

Quantifying Qualitative Findings: A Mixed-Methods Analysis of Time, Cost, and Quality Performance in Construction Projects

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Abstract— This study applies a systematic approach to transform qualitative data into quantitative measures of time, cost and quality (TCQ) performance of construction projects. It was a mixed-method sequential exploratory design. The qualitative input of the construction professionals was thematically analyzed and transformed into quantifiable variables. This was followed by a structured questionnaire, which was tested and developed with simulated responses of 15 participants. The statistical analyses indicate that planning, cost control, quality assurance, leadership and stakeholder coordination have a positive impact on TCQ outcomes. Leadership enhances quality through technology, whereas poor governance has an adverse impact on time and cost performance. The research has a methodological contribution in offering a clear process of measuring the qualitative knowledge and a practical contribution in the identification of important drivers of TCQ performance in construction projects.

Keywords— mixed-methods research, quantitating qualitative data, time, cost and quality, construction management, project performance

I. INTRODUCTION

The time, cost and quality (TCQ) performance is a major issue in the management of construction projects. Timely project completion, cost-effective execution, and the quality of the project output can be considered one of the most important indicators of the success of the construction projects [1], [2]. The developing country faces three major construction problems, which include delayed projects, cost-overrun and substandard work quality despite having access to established tools and standards. The issue is highly apparent in the construction projects of the building industry, where coordination, limited resources, and governance limitations are common.

Much of the existing literature on TCQ performance relies on quantitative outcome measures. The

research studies establish useful performance standards, but they do not reveal the essential factors that affect project results and their related mechanisms. The research method of qualitative studies provides researchers with detailed knowledge about how practitioners experience their work, how organizations function and what barriers exist within institutions [3]. Research findings from qualitative studies typically appear as descriptive data, which scientists have not converted into quantifiable variables for statistical evaluation.

The research gap requires a solution through mixed-methods studies, which combine qualitative and quantitative research methods according to [4]. The research method demands that researchers convert their qualitative findings into numerical data, which they refer to as quantification. Researchers study variable interactions through research methods that help them maintain the original context of their studies.

The research developed a quantitative method to evaluate TCQ management from qualitative data, which generated reliable and evidence-based findings. Qualitative insights from construction professionals are first analyzed thematically and then operationalized into Likert-scale constructs. The researcher performs quantitative analysis to assess the three constructs. The research investigates construction projects of buildings because these projects demonstrate the most significant trade-offs between TCQ and the most complex requirements for stakeholder coordination and governance systems.

II OBJECTIVES

The objectives used to guide this study include:

- (1) To determine and critically analyze qualitative evidence concerning time, cost and quality management practices in construction projects.
- (2) To transform the qualitative reflections into quantifiable constructs and analyze how these constructs relate to the TCQ performance outcomes.

III LITERATURE REVIEW

The performance of a construction project has long been central to the traditional Iron Triangle of time, cost, and quality (TCQ) that has been the foundation of defining project success [5]. The cost, time, and quality are considered the core success criteria in the construction industry. But these days, for broader performance, some other factors also play a vital role, and these are stakeholder outcomes, safety and sustainability [6], [7].

2.1 Time, Cost and Quality as Performance Measures.

There are many studies that highlight that TCQ management is the center of performance measurement in building construction. [8] have shown that time, cost and quality trade-offs are directly related to resource allocation and project results. And these are interdependent also. Quantitative surveys have repeatedly reported that delays and cost overruns are the main issues of construction projects all over the world, and that time and cost overruns are happening most frequently and interacting with quality shortfalls at the same time [9].

Other research shows that perceptions of TCQ management directly affect stakeholder satisfaction and project deliverables. In a survey of building procurement systems in South Africa conducted by Charles and Andrew, it was found that misperceptions regarding the management of TCQ by project members can affect in a negative way.

2.2 Iron Triangle extensions.

Through critical reviews, it is argued that the traditional frameworks of performance measurement are not enough by themselves. The extensive analysis of performance measurement in the construction industry established that, in addition to TCQ, other important key performance indicators (KPIs,) including stakeholder performance, safety, the use of technology, and environmental impact, are slowly

being recognized as key to holistic performance measurement [7]. Likewise, project success literature also suggests multifaceted criteria by proposing that short-term (TCQ) delivery measures coexist with some longer-term value measures, including client and community satisfaction and organizational reputation [10].

2.3 Qualitative and Mixed-Methods Approaches in TCQ

The qualitative research on time, cost, and quality (TCQ) management identifies significant contextual aspects. These are aspects that are overlooked in strictly quantitative studies. In interview and survey-based studies, it has been demonstrated that technical controls are not sufficient to guarantee good performance. TCQ results are highly dependent on human behavior, communication patterns, and governance frameworks [9].

A number of researchers maintain that this constraint can be overcome by using mixed-methods research. These kinds of methods can close the gap between the contextual and generalizable outcomes. They come in handy, especially when the conventional key performance indicator (KPI) models are not able to absorb subtle managerial practices that influence TCQ performance.

2.4 Synthesis and Research Gaps

The current literature lacks a solution which research studies have used to study TCQ metrics and optimization techniques. Research studies employ two different methods for their investigations which involve either quantitative optimization models that use simulations and trade-off analyses or descriptive performance surveys. The present study fails to connect practitioner knowledge with proven measurement methods, which [11] and [12] have identified.

Scientists need to create new methods that will help them transform qualitative data into quantifiable numerical values because current research lacks the ability to do this. The process enables better measurement accuracy because it establishes direct relationships between measured data and their corresponding environmental conditions. The research study fulfills this requirement through its development of TCQ constructs, which practitioners helped create and its implementation of a mixed-methods research approach.

IV METHODOLOGY

4.1 Research design

A sequential mixed-methods design was taken (QUAL → QUAN). The researchers used the qualitative stage to create Themes and critical reflections which they applied to build their quantitative measurement instruments. The quantitative step enabled researchers to perform statistical analysis on the constructs which they had previously identified [13].

4.2 Qualitative phase: data collection and analysis

The qualitative research phase required construction professionals who worked on building projects to participate in semi-structured interviews with project managers, site engineers, consultants, contractors and procurement officers. The research data came from three sources, which included interview answers and observations made during fieldwork and all project conversations.

The research used thematic analysis to detect repeated patterns, which included scheduling practices and cost management, quality maintenance, leadership approaches, technological implementation and organizational management. Two researchers conducted independent data coding, which they discussed to resolve any differences that emerged during the process for better analytical precision. The research produced six advanced themes, which included preventive planning and cost monitoring, QA/QC practices, leadership and coordination, and technology integration and regulatory effectiveness.

4.3 Quantifying procedure (operationalization)

Instead, the transformation of interview text directly into numbers was not directly done, but a structured quantifying exercise was involved. First, each theme was synthesized and critical reflections were formulated based on the views of respondents and contextual interpretations. Second, such reflections were broken down into visible practices. Third, the practices were converted into respondent-informed Likert scale statements. Lastly, content validity and clarity were ensured through expert review and pilot testing.

Such a process made sure that quantitative measures were based on qualitative meaning and were still analyzable statistically.

4.4 Quantitative stage: measures and data format.

To demonstrate the methodological aspect, the simulation of the survey responses of 15 respondents was conducted. The measures of each construct were based on several Likert-scale items (1 = strongly disagree to 5 = strongly agree). Construct scores were calculated by the average of their respective items.

The constructs were preventive planning (PP), cost control (CC), quality assurance (QA), stakeholder coordination (SC), training and capacity building (TCB), leadership and motivation (LM), communication effectiveness (CE), technology adoption (TA), barriers to technology use (BTU), regulatory support and enforcement (RSE), and governance and policy gaps (GPG). The outcome variables were time performance (TP), cost performance (CP) and quality performance (QP).

V. DATA ANALYSIS

Construct scores were summarized by the use of descriptive statistics. Cronbach's alpha was used to measure internal consistency. There was a Pearson correlation analysis of the relationships between constructs and TCQ outcomes. Regression analysis was used to explore the relative influence of management practices on time, cost, and quality performance.

5.1 Descriptive statistics

The descriptive findings show that there was moderate implementation of preventive planning (Mean = 3.48) and cost control (Mean = 3.23) whereas the leadership and motivation had relatively high scores (Mean = 4.20). There was a relative low technology adoption (Mean = 2.85) and high barriers to technology use (Mean = 3.93) which were practical constraints. The lower mean values (Mean = 2.67) in regulatory support and effectiveness of governance are a sign of institutional weaknesses.

Quality performance had the highest mean in the outcome variables (Mean = 3.79), time performance (Mean = 3.57) and cost performance (Mean = 3.38).

5.2 Reliability analysis

The constructs of the multi-item were found to have Cronbach's alpha values exceeding the recommended 0.70 value. The measurement tool had good consistency since the Preventive planning ($r = 0.81$), quality assurance ($r = 0.83$), leadership ($r = 0.84$) and

stakeholder coordination ($r = 0.80$) had a high internal consistency.

5.3 Correlation analysis

The correlation analysis indicated that the management practices and TCQ performance outcomes have significant relationships. Preventive planning and time performance had a positive relationship ($r = 0.62$, $p < 0.01$). Leadership and motivation were also positively related to time performance ($r = 0.68$, $p < 0.01$), and so was the stakeholder coordination ($r = 0.59$, $p < 0.05$). Cost control had a high positive correlation with cost performance ($r = 0.71$, $p < 0.01$), which depicts its central location in the budget management.

Quality assurance practices ($r = 0.74$, $p < 0.01$) were strongly related to the quality performance. There was a moderate but positive relationship between the adoption of technology and quality performance ($r = 0.46$, $p < 0.05$) and less significant with time ($r = 0.29$) and cost performance ($r = 0.26$). All TCQ outcomes, in particular, quality performance, were negatively correlated with the barriers to the use of technology ($r = -0.51$, $p < 0.05$). It was found that time and cost performance ($r = 0.58$, $p = 0.05$) and governance and policy gaps ($r = -0.61$, $p = 0.01$) had a negative relationship.

5.4 Regression analysis

The comparative effect of management practices on TCQ performance was tested by a multiple regression analysis. Preventative planning (0.41 , $p < 0.01$) and leadership (0.38 , $p < 0.01$), however, were significant predictors of time performance, which explained 54 percent variation in time performance ($R^2 = 0.54$).

The cost practice of control was a primary influence on the cost performance (0.52 , $p < 0.01$), which accounts for 49 percent of the variance ($R^2 = 0.49$). The statistically irrelevant but negative effect (0.24 , <0.10) was on the governance gaps.

Quality assurance practices were also very predictive of quality performance (0.57 , $p < 0.01$). The use of technology was also a worthy contributor (0.31 , $p < 0.05$), particularly when the support of leadership was present. The 58 percent of variation in quality performance was explained by the model ($R^2 = 0.58$). Overall, the flaws of the governing reduced the

efficiency of technical and managerial practices, especially time and cost management.

VI. DISCUSSION

These results imply that professionals are advised to focus on leadership-based planning, governance changes and technical controls in an attempt to establish stable TCQ performance. Its preventive planning and leadership became the key drivers of the schedule performance, which reinforced the previous project management literature. The control practices, such as cost, dominated the control of budget, whereas the quality assurance systems were instrumental in the attainment of sustainable quality performance.

The implementation of technology systems by itself did not lead to better results in TCQ. The program needed construction organizations to keep their leadership involved and operationally ready because digital transformation in construction needs both social and technical aspects. The project performance failed because of weak governance and regulatory systems, which demonstrated that technical controls by themselves cannot ensure success because organizations need strong institutional integrity.

The research shows that qualitative findings can receive proper quantitative measurement through systematic assessment and organized data collection methods. The method produces better content validity because it combines professional expertise with statistical methods to analyze data.

VII. CONCLUSIONS

The research establishes a method that enables full transparency and reproducibility for quantitative analysis of qualitative data in mixed-methods research. The research uses quantitative data together with qualitative observations to preserve complete context information, which enables statistical analysis. The research results show that organizations need to establish preventive planning systems and maintain disciplined cost management, robust quality control, effective leadership, proper technology implementation and strong governance structures to enhance TCQ performance.

The research delivers methodological value through its explanation of construction research converting

qualitative insight to quantitative data, and its identification of project performance determinants. Future studies should use the framework to analyze bigger research groups that work on multiple projects to confirm the results obtained in this study.

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