Using Project Performance to Measure Effectiveness of Quality Management System Maintenance and Practices in Construction Industry

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Received 12 December 2013; Accepted 15 January 2014; Published 19 February 2014

Academic Editors: A. K. Gupta and B. Lin

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This paper proposed seven existing and new performance indicators to measure the effectiveness of quality management system (QMS) maintenance and practices in construction industry. This research is carried out with a questionnaire based on QMS variables which are extracted from literature review and project performance indicators which are established from project management’s theory. Data collected was analyzed using correlation and regression analysis. The findings indicate that client satisfaction and time variance have positive and significant relationship with QMS while other project performance indicators do not show significant results. Further studies can use the same project performance indicators to study the effectiveness of QMS in different sampling area to improve the generalizability of the findings.

1. Introduction

Quality management system has been widely implemented and adopted in construction industry especially those companies which are able to handle megaprojects. Although uncountable researches have been carried out to study the relationship of quality management system with various industries (e.g., manufacturing, food, service, etc.), there is lack of relevant studies on construction industry. It is because those researchers are more interested in looking into the quality of the project works and costing of the projects in construction industry [1–3] compared to quality management system. Those studies conducted some international comparisons on construction quality among United States, United Kingdom, and Japan [2] and between Singapore and Hong Kong [3]. Some robust benchmarks have been generated through these attempts for the professionals in various countries so that they can improve their competitiveness. Furthermore, some studies have examined the effects and benefit of implementing quality management system in construction industry. Some evidence finds that implementing quality management system can improve communication problems; minimize mistakes, rework, and material wastage; have better control of subcontractors and suppliers. Hence, the productivity, profitability, and market share have been generally increased and also enable contractors to meet the client requirements [4]. Besides, there is a study trying to construct a model for the quality management system maintenance processes because it has been suggested as an essential activity for every organization including construction industry [5]. Initially, maintenance concepts have been linked with concept of quality management matrix to define the maintenance of quality management [6–8].

Nonetheless, most of the quality management system studies are not specifically designed to examine the objectives (time, cost, and quality) in construction industry and usually
The scope of study will include numerous industries for comparison purpose. For example, there is a study that identified 10 critical success factors for quality management system implementation after reviewing 100 studies from different industries backgrounds [9]. Furthermore, some researchers have focused their studies on relationship between quality management system and organizational performance and business performance instead of project performance [10, 11]. Some studies also indicated that implementation of ISO 9000 can benefit organizations by improving production performance and quality awareness of the employees in diverse industries [12–16].

Even though there are many studies indicating that some organizations have received benefits of quality and also increased their productivity after implementing quality management system, there are limited researches looking into the relationship between QMS and project performance. Therefore, there is a need to know whether QMS is able to improve project performance so that the benefit and effectiveness of QMS can be measured with project management theory. Furthermore, some new project performance indicators will be used in this research to establish significant performance indicators.

2. Literature Review

Effectiveness and efficiency of quality management implementation are important for improving performance of an organization. In the past quality management literature, there are many studies investigating the effects of different quality management practices on quality performance [17–20], operational performance [21–23], and business performance [24, 25]. Most of the findings have indicated that quality management practices have a clear and significant relationship with quality and operational performance, but they have insignificant and unclear effects on business performance. Furthermore, a research shows that quality can assist a company to obtain competitive advantages by meeting customer needs when delivering quality products to the marketplace. The results also indicate that the quality dimensions which have been used in the research are correlated with business performance [26]. Nevertheless, those performance indicators are not suitable for measuring construction projects.

The success of a construction project can be indicated by project performance. The performance of a project will be dependent on various factors including project complexity, contractual arrangements, relationships between participants in the project, competency of project manager, and the abilities of the key members in projects. Project performance is usually judged and quantified by performance measurement. Performance measurement is the common method to collect and report the information related to the inputs, efficiency, and effectiveness of a construction project [27]. Furthermore, measurements are crucial for tracking, forecasting, and controlling the important variables in the end to ensure the success of projects [28–32].

Generally, it has been widely accepted that time, cost, and quality are the major concerned factors in the performance measurements of a project [33]. Moreover, these three major components are noted as “iron triangle” (see Figure 1) according to a researcher [34]. On the other hand, there are other criteria that have been suggested to be considered in a project [35]. Those criteria include meeting the budget, schedule, quality of workmanship, stakeholders’ satisfaction, safety and health, and transfer of technology. At the same time, some researchers also noted that there are other various key components such as design performance, safety and health, performance of environmental management, expectation or satisfaction of the end user, client’s satisfaction, and commercial value that are used in project performance measurement [36]. Hence, there are five major variables that have been identified to measure projects performance. There are cost performance, time performance, quality performance, safety and health, and clients’ satisfaction.

2.1. Cost Performance. It is stated as the degree to which the general conditions promote the completion of a project within the estimated budget [37]. The cost variance is the technique usually used for design performance measurement of a project in construction industry [38]. Moreover, cost variance technique is not only limited to the calculation of the tender sum but also includes the overall costing that incurs in a project from commencement to completion. The overall costs comprise all the costs involved in variation work or modification work and also the costs involved in any legal claims such as arbitration or litigation upon the construction period. Cost variance is measured in terms of unit cost, percentage of net variation over the final cost [36]. Besides, Cost variance has been used in a research as the measurement for project performance in a construction project which has problems of defective design [39]. Furthermore, the element of cost also has been suggested to measure the performance in engineering projects [40]. Besides cost variance, cost performance index (CPI) also has been used to measure performance of a project for the reliability and the confidence of results. The formula of the elements and indication are shown as follows.

2.1.1. Cost Variance (CV). The project is ideally on budget when the value of CV is equal to zero. When the CV value is greater than zero, that means the earning of project has more value than the planned earning; therefore it is under budget. When the CV value is less than zero, that means the earning
of project has less value than the planned earning; hence it is over budget.

\[ CV = BCWP - ACWP, \]

(1)

where BCWP is the budgeted cost of work performed and ACWP is the actual cost of work performed.

2.1.2. Cost Performance Index (CPI). The project is ideally on budget when the value of CPI is equal to one. When the CPI value is less than one, that means the project is over budget. When the CPI value is greater than one, that means the project is under budget. A project with good performance must maintain its CPI value as near to one as possible.

\[ CPI = \frac{BCWP}{ACWP}, \]

(2)

2.2. Time Performance. From the perspective of client, end users, stakeholders, or the general public, the first criteria to measure success of the project will be the completion time. Therefore, it is very crucial to complete the construction project on time when people judge the project success from the macroview [41]. Time variance (TV) has been suggested as one of the techniques of assessing performance of project in construction industry [38, 42]. The formula for time variance is shown as below:

\[ TV = BTWP - ATWP, \]

(3)

where BTWP is the budgeted time of work performed and ATWP is the actual time of work performed.

The indication from the element of time can give awareness for project manager to be aware that the project is not running as well as scheduled. Moreover, delivery of projects on time has been suggested as one of the main requirements of clients in the construction contracts [43].

2.3. Quality Performance. Quality is described as the totality of features required by a product or service to satisfy a given need; fitness for purpose [44]. In other words, quality in construction industry emphasizes the capability to establish requirements with conformance to the quality standard. Requirements will be predefined by client in contract agreement and the requirements consist of the established characteristics of products, processes, and services. All the parties involved in the project must fully understand those requirements and expectation in order to achieve a complete project that meets clients' quality expectation [45]. Quality performance can be measured by looking into the nonconformity report (NCR) in the ISO 9000 certified company. Moreover, quality performance can be determined by taking clients’ satisfaction into consideration.

2.4. Client’s Satisfaction. Satisfaction has been explained as a function to make comparison between a perception of an outcome by an individual and the expectation of the outcome [46]. Client’s satisfaction has become challenging issue for the past few decades in construction industry. Usually, clients of construction sector experienced dissatisfaction in many aspects including overspend in project cost, delay of completion, poor quality, and incompetent project teams like subcontractors and consultants. There is a research suggesting that to build up relationship with a new client in construction industry is five times more expensive than to maintain existing one [47]. The findings also show that construction companies can increase their profits by 100 percent if they are able to retain five percent or more from the existing clients. Therefore, clients’ satisfaction is one of the key performance indicators for all the participants in construction industry. They must always show improvement in the performance if they want to survive and sustain in the global marketplace. However, quality performance of the products and services which have been received by client within cost and time is always tightly related to the measurement of clients’ satisfaction [48, 49].

2.5. Safety and Health. Safety and health is stated as the degree to which the general conditions promote the completion of a project without major fatalities or injuries [37]. Measurement of safety is primarily look at the amount of accidents occur during construction period. Construction works are well known as one of the most dangerous and risky activities throughout the world because large amount of people are being killed and injured every year. The finding of a research indicates that construction worker has three times more higher chances of dying and two times higher chances of getting injured compared to the workers involved in other industrial activities [50]. The safety performance is traditionally measured by using statistic data of injury and fatality. The main intention in measuring safety and health performance is providing information on the progress and current situation of site activities to control safety and health risks. Moreover, measurement will be only considered effective when it is reporting on the risk levels and also investigating the reason of exposing to current risk level. Then, the corrective actions will be taken to improve overall project performance ultimately.

3. Research Methodology

This study conducted survey to obtain the quantitative and qualitative profile of the QMS maintenance and practices towards project performance in construction industry. The survey is carried out by using questionnaires. The questionnaires are delivered by researchers. This method is employed in the study because face-to-face survey interview can clarify the questions, clear doubts, and make sure the questions are fully understood by the respondents before they answer the questionnaires. Besides, this method will reduce the “nonresponse” rate and obtain richer data about the QMS maintenance during the interview session. The following sections provide a detailed description of the methodology utilized in the survey.

3.1. Population. The population of this research consists of all the local construction projects of construction companies
4. Findings

The total number of respondents was 1050 and they are from 350 different construction projects which are scattered in Malaysia. The projects in construction are generally divided into 3 categories which are building, civil, and mechanical and electrical. A breakdown of the number of respondents obtained and the information of the project in which they are involved are detailed in Table 1.

4.1. Effectiveness of QMS in Project Performance. Effectiveness of QMS variables in project performance was tested with regression analysis. Project performance was broken down into seven variables including cost variance (CV), cost performance index (CPI), time variance (TV), nonconformance report (NCR), client satisfaction (CS), number of accidents (NA), and fatalities (F). Regression quantified the effectiveness of QMS variables in project performance. At the same time, regression explored pattern of relationship of QMS variables to every project performance indicator. QMS variables illustrate significant positive impact on client satisfaction and time variance. At the same time, QMS variables also show significant negative impact on the number of accidents and fatalities (Table 2).

4.2. Relationship between QMS and Project Performance. Correlation determined the relationship of every project performance indicator to QMS variables. QMS variables show significant but weak correlation with client satisfaction and time variance and very weak correlation with other significant project performance indicators (Table 3).

5. Discussion

Most of the companies adopt quality management to get competitiveness by improving quality performance [54–56] while construction companies implement QMS to improve their project performance (time, cost, and quality). There are seven indicators that have been used in this research to measure project performance, including cost variance, cost performance index, time variance, nonconformance reports, client satisfaction, number of accidents, and fatalities. Usually contractors will emphasize time, cost, and quality, but none of them can indicate overall project performance.

According to the client structure of a construction company [57], client (developer) will hire and manage the contractors to ensure the quality of the end products before handing over to end user. Furthermore, clients will normally list their requirements in detailed descriptions in the contract when awarding the project to contractors. That means client will have checklist and specification to evaluate project management performance from various aspects which have been stated in the contract. Hence, the client satisfaction may represent the overall project performance. In this research, two project performance indicators (client satisfaction and time variance) have shown significant positive relationship with QMS variables in regression analysis. At the same time, both client satisfaction and time variance also illustrated weak but significant correlation with QMS variables. That has explained why time is always tightly related to the measurement of clients’ satisfaction in previous studies [48, 49].
Table 1: Profile of respondents.

| Factor                             | Building | Civil | M and E | Overall |
|------------------------------------|----------|-------|---------|---------|
|                                    | Freq. %  | Freq. %| Freq. % | Freq. % |
| Gender                             |          |       |         |         |
| Male                               | 494 62.8 | 72 63.2| 101 67.3| 667 63.5|
| Female                             | 292 37.2 | 42 36.8| 49 32.7 | 383 36.5|
| Age                                |          |       |         |         |
| 20s                                | 350 44.5 | 55 48.2| 69 46.0 | 474 45.1|
| 30s                                | 399 50.8 | 52 45.6| 72 48.0 | 523 49.8|
| 40s                                | 26 3.3   | 7 6.1 | 7 4.7   | 40 3.8 |
| 50s                                | 8 1.0    | 0 0.0 | 2 1.3   | 10 1.0 |
| 60s and above                      | 3 0.4    | 0 0.0 | 0 0.0   | 3 0.3 |
| Role of interviewee’s company in project |        |       |         |         |
| Developer                           | 6 0.8    | 0 0.0 | 0 0.0   | 6 0.6 |
| Consultant                          | 3 0.4    | 3 2.6 | 0 0.0   | 6 0.6 |
| Main contractor                     | 744 94.6 | 108 94.8| 117 78.0| 969 92.2|
| Subcontractor                       | 33 4.2   | 3 2.6 | 33 22.0 | 69 6.6 |
| Year of service                     |          |       |         |         |
| 2 years and below                  | 208 26.5 | 35 30.6| 42 28.0 | 285 27.1|
| 3 to 5 years                       | 420 53.3 | 57 50.0| 70 46.6 | 547 52.1|
| 6 to 10 years                      | 132 16.8 | 19 16.7| 30 20.0 | 181 17.2|
| 11 to 15 years                     | 21 2.7   | 2 1.8 | 4 2.7   | 27 2.6 |
| 16 to 20 years                     | 3 0.4    | 1 0.9 | 4 2.7   | 8 0.8 |
| 21 years and above                 | 2 0.3    | 0 0.0 | 0 0.0   | 2 0.2 |
| Position                            |          |       |         |         |
| Top management¹                     | 66 8.4   | 9 7.9 | 11 7.3  | 86 8.2 |
| Middle management²                  | 628 79.9 | 89 78.1| 121 80.7| 838 79.8|
| Lower management³                   | 92 11.7  | 16 14.0| 18 12.0 | 126 12.0|

¹Managers level and above. ²Engineers, quantity surveyor, contract executive, and quality management executive. ³Supervisor, site administrator, and drought person.

Table 2: Regression result.

| Dependent variable               | Model      | B         | Std. error | Sig. |
|----------------------------------|------------|-----------|------------|------|
| Cost variance                    | Constant   | 3.816     | 0.246      | 0.000|
|                                  | QMS variables | -0.059  | 0.055      | 0.284|
| Cost performance index           | Constant   | 3.327     | 0.097      | 0.000|
|                                  | QMS variables | 0.004   | 0.022      | 0.842|
| Client satisfaction*             | Constant   | 4.567     | 0.098      | 0.000|
|                                  | QMS variables | 0.178   | 0.022      | 0.000|
| Nonconformance report            | Constant   | 5.206     | 0.184      | 0.000|
|                                  | QMS variables | 0.065   | 0.041      | 0.115|
| No. of accidents                 | Constant   | 5.114     | 0.044      | 0.000|
|                                  | QMS variables | -0.032  | 0.010      | 0.301|
| Time variance*                   | Constant   | 3.503     | 0.221      | 0.000|
|                                  | QMS variables | 0.345   | 0.049      | 0.000|
| Fatalities                       | Constant   | 2.062     | 0.015      | 0.000|
|                                  | QMS variables | -0.016  | 0.003      | 0.145|

*Significant at 0.05 level.
The overall ISO 9000 standards when those ISO certified companies have been set out in Clause 4 of the this context, In this context, QMS variables are refer to the interpretation and further discussion of this research. In performance indicators used in this research is crucial for complicated.

Hence, possibility of getting nonconformance reports tractors. All those factors will increase the chances of human errors. Hence, possibility of getting nonconformance reports also increases when the project size is getting bigger or more complicated.

Justification of each type of analysis result and project performance indicators used in this research is crucial for interpretation and further discussion of this research. In this context, In this context, QMS variables are refer to the requirements which have been set out in Clause 4 of the ISO 9000 standards when those ISO certified companies implemented quality management systems [58]. The overall results show that QMS variables have positive and significant relationship with client satisfaction and time variance. That coincides with the finding of an ISO 9000 study in Malaysia construction industry. That research concluded client satisfaction as one of the most important criteria to measure construction project performance [47] even though time and cost have been widely accepted as performance measures of a construction project [33].

Moreover, there are some studies also showing that QMS maintenance and practices can improve customer satisfaction and also quality performance such as structure documentation procedures and better control; cut the cost of project; reduce wastage of project; decrease chance to rework; and diminish conflicts, claims and disputes [59–65]. Nonetheless, those quality performance indicators are not used in this research because there is no standardized formula or measurement tools for those indicators. Furthermore, there is a research indicating that time variance has positive relationship with QMS maintenance and practices [66] which is supported by the result of this research also. For the other five project performance indicators, there are limited researches which are fully focused on the relationship between project performance and QMS maintenance and practices for comparison [67].

Nevertheless, there are some studies stating that some companies may not have improvement on performance after implementation of QMS [68–76]. Thus, QMS variables do not show strong relationship with client satisfaction because the data is only collected from construction companies within Malaysia. However, results of this research conclude that QMS maintenance and practices are generally able to improve project performance and overall performance which have been evidenced by client satisfaction and time variance from this research and other aspects from previous studies.

### 6. Conclusion

This research was set out to examine and verify the relationship between project performance indicators and QMS variables to contribute new knowledge of measuring project performance to construction industry. New and existing project performance indicators are assessed together towards QMS variables for comparison. The findings indicate that client satisfaction and time variance have positive and significant relationship with QMS while other project performance indicators do not show significant results. Previous studies have tended to examine effectiveness of QMS with other performance indicators. Moreover, there are limited researches in construction industry using project performance indicators to measure the effectiveness of QMS maintenance and practices. The findings of this research have enhanced the theory of project performance and QMS.

Nevertheless, a limitation of the research method is that the sampling of research is confined to Malaysia construction industry. Construction companies in different countries may have different results because their managing culture and environment are different. Therefore, that will affect the effectiveness of QMS maintenance and practices in project performance. However, the limitations above are uncertainty for this research because the data collected have passed the reliability and validation test. Thus, the thesis has resulted in

### Table 3: Correlation result.

| Variable           | QMS variables |
|--------------------|---------------|
| Cost variance      | Not significant |
| Cost performance index | Not significant |
| Client satisfaction* | Weak (0.230) |
| Nonconformance report* | Very weak (0.101) |
| No. of accidents*  | Very weak (−0.114) |
| Time variance*     | Weak (0.263) |
| Fatalities*        | Very weak (−0.111) |

*Significant at 0.05 level.
new findings and raises further areas that need to be explored. The recommendation to resolve the issues is doing further replications of the study in different countries in order to improve the generalizability of the findings. Further studies can also examine project performance indicators with other types of QMS such as total quality management and Kaizen.

**Conflict of Interests**

The authors declare that there is no conflict of interests regarding the publication of this paper.

**Acknowledgments**

The authors would like to thank the Faculty of Management and Human Resource Development, FRGS research Grant Vol. 4F093 (MOHE), MyBraini5 (MOHE), and UTM, Johor Bahru.

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