at the project level. Ref [3], for example, investigates the benchmarking and performance evaluation of a construction project, ref [4] proposes the indicators to measure the project success, while the return on scale of construction costs is explored by ref [5], and the performance measurement of R&D project is studied by ref [6].

The above research studies provide an insight into construction performance evaluation. However, most of these studies focus primarily on performance measurement at the project level, while the studies on the performance measurement at the company level are still lacked. This paper, therefore, aims at examining key factors affecting construction performance utilizing an exploratory factor analysis (EFA) method. It is expected that the study results assist a construction company to better understand key factors affecting construction performance, and effectively plan for performance improvement. The research flow of this study is as shown in figure-1.
2. Construction performance

Many research studies have been conducted to evaluate and improve performance in the construction industry. Traditionally, the industry evaluates its performance using three key indicators; time, cost, and quality [7]. Ref [3], however, claims that the traditional indicators can no longer be an effective measurement of project success. In real practice, many factors apart from those three key factors affecting construction performance, directly and indirectly. Ref [8] mentions to include safety and health aspect for better construction performance, whereas ref [9] claims the importance of financial aspects for the profitability and survivability of a construction company. Similarly, ref [10] discuss about environmental aspects for better construction performance, the importance of client/customer satisfaction is pointed out by ref [11]. On the other hand, ref [12] argues that stakeholder management is crucial to improve company performance. Based on the above researches, this study hypothesizes nine key factors, with a total of 64 associated items, as shown in table 1. The hypothesized factors, with their associated items, are then used to develop questionnaire survey to gather data for further analyses.

3. Questionnaire survey and data screening

3.1. Survey development

A survey questionnaire is developed based on the 64 items with nine hypothesized factors to gather data on performance measurement at the company level. The targeted respondent group is the manager or above level with at least five years working experience in the construction industry, who have involved in the various decision making related to the construction improvement process of the company. The data are targeted to collect in the companies, which are working as the building contractors, mainly in the Bangkok metropolitan area.

There are four sections in each set of questionnaire. The first section includes five questions related to demographic information of the respondent. The second section is questions about items affecting the construction performance. The respondents are asked to rate their agreement on each statement using a 5-point likert scale, ranging from 1=strongly disagree to 5= strongly agree. The third section is to rank the top three most important factors among nine hypothesized factors. And the last section is the suggestion part.
Table 1. Nine hypothesized with 64 associated items factors affecting construction performance.

| Factor          | Items affecting construction performance | Reference |
|-----------------|------------------------------------------|-----------|
| **Time (TM)**   | Litigation                              | LTG [13],[14],[15] |
| 1.1             |                                         |           |
| 1.2             | Contract Duration                       | CTD [14],[16] |
| 1.3             | Supplier Capacity in providing required resources | RAV [14],[17] |
| 1.4             | Required Time for Imported Material     | PCD [13],[15] |
| 1.5             | Accessibility to Site                   | ACS [16] |
| 1.6             | Time for Resources & Document Approval  | APD [3],[18] |
| 1.7             | Time Ratio for Environmental Performance| EVS [19],[20] |
| 1.8             | Delays in Subcontractors Work           | DLS [18],[19] |
| **Cost (CT)**   | Error in Determining Project Scope      | AES [3],[14] |
| 2.1             | Payment Term                            | PAT [17],[18] |
| 2.2             | Need for Jobs                           | CTP [14],[21] |
| 2.3             | Performance Bond                        | PFB [3],[16] |
| 2.4             | Inaccurate Estimation                   | IAE [3],[21] |
| 2.5             | Estimator Cognitive Biases              | ESBI [3],[16] |
| 2.6             | Resource Availability                   | RSA [18],[22] |
| 2.7             | Design Change                           | DSC [3],[22] |
| **Quality (QT)**| Clear Understanding of Quality Goals and Policy | QTP [13],[14] |
| 3.1             | Supplier Quality Management             | SQM [23],[24] |
| 3.2             | Resources Quality                       | RQT [3] |
| 3.3             | Quality Control                         | QTI [13],[14] |
| 3.4             | Availability of Cost of Quality         | CTQ [3],[15] |
| **Safety & health (SH)** | Compliance to Health and Safety Regulation | HSC [23],[25] |
| 4.1             | Safety-Committee Policy                 | SHC [17],[24] |
| 4.2             | Risk Management                         | SHM [3],[15] |
| 4.3             | Level of Safety Awareness               | SHA [15],[24] |
| 4.4             | Site Condition                          | STC [23],[25],[24] |
| 4.5             | Availability of Safety Equipment/ Posters/ Displays | SHE [3],[20],[17] |
| **Client satisfaction (CS)** | Clients Requirements in Project Scope | CRS [21],[23] |
| 5.1             | Provide Periodic Listings of Milestones  | PMS [18],[25] |
| 5.2             | Clear Problem Solution                  | CPS [18],[24] |
| 5.3             | Adequate Financing Arrangements         | AFA [24],[25] |
| 5.4             | Prompt Reactions to Problems            | PTR [14],[24] |
| 5.5             | Meet all specifications                 | SPF [3],[23] |
| 5.6             | Provide Notifications and Explanations for Work Delays | NED [23],[25] |
| **Environment (EV)** | Compliance to Environmental Regulations | EVC [22],[25] |
| 6.1             | Improving Corporate Image in environmental Performance | EVI [3],[22],[6] |
| 6.2             | Waste Management on Site                | SWM [3],[5],[22] |
| 6.3             | Feedbacks on Environmental Issue        | NRS [3],[5] |
| 6.4             | Reduction, Reuse & Recycling of C&D Wastes | RSC [6] |
| 6.5             | Natural Resource Consumption             | POC [5],[22] |
| **Financial performance (FP)** | Financial Strategies                   | PFF [16] |
| 7.1             | Realistic of Contract Agreement         | COR [14],[26] |
| 7.2             | Nominated Sub-con and Suppliers from Clients | NSS [14], |
| 7.3             | Financial Indices                       | FPI [14],[16] |
| **People (PE)** | Commitment of Work                      | WCT [26] |
| 8.1             | Teamwork                                | TWK [27] |
| 8.2             | Communications between Participants     | COM [14],[3], |
| 8.3             | Workers' Moral                          | MOR [19] |
| 8.4             | Attitude of Project Participants        | ATT [27] |
| 8.5             | Empowerment/ Responsibilities           | EMP [14],[26] |
| 8.6             | Stakeholder’s Competence                | CPT [15],[19] |
| 8.7             | Monitoring and feedback by Project Participants | MNT [19],[27] |
| 8.8             | Labour Productivity                     | PDT [14],[18] |
| 8.9             | Job Assignment                          | JSE [18],[26] |
| 8.10            | Labour Stress                           | STS [15],[26] |
| 8.11            | Job Security                            | JAS [19],[27] |
| 8.12            | Stakeholder’s Work Behaviour            | WVB [20],[26] |
| 8.13            | Relationship between Stakeholders/ Working Environment | WEV [19],[27] |
| 8.14            | Education and Training                  | EITG [27] |
| 8.15            | Employee's Satisfaction                 | EMS [27] |
| 8.16            | External Partners Management            | EPM [15],[27] |
| **Information, technology & innovation (IT)** | Technological Support                   | TES [19] |
| 9.1             | Availability of All Related Data/ Information | TMD [6],[3]| |
| 9.2             | Use of New Construction Techniques      | INN [3],[19] |
3.2. Pilot test
To validate the effectiveness of the questionnaires, a pilot study was conducted among eight professionals, including two executives and six project managers. Their experience in the construction industry is up to 20 years. Ref [2] points out that the management level with ten years working experience in the construction industry has enough knowledge to make major decisions, regarding to the performance improvement. The experts for the pilot study is selected to include different types of construction. Among experts, one executive and two project managers are working in the construction companies which focus mainly on the industrial projects. And, another executive and one project manager are from the commercial building contractors. The last three project managers have working with a company, which focuses more in the residential projects. But, all of them have experience in both public and private construction projects.

Based on the comments from the experts during the pilot test, the seven items including; accessibility to site (ACS), inaccurate estimation (IAE), empowerment/ responsibilities (EMP), external partnership management (EPM), delays in subcontractors work (DLS), resource availability (RSA), nominated Sub-con and suppliers from clients (NSS) were changed. The ACS item is marked as the unimportant item by the experts. The IAE item and the EMP item is indirectly explained by the stakeholder competence (CPT) and the job assignment (JAS) items respectively. There was also a suggestion to separate the EPM item into supplier selection criteria (SRC), sub-contractor selection criteria (SCC), and nominated stakeholder (NST) items. By separating into three items, the DLS item and the RSA items are integrated with SCC and SRC items respectively, while the NSS item becomes the NST item. The feedbacks from the experts also ensures that the items were clearly worded. These results in 57 items for final questionnaire survey.

3.3. Survey result
The data collection process was conducted from June, 2016 to September, 2016 among the building construction companies in Bangkok and vicinity areas. A total of 720 sets of questionnaire are distributed, with 345 completed responses return, representing the 47.9% response rate, which is a very good response rate [28]. The respondents comprise 50 executives (14%), 68 project managers (20%), 133 senior engineers (39%), and 94 engineers (27%). The data show that more than 70% of the respondents hold the management titles and around 75% of the respondents have more than 5 years working experience in the construction industry and in their respective companies. Moreover, 75% of the respondents are working in the medium and large size companies, with more than 50 workers working in the company or more than 50 million Thai Baht of capital investment [29]. The demographic information proves the appropriateness of the respondents in providing information for the analyses.

3.4. Data screening
The data screening process is an essential step to increase the confidence in the collected data [30]. In this study, data collected from the questionnaire survey are tested with two major data screening analyses; normality and outlier tests. The normality of the data are confirmed with skewness and kurtosis values. The skewness is a measure of symmetry, while kurtosis is a parameter that describes the shape of a random variable’s probability distribution [31]. The results show normal distribution of all 57 items.

Outlier test is an additional step of data screening process as it investigates unusual data [30]. The 5% trimmed mean, and Z-score are used to detect outliers. The items with difference between mean and 5% trimmed mean of greater than 0.2 [30], and the Z-score of higher than 3 are potential outliers [30]. The results shows that the arithmetic mean and 5% trimmed means range from the 0.02 to 0.1. The Z-score values are also in the allowable limit of 3. Therefore, it can be concluded that there is no non-normality and outliers in the collected data, and that they can be used to perform the EFA.

4. Exploratory factor analysis (EFA)
The EFA is used to determine the factor and factor loading of measured variables, and to confirm what is expected on the basic or pre-established theory [32]. Researchers suggest that construct validity can
be assessed by examining factor loadings of indicators and composite reliability [32]. In this study, the EFA is performed to extract the 57 items into key factors affecting construction performance. The principal component analysis (PCA) method and the varimax rotation method are used, with the factor loading of 0.35. The results, as shown in table 2, grouped the 57 items into 10 key factors, with the total variance of 62.9%. The extracted factors are consistent with the nine factors, previously hypothesized, except the PE factor that is separated into two components. After analyzing the items included under each component, they are named as internal stakeholders and external stakeholders. Therefore, as the outcome of the EFA, 10 key factors are extracted with their associated items.

The time (TM) factors consisted of six items, with factor loadings from 0.42 to 0.78. The result is confirmed by the ref [14] by stating that litigation is not uncommon in the construction industry because of its adversarial nature and the tendency for disputes to arise. Similarly, ref [13] claims that the contract time often arises as an issue when there is too much time or too little time given in the contract. There are six items in the cost (CT) factor, while only four items in the quality (QT) factor. Although ref [19] claims that CTQ item should have been loaded under the CT factor, but the results from the factor analysis reveals that it loaded under the QT factor, with the value of 0.767. A closer looks at the survey instrument indicates that the respondents perceived the cost of quality to be a cost-related attributes, but this item is empirically by the performance related to the quality performance.

There are five items under the client satisfaction (CS) factor, as similar the pre-defined items. The client satisfaction has been proposed as an important measure in the last decades [23], [25], [24]. Ref [18] also suggests that their level of satisfaction can also be taken as an indicator of project success. The safety & health (SH) factor consists of six items. Ref [21] indicated that project safety should always be considered due to the risky nature of construction activities when evaluating the performance of construction facilities. It is important for every project organization to focus on safety during construction because if accidents occur, both contractors and clients may be subject to legal claims, financial loss and delay in the overall completion of construction [17].

Both the financial performance (FP) and the information, technology & innovation (IT) factors consist of three items each, with the factor loading ranging from 0.81 to 0.89 and 0.70 to 0.78 respectively. Although the financial performance factor (FP) is closely associated with the cost factor (CT), the significant different is that the FP focuses in the revenue side, which is the most important for survival of a company, while the CT focuses to reduce the cost [18]. Therefore, it can be concluded that FP is related more with the company level, and the CT is at the project level [26]. On the other hand, the environment (EV) factor includes six items. Ref [18] reported that environmental issues in construction have become a global concern and therefore, should be considered an integral part of construction. All construction companies should address environmental issues for the purpose of achieving sustainable development [5].

The people factor (PE) is extracted into two components during the factor analysis process. There were originally 18 factors in the PE factors, while pre-grouping as suggested by the literature. However, during EFA process, the items are separated into two components. It is evident that 14 items loaded under the first component are associated with the internal stakeholders, and is named as the internal stakeholder factor (IS), while another component is named as external stakeholder (ES). It is important that the stakeholders have the responsibility to minimize disputes amongst themselves and formulate strategies to govern their relationships during project construction. Ref [27] and [12] have observed that performance measurement should also consider the level of work related disputes encountered during construction and after.

5. Conclusion and limitation
The empirical findings of the study and the subsequent analyses suggest that the performance of a construction companies does not merely depends on the traditional iron triangle of time, cost, and quality. It also depends on many other factors such as safety & health, environment, client satisfaction, financial performance, internal stakeholder, external stakeholder, and information, technology and innovation.
Table 2. Results of the EFA

| Items affecting construction performance | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 | Factor 8 | Factor 9 | Factor 10 |
|-----------------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| APD                                     | 0.77     |          |          |          |          |          |          |          |          |           |
| RAV                                     | 0.76     |          |          |          |          |          |          |          |          |           |
| PCD                                     | 0.72     |          |          |          |          |          |          |          |          |           |
| CTD                                     | 0.60     |          |          |          |          |          |          |          |          |           |
| EVS                                     | 0.56     |          |          |          |          |          |          |          |          |           |
| LTG                                     | 0.42     |          |          |          |          |          |          |          |          |           |
| AES                                     | 0.73     |          |          |          |          |          |          |          |          |           |
| PFB                                     | 0.69     |          |          |          |          |          |          |          |          |           |
| ESB                                     | 0.65     |          |          |          |          |          |          |          |          |           |
| PAT                                     | 0.60     |          |          |          |          |          |          |          |          |           |
| CTP                                     | 0.58     |          |          |          |          |          |          |          |          |           |
| DSC                                     | 0.58     |          |          |          |          |          |          |          |          |           |
| QTI                                     | 0.83     |          |          |          |          |          |          |          |          |           |
| RQT                                     | 0.78     |          |          |          |          |          |          |          |          |           |
| CTQ                                     | 0.77     |          |          |          |          |          |          |          |          |           |
| QTP                                     | 0.54     |          |          |          |          |          |          |          |          |           |
| SHA                                     | 0.79     |          |          |          |          |          |          |          |          |           |
| HSC                                     | 0.77     |          |          |          |          |          |          |          |          |           |
| SHE                                     | 0.74     |          |          |          |          |          |          |          |          |           |
| SHM                                     | 0.71     |          |          |          |          |          |          |          |          |           |
| SHC                                     | 0.69     |          |          |          |          |          |          |          |          |           |
| STC                                     | 0.69     |          |          |          |          |          |          |          |          |           |
| CPS                                     | 0.81     |          |          |          |          |          |          |          |          |           |
| PTR                                     | 0.79     |          |          |          |          |          |          |          |          |           |
| CRS                                     | 0.73     |          |          |          |          |          |          |          |          |           |
| PMS                                     | 0.65     |          |          |          |          |          |          |          |          |           |
| SPF                                     | 0.56     |          |          |          |          |          |          |          |          |           |
| EVI                                     | 0.80     |          |          |          |          |          |          |          |          |           |
| NRS                                     | 0.76     |          |          |          |          |          |          |          |          |           |
| SWM                                     | 0.74     |          |          |          |          |          |          |          |          |           |
| POC                                     | 0.74     |          |          |          |          |          |          |          |          |           |
| EVC                                     | 0.70     |          |          |          |          |          |          |          |          |           |
| RSC                                     | 0.66     |          |          |          |          |          |          |          |          |           |
| PFT                                     |          | 0.88     |          |          |          |          |          |          |          |           |
| COR                                     |          | 0.87     |          |          |          |          |          |          |          |           |
| FPI                                     |          | 0.81     |          |          |          |          |          |          |          |           |
| MOR                                     |          |          | 0.73     |          |          |          |          |          |          |           |
| ATT                                     |          |          | 0.72     |          |          |          |          |          |          |           |
| JAS                                     |          |          | 0.71     |          |          |          |          |          |          |           |
| MNT                                     |          |          | 0.67     |          |          |          |          |          |          |           |
| PDT                                     |          |          | 0.66     |          |          |          |          |          |          |           |
| TWK                                     |          |          | 0.63     |          |          |          |          |          |          |           |
| COM                                     |          |          | 0.62     |          |          |          |          |          |          |           |
| WEV                                     |          |          | 0.61     |          |          |          |          |          |          |           |
| ETG                                     |          |          | 0.60     |          |          |          |          |          |          |           |
| JSE                                     |          |          | 0.59     |          |          |          |          |          |          |           |
| CPT                                     |          |          | 0.58     |          |          |          |          |          |          |           |
| WCT                                     |          |          | 0.58     |          |          |          |          |          |          |           |
| WBV                                     |          |          | 0.56     |          |          |          |          |          |          |           |
| STS                                     |          |          | 0.48     |          |          |          |          |          |          |           |
| SCC                                     |          |          |          | 0.66     |          |          |          |          |          |           |
| SRC                                     |          |          |          | 0.63     |          |          |          |          |          |           |
| ESF                                     |          |          |          | 0.61     |          |          |          |          |          |           |
| NST                                     |          |          |          | 0.56     |          |          |          |          |          |           |
| TES                                     |          |          |          |          | 0.78     |          |          |          |          |           |
| TMD                                     |          |          |          |          | 0.74     |          |          |          |          |           |
| INN                                     |          |          |          |          | 0.70     |          |          |          |          |           |

The analysis helps to develop multi-dimensional performance evaluation framework for an effective measurement of the construction performance. The 10 key performance measures can be broadly categorized into economic aspect, social aspect, environmental aspect, and technology aspects. The time (TM), cost (CT), quality (QT), and financial performance (FP) factors continue to capture economic dimensions. The safety & health (SH) and the internal stakeholder (IS) factors account for the internal...
social aspects, while the external stakeholder (ES) and the client satisfaction (CS) factors are closely associated with the external social aspects. The environment factor (EV) takes care of the environment aspects, while the information, technology and innovation factor deals with the technology aspects. The above 10 factors constitute the 10 key performance indices (KPI) for a construction company to create the leverage over the others [3].

The study has its own limitations. The data collection process for the survey was conducted in Bangkok, Thailand, and hence it is important need to undergo cross-cultural validation of the instrument in order to enhance the generalization of items. Secondly, the present study did not investigate the casual relationships among the factors affecting construction performance. Therefore, it is a need for carrying out the confirmatory factor analysis (CFA) to establish the soundness of measurement scale. The development of a path model for structural equation modeling (SEM) based on the data and extracted factors reported in this paper will be addressed in future researches.

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