Examining Influence of Construction Projects' Quality Factors on Client Satisfaction Using Partial Least Squares Structural Equation Modeling

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Abstract: Quality and client satisfaction is a long-established focus of attention in the construction industry due to its significant role in the success or failure of a project, yet few studies have examined the impact of a lack of quality on client satisfaction in the context of public construction projects. This study, therefore, proposes that lack of quality in construction projects has a significant impact on client satisfaction using a partial least squares structural equation modeling (PLS-SEM) technique. A conceptual model was developed for assessment of client satisfaction, and the model consisted of two main latent variables. Through the questionnaire survey, an empirical analysis was carried out to test the conceptual model. Data were collected from 484 construction experts employed in the Pakistani public construction industry. The result of the analysis found that the R^2 value of the model was 0.454, which revealed that lack of quality in projects has a significant impact on client satisfaction. Based on the final form of the model, the construction-related factor (beta = 0.491) has a greater influence on client satisfaction. The goodness of fit index of the conceptual model was measured to be 0.54, which revealed that the conceptual model has appropriate reliability and validity and fits the data correctly. This study adds to the body of knowledge by offering new insights and contributes toward greater understanding of lack of quality in public projects and its impact on client satisfaction, and use of applied advance statistical method, PLS-SEM, which is previously missing in the literature. The lessons from this study would be helpful for policymakers and decision makers to focus on highlighted issues and problems faced by the public construction industry worldwide. **DOI: 10.1061/(ASCE)CO.1943-7862.0001655.**

Author keywords: Lack of quality; Impact client satisfaction; Structural equation model; Public construction projects.

Introduction

In construction projects, the client's role is indispensable (Cherns and Bryant 1984) because the client can assist in completing the project on schedule, within planned budget, and with the highest quality to satisfy the client's requirements for the project (Kamara et al. 2002; Yu et al. 2010). The literature has stated client satisfaction faces subsequent critical problems in being realized: lack of quality, overrunning project cost, time extension, unsafe construction, and incompetent service providers (Rashvand et al. 2014; Sambasivan and Soon 2007; Shehu et al. 2014). Client dissatisfaction, therefore, is not only hindrance to deteriorating motivation and teamwork among project participants, but also decreases the opportunity for successful project completion.

The construction industry is complex in nature (Rashvand et al. 2014) because it involves many parties (Doloi et al. 2011; Yang and Kao 2011) that closely interact and are interrelated until project completion (Leung et al. 2004; Yang and Peng 2008). The primary aim of parties involved in a project is to have a successful execution of that construction project in accordance with the plans and specification, within a predefined time, cost, and quality (Harmon 2003; Maloney 2002; Yang and Peng 2008). Quality in the construction industry is getting the predetermined requisites and specification (Shanmugapriya and Subramanian 2015). It is a key contributor to any project, where lack of a quality monitoring mechanism (Luo et al. 2015), lack of skilled workers (Hoonakker et al. 2010), aggressive competition during tendering (Jha and Iyer 2006), poor communication and coordination (Gan et al. 2017), incompetence of technology and equipment (Luo et al. 2015), lack of contractor experience (Luo et al. 2015; Tam et al. 2007), and lack of project standards will negatively impact project quality. The final product in any industry should be manufactured in accordance with the required standard (Chan and Tam 2000). Projects that are incomplete in terms of quality and the required standard will have an impact on the project performance (Tan and Lu 1995) and client satisfaction, which leads to violation of the contract agreement.

Many researchers have argued that client satisfaction is one of the important dimensions of project success (Davis 2014; Dov et al. 2003; Joslin and Müller 2016). The client (owner) is responsible for the planning, bidding, financing, and overall management of the project, so client satisfaction is imperative to the critical success of projects (Chan and Chan 2004). According to ISO 9000 standard (ISO 1992), total quality management is a complete management philosophy, specifically with regard to continuous improvement to product, process, and client satisfaction. Many researchers and practitioners, for example, Sroufe and Curkovic (2008), Calisir (2007), and Singels et al. (2001), have endorsed that client satisfaction is imperative for total quality management philosophy. Clients' expectations and perceived quality are functions of client

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satisfaction. Because of inexperience or lack of adequate time for an efficient investment decision-making approaches, there is a meaningful difference between the stated and actual need (Nkado and Mbachu 2001). This may be the cause of the reported high degree of client dissatisfaction within the construction industry (Liu and Walker 1998), and client dissatisfaction can lead to loss of revenue (Band 1991). Subsequently, the lack of quality in public infrastructure projects, as one dimension of impact of client satisfaction, is among the most vital problems in the public construction industry. However, this study aims to analyze client satisfaction not only as a criterion but also as a foundation of competitive advantage, i.e., successful implementation of a public construction project.

The public construction industry in Pakistan is considered a dynamic sector due to its rapid and constant changes, and its growth has exceeded that of various other areas of the economy. A number of government-budgeted projects have failed to attain the quality performance assigned in the project contract agreement with the contractor. For government-funded construction projects, the goal and expectations of clients are to ensure that projects are completed according to agreed standards for the sake of satisfaction and project sustainability (Hussain et al. 2018). A successful project means that the project goals and expectations are met (Alzahrani and Emsley 2013). The public construction industry is potentially established by public projects, where the project quality and client satisfaction are associated with each other. Thus, client satisfaction is an important issue in the public construction industry, which takes serious consideration of improving project quality. Hence, it is indispensable to reveal the lack of quality factors that potentially impact client satisfaction in the public construction industry. In this regard, this study therefore seeks to investigate and provide answers to the following questions:

- Which factor (construct) is root cause of lack of quality in public construction industry?
- Is the lack of quality in project having a direct impact on client satisfaction?
- How can partial least squares structural equation modeling (PLS-SEM) method be applied to examine the lack of quality factors that affect the client satisfaction in public construction industry?
- How can this study help practitioners in future to prevent or minimize the lack of quality in public projects?

Quality and client satisfaction have been addressed by countless studies, but little attention has been given to how client satisfaction is influenced by lack of quality in the context of public infrastructure projects, especially in Pakistan. To the best of the authors' knowledge, there is a lack of studies that have provided a comprehensive model that demonstrates how the lack of construction quality has directly influence client satisfaction. In this study, the authors attempt to provide an empirical model that will help not only construction practitioners but also researchers to reveal how client satisfaction can be influenced by lack of quality in construction projects. In addition, this study has used PLS-SEM, containing a number of newly developed latest analysis methods, to measure the proposed model and the relationship between the latent variables, hence offering an important methodological contribution to the existing body of literature.

Objectives of the Study

The key purpose of this study is to assess the views of public construction practitioners toward factors affecting quality and its effect on client satisfaction. Furthermore, the study presents the most effective techniques in preventing/mitigating factors affecting quality that affect the client satisfaction in the public infrastructure industry. The key objectives of this study include

- identifying factors affecting quality in public construction projects so similar mistakes could be avoided in future,
- investigating the views of clients that a lack of quality has direct impact on client satisfaction, and
- using the PLS-SEM method to examine the lack of quality factors that affect client satisfaction in public construction industry.

Literature Review

Factors Affecting Quality

Researchers have defined construction quality as "meeting expectations of the customer" (Kanji and Wong 1998; Kärnä 2004; Torbica and Stroh 1999), "conformance to ISO 9000 criteria" (Loushine et al. 2006; Tan and Lu 1995), and "completion on-time and within budget" (Loushine et al. 2006; Love et al. 1999). Thus, the quality management should not be based on "controlling the construction process," but quality should be defined as the project expectations of the client/owner (Loushine et al. 2006). Quality management is one of the most vital commitments to customers by industries in general and the public construction industry in particular. Construction industries have progressively implemented quality management as an initiative to elucidate quality challenges and fulfill the requirements of the final customer (Hoonakker et al. 2010; Kanji and Wong 1998), steps that can contribute to the sustainability and successful completion of the project.

For good performance in terms of quality of construction projects, Adenuga (2013) studied factors affecting quality in public housing projects and found that joint working, mutual objectives, no blame culture, introducing quality assurance methods, effective management team of contractors, no enforcement of bureaucracy, and politics were the most significant factors. Barrett (2000) recognized that quality in construction could be considered as the satisfaction of a complete range of performance benchmarks held by a range of participants and facilitated by a variety of approaches. Hoonakker et al. (2010) identified the problems of defining quality, measured possible benefits of implementing quality in the construction industry, and looked at hurdles to quality implementation in construction.

Abdel-Razek (1998) described how construction managers agree in terms of opinions on factors to improve quality on construction projects and found that "improvement of employee satisfaction" was the fundamental area in contributing to quality improvement in Egypt. Bubshait and Al-Atiq (1999) surveyed quality standards in construction, which confirmed that consistent quality was necessary for avoiding problems and repetitions of problems. Their survey also indicated that the majority of the contractors have a dearth of documentation of a quality system. Shammas-Toma et al. (1998) measured some hindrances to implementing total quality management and focused on coordination as a key requirement. Those authors considered three main characteristics of contemporary practice and provided proof that there was a coordination problem regarding these in the construction process, and that this was reflected in a significant degree of inadequate quality. Chan and Tam (2000) surveyed the fundamental causes affecting the quality of building projects in the Hong Kong construction industry. Those authors proposed that project management action by the project team was the most important quality factor, followed by efficiency of the construction project management leader and importance of quality to the client. Jha and Iyer (2006)

studied critical factors affecting quality performance in construction projects and found that conflict among project participants, hostile socioeconomic environment, project manager's ignorance and lack of knowledge, and aggressive competition during tendering negatively affect the quality performance of construction projects.

Client Satisfaction/Dissatisfaction

Client satisfaction has been viewed as an important objective or as a performance measurement tool in the development of construction projects. In order to evaluate client satisfaction in the public construction industry, the basic meaning must be determined. A client may be stated as the owner of the project. The owner is the investor (Turner and Zolin 2012) and the one who needs the constructed facility. Meanwhile, satisfaction has been defined by Czepiel et al. (1985) as "the result of some comparison process in which expectations are compared to what is actually received." However, client satisfaction has been defined as how completely a contractor or service provider meets or exceeds the client's expectations (Maloney 2002). Researchers proposed that satisfaction is an antecedent of quality (Anderson et al. 1994). The client verifies the project's performance against an internal standard and are satisfied when the project is ahead of the standard but dissatisfied when it falls behind (Haverila and Fehr 2016).

Many studies have suggested the significance of client satisfaction and its use for assessing quality from the clients' view (Barrett 2000; Maloney 2002; Torbica and Stroh 2001). Toor and Ogunlana (2009) demonstrated use of client satisfaction as a criterion for measuring project success and argued that a project might not be regarded as successful until it has accomplished the final objectives and met client expectations. Ahmed and Kangari (1995) analyzed client satisfaction in the construction industry and proposed six key factors as imperative for client satisfaction: time, cost, quality, client orientation, communication skills, and response to complaints. Moreover, they determined that these six factors were equally significant when assessing client satisfaction. Tang et al. (2003) studied the Hong Kong construction industry and found that clients will be more satisfied when engineering consulting firms can show professionalism, competitiveness of service, timeliness of service, quality of design, innovativeness, support for the client, and good supervision at the implementation stage of the project. Lim and Mohamed (1999) classified project success into two levels, i.e., micro and macro, where the micro perspective is associated with the project or organization objectives/goals, for instance time, cost, quality, performance, and safety, whereas the macro perspective relates to the clients' satisfaction.

Dissatisfaction, on the other hand, is extensively faced by clients of the public construction sector. It may be initiated by numerous features, but is mainly attributable to increases in project costs, time extensions, falling behind schedule, delayed or postponed completion, poorer quality, and incapable contractors (Chan 2001). Client dissatisfaction in the construction industry has been considerably discussed in the literature (Kometa et al. 1994; Mbachu 2003). Nkado and Mbachu (2001) argued that a key standard for evaluating client satisfaction in the construction industry was based on clients' "stated" and "latent" needs and objectives. Moreover, by failing to incorporate clients' planned goals and other tacit needs in handover of the project, service providers fail to fulfill client satisfaction. If the project team fails to meet requirements from the client point of view, the client can be dissatisfied (Mbachu and Nkado 2006).

Turner (1990) realized that the lack of right selection of procurement direction could lead to dissatisfactory consequences despite reliable endeavors by the project team in the procurement process. Dulaimi et al. (1996) determined that the failure of clients' needs to be fully realized and properly executed is primarily responsible for the generally stated client dissatisfaction. Atkinson et al. (1997) reported that the client could be dissatisfied if the final project fails to achieve the cost, time, quality, functionality, and performance standard. Kumaraswamy and Walker (1999) reported that variations have been acknowledged on the basis of contractors' claims, and excessive claims of contractors can lead to dissatisfied clients. Moreover, those authors suggested that contractor selection criteria incorporate a variety of considerations other than a lowest-bid-wins system. If not incorporated, the lack of such measures could be contributing to client dissatisfaction at the end of the construction phase. McDermott (1999) assumed that construction claims were the outcome of a poor selection of procurement strategy. Moreover, that study's findings showed a connection between use of a traditional procurement strategy and construction project delay claims. A traditional procurement strategy is one in which the contractors or service provider is not involved in the initial project process; this can cause a delay in construction projects and lead to client dissatisfaction.

Research Method

Conceptual Model

PLS-SEM is an extensive multivariate analysis method to calculate variance-based structural equation models, especially in the social sciences (Rigdon 2012; Rönkkö et al. 2016). Path models with latent variables contain measurement models that explain the relationships between latent variables and their observed indicators. The SEM method is extensively used to investigate and test complex system of association and causal relationships (Sarstedt et al. 2014; Schubring et al. 2016). SEM is a mixture of regression, multiple correlations, factor analysis, and path analysis.

The relationship between project quality and client satisfaction can be found in literature, although understanding remains in its initial stages (Davis 2014; Krajangsri and Pongpeng 2016; Li et al. 2013; Tang et al. 2003; Yeung et al. 2009). Nonetheless, there is a paucity of research that develop a holistic variable model of how the lack of quality in projects directly impacts client satisfaction in order to help construction participants identify and evaluate such quality defects, possibly because of the difficulty in identification. When assessing the lack of quality factors and their direct impact on client satisfaction using PLS-SEM, a conceptual model is mandatory. The conceptual model is explained in terms of the relations between latent variables and respective observed variables. The first step is to ascertain the latent variables in the structural model and establish the hypothesis for investigation, which is quality and satisfaction. Because latent (unobserved) variables are not directly measured, a model must be created to measure them using manifest (observed) variables. The model created in this study is based on 18 observed variables that affect quality. These variables, which are called exogenous latent variables, are categorized into four groups: a design-related factor, material-related factor, construction-related factor, and stakeholder-related factor. The endogenous latent variable is client satisfaction, which is based on four indicators. Observed variables are directly measured using a 5-point Likert scale. The conceptual model demonstrating the relation between exogenous manifest variables and endogenous manifest variables as well as latent variables is shown in Fig. 1. Endogenous variables are also referred to as latent dependent variables (DV), which can be affected by both endogenous and

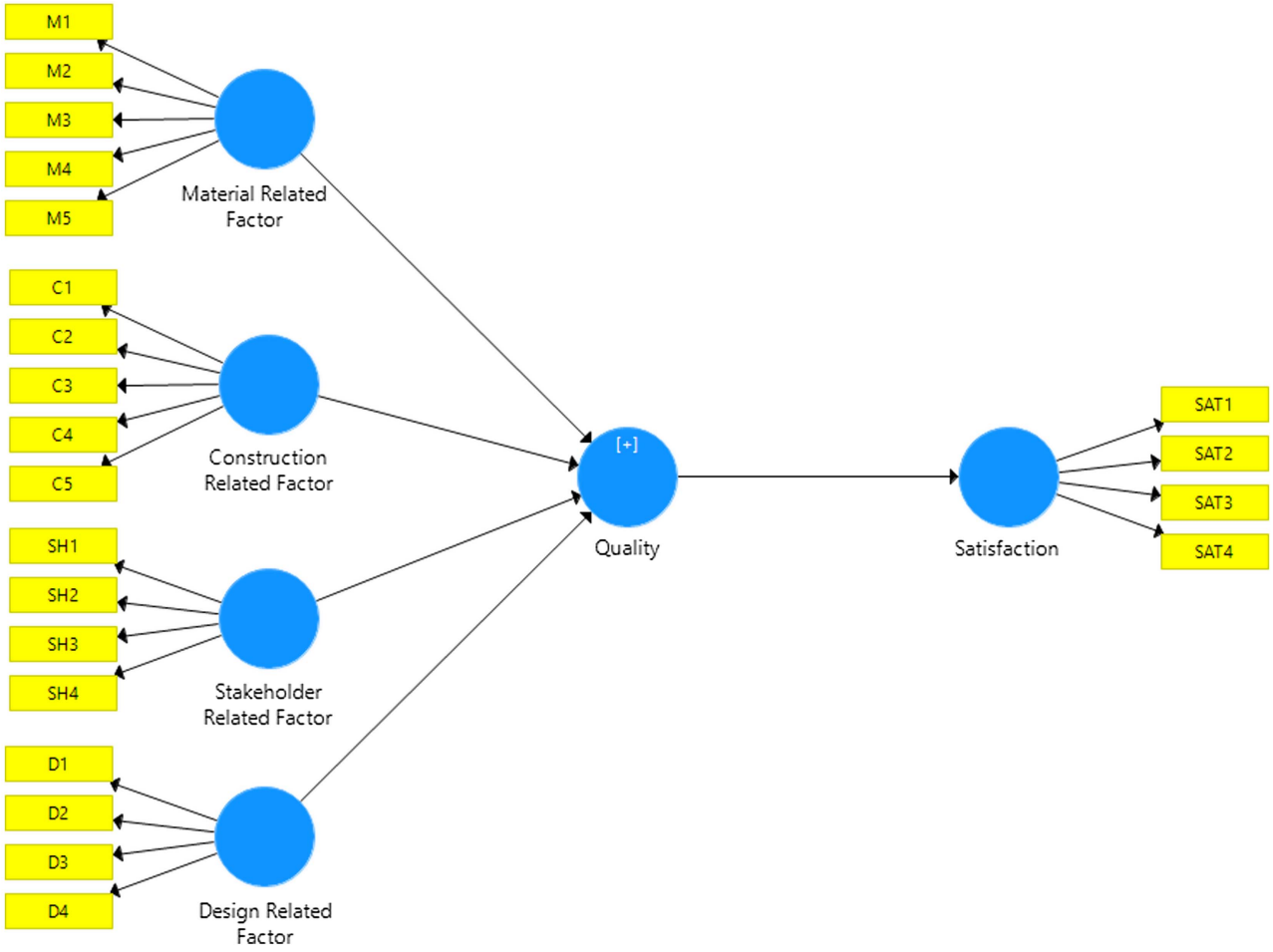

Fig. 1. Conceptual model.

exogenous variables, whereas exogenous variables are stated as independent latent variables (IV) (Krajangsri and Pongpeng 2016).

However, the question of what factors affect the project quality and impact on client satisfaction at the project level clearly remains unanswered in the context of the public construction industry through structural equation modeling, and further investigation is needed. Therefore, this study aims to address this knowledge gap. For this study, the hypothesis is as follows:

Hypothesis 1 (H1) Lack of project quality significantly affects client satisfaction.

Questionnaire Design

A questionnaire-based survey was used to collect data from public construction industry practitioners. The first step was to identify factors that affect quality and client satisfaction through a detailed literature review. A questionnaire was devised to get the perceptions of construction experts in the public construction industry in the Pakistan. A comprehensive questionnaire was developed and used to get input from participants, consisting of two sections. The first section of the questionnaire contained general information about the target respondents, such as years of working experience, education background, and working position in the organization. The second section consisted of the main questions divided into two parts. As indicated in Table 1, the first part focused on identified factors influencing the quality and the second part of the questionnaire focused on factors affecting client satisfaction. The questions were close-ended using a Likert scale from 1 (strongly disagree) to 5 (strongly agree). It required every respondent to select a perceived importance rating of the 22 variables on the basis of personal experience.

Data Collection and Sampling

In total, 22 variables were identified from the literature; this provided the foundation for the creation of a preliminary questionnaire. The questionnaire was formulated with the aim to be as understandable as possible. Before the final survey, a pilot study was carried out to pretest the survey, and consequently, alter it before a final form was produced; 12 public construction experts were involved in reviewing the structure and design of the questionnaire to ensure easy understanding for respondents. These professionals were from the public construction industry with sufficient industry and academic expertise in managing public construction projects in Pakistan. The primary aim of the pilot study was to validate the completeness of the questionnaire and verify whether the significance of the hypothesized factors affecting the quality and client satisfaction were valid and relevant to the Pakistan public construction industry. Finally, a modified list of variables was framed, which was used to develop the formal questionnaire for collecting the data to formulate fundamental relations and relative significance among the variables, which helped the successive analyses of the quality defects and client satisfaction.

The final list of the questions in the form of a questionnaire was emailed and personally handed to a total of 900 public

Table 1. Preliminary list of factors affecting quality and client satisfaction

Factor	Code	References
Quality influencing factors		
Construction-related factors		
1. Low level of skill and labor experience	C1	Gan et al. (2017), Hoonakker et al. (2010), and Oyedele et al. (2015)
2. Contractors' poor technical knowledge	C2	Gan et al. (2017), Hoonakker et al. (2010), and Tan and Lu (1995)
3. Inadequate site supervision by contractor	C3	Gan et al. (2017) and Tan and Lu (1995)
4. Obsolescent construction technology and equipment	C4	Gan et al. (2017)
5. Limited construction time imposed by project clients	C5	Hoonakker et al. (2010) and Oyedele et al. (2015)
Design-related factors		
1. Low quality design and specification	D1	Arditi and Gunaydin (1998)
2. Flaws in design specification	D2	Abas et al. (2015)
3. Design changes during construction	D3	Gan et al. (2017) and Tan and Lu (1995)
4. Difficult to data collection during design	D4	Arditi and Gunaydin (1997)
Material-related factors		
1. Lack of quality criteria for component materials	M1	Delgado-Hernandez and Aspinwall (2008) and Gan et al. (2017)
2. Poor equipment for material quality testing	M2	Gan et al. (2017)
3. Escalation of material prices	M3	Gan et al. (2017)
4. Poor quality of raw material	M4	Abas et al. (2015)
5. Low bid	M5	Jha and Iyer (2006)
Stakeholder-related factors		
1. Lack of contractor supervision	SH1	Arditi and Gunaydin (1998), Hoonakker et al. (2010), and Oyedele et al. (2015)
2. Lack of project managers in construction site	SH2	Gan et al. (2017)
3. Poor quality procedure/policy	SH3	Arditi and Gunaydin (1997) and Delgado-Hernandez and Aspinwall (2008)
4. Lack of management commitment to quality	SH5	Hiyassat (2000), Oyedele et al. (2015), and Yung and Yip (2010)
Factors affecting client satisfaction		
1. Lack of safety issues	SAT1	Kärnä et al. (2009)
2. Lack of project completed within budget	SAT2	Enshassi et al. (2009a) and Gunduz et al. (2013)
3. Lack of project completed on time	SAT3	Kärnä (2004) and Oyewobi et al. (2015)
4. Deviation between expected and actual construction performance	SAT4	Enshassi et al. (2009b)

construction experts who showed willingness or who accepted an invitation to take part in the research, along with a covering letter explaining the study aim and assuring them of privacy. Both mailed and personally administered survey methods were used with the help of a structured (close-ended) questionnaire survey. Data for this study were collected from public construction industries [City Development Authority (CDA), Public Work Department (PWD), Defense Housing Authority (DHA), Water and Power Development Authority (WAPDA), National Logistics Cell (NLC), and Water and Sanitation Agency (WASA)] in Pakistan. The key target respondents for the survey were clients (from government officials and departments). All participated respondents were male from the same industrial sector in Pakistan, and most of them were civil engineers by education. The respondents were executives, project managers, engineers, subengineers, quantity surveyors, and designers in each of the public construction industries who had acquired satisfactory professional experience to explain the relationships in this study.

A simple random sampling technique was used to select the sample from the public construction industry in Pakistan. The samples were selected from publicly available online sources, government directories, and organization records. Support from the client and follow-up phone calls or emails as frequent reminders resulted in an effective response rate. The survey was conducted from June 14, 2017, to September 12, 2017. Ultimately, 490 responses were received over a period of 3 months. Of these, six were rejected because of invalid or insufficient information provided by the respondent. The remaining 484 valid and effective questionnaires were used for final analysis, representing a response rate of 53.7%.

The demographic information is presented in Table 2. Among the 484 effective responses, 67% of respondents had more than 16 years of experience in managing the public construction industry. Moreover, 81% of the respondents had an engineering degree, and most of them were project managers in their respective field. This signifies that the respondents in the survey were experienced and had adequate knowledge to understand the questionnaire and respond accordingly. Hence the collected data are believed

Table 2. Respondent demographic information

Characteristic	Frequency	Percentage	Cumulative percentage
Experience (years)			
0–5	65	13	13
6–15	95	20	33
16–20	190	39	72
>20	134	28	100
Education			
Diploma in Civil Engineering	90	19	19
B-Tech. Civil	80	17	35
B.Sc. Civil Engineering	214	44	79
M.Sc. Engineering	100	21	100
Working Position			
Executive	90	19	19
Project manager	120	25	43
Engineer	98	20	64
Subengineer	86	18	81
Quantity surveying	40	8	90
Designer	50	10	100

sufficient to get a sound judgment from experienced respondents in a perception study of this nature.

Data Analysis

This section summarizes detailed results from several analyses that were performed on empirical data collected from the survey. PLS-SEM is a technique for estimating structural equation models. In this study, PLS-SEM is used for analysis of the collected data. The aim of this study is to identify the factors affecting project quality that contribute to impact the client satisfaction. In total, 18 factors affecting the quality and four factors impacting client satisfaction were identified through literature review and used to develop a model. The developed conceptual model was implemented in Smart-PLS version 3 (Ringle et al. 2005) software for simulation work in measuring the effect of project quality factors (IDV) on client satisfaction (DV).

The model assessment is divided into two approaches through which the model is analyzed (Henseler et al. 2009). The first one is an assessment of the outer measurement model and the second is an assessment of the inner structural model. Smart-PLS software was used for analysis and validation of the model in this study.

Assessment of Outer Measurement Model

The outer measurement model is designed to measure the consistency and validity of the observed variables. The measure of internal consistency is computed through individual manifest and construct reliability test, and on the other hand, the validity of the variables is tested based on convergent and discriminant validity (Hair et al. 2012). Single manifest reliability describes the manifest comparative with a latent variable by computing consistent outer loading of the manifest variables. A value of manifest variables with outer loading greater than 0.7 is acceptable (Henseler et al. 2009).

Cronbach's alpha, composite reliability (CR) scores, and average variance extracted (AVE) are the three tests in PLS path modeling that can be used to determine the convergent validity of the measured constructs (Shanmugapriya and Subramanian 2015). Cronbach's alpha is the coefficient used to calculate the internal consistency of the measurement items (Hassan et al. 2016). It supposes that all indicators measuring a construct are equally reliable in PLS path models. Litwin and Fink (1995) proposed that the Cronbach's alpha value should be greater than 0.7. CR is similar to Cronbach alpha, but CR uses the standardized loadings of the manifest variables and is a better measure of internal consistency. The value of CR should also be greater than 0.7 (Hair et al. 2012). However, Fornell and Larcker (1981) recommended using the AVE as a criterion of convergent validity, where values of the AVEs should be greater than 0.50. A minimum AVE value of 0.5 denotes satisfactory convergent validity because it indicates that on average, the construct explains over 50% of the variance of its items (Hair et al. 2011).

Discriminant validity can be found by assessing the Fornell-Larcker criterion and cross loading of indicators (Hair et al. 2012), and it can be concluded that the manifest variables in any construct are related to the chosen latent variables if the AVE of each variable is higher than the highest squared correlation with any other latent variable. Hulland (1999) suggested two measures for measuring the discriminant validity, namely Fornell-Larcker criterion and cross-loading tests.

Based on the aforementioned rules, the measurement model was calculated. The results of reliability and validity are shown in Table 3. In Table 3 the Cronbach's alpha and composite reliability values of individual constructs are greater than 0.7, as well as the AVE value of all constructs higher than the critical value of 0.5. Moreover, the loadings of all the variables are within the acceptable range which is greater than 0.7. These results indicate that the measurement model possesses acceptable reliability and validity.

The model was tested for discriminant validity based on Fornell-Larcker criterion, and the cross-loading values generated are given in Tables 4 and 5, respectively. The measurement shows satisfactory discriminant validity because all individual manifest variables have higher values than those in the corresponding rows. This verifies that the measurement model shows adequate convergent and discriminant validity.

Table 3. Construct reliability and validity

Construct	Item	Loading	Cronbach's alpha	AVE	CR
Construction-related factor	C1	0.850	0.881	0.677	0.913
	C2	0.782			
	C3	0.799			
	C4	0.841			
	C5	0.840			
Design-related factor	D1	0.836	0.796	0.622	0.868
	D2	0.849			
	D3	0.754			
	D4	0.708			
Material-related factor	M1	0.784	0.860	0.641	0.899
	M2	0.828			
	M3	0.774			
	M4	0.847			
	M5	0.768			
Stakeholder-related factor	SH1	0.754	0.814	0.644	0.878
	SH2	0.848			
	SH3	0.844			
	SH4	0.758			
Satisfaction	SAT1	0.776	0.838	0.675	0.892
	SAT2	0.766			
	SAT3	0.900			
	SAT4	0.838			

Assessment of Inner Structural Model

The following techniques were used to measure the structural model results. This entails observing the model's predictive competences and the connection between the constructs. The key criteria for measuring the inner structural model, the coefficient of

Table 4. Fornell-Larcker criterion test

Factor	Construction-related factor	Design-related factor	Material-related factor	Satisfaction	Stakeholder-related factor
Construction-related factor	**0.823**				
Design-related factor	0.254	**0.789**			
Material-related factor	0.239	0.24	**0.801**		
Satisfaction	0.490	0.365	0.47	**0.822**	
Stakeholder-related factor	0.223	0.224	0.248	0.403	**0.802**

Note: Values in bold are square root of AVE.

Table 5. Cross-loading values

Code	Construction-related factor	Design-related factor	Material-related factor	Satisfaction	Stakeholder-related factor
C1	**0.850**	0.206	0.215	0.403	0.181
C2	**0.782**	0.204	0.186	0.394	0.214
C3	**0.799**	0.208	0.150	0.424	0.215
C4	**0.841**	0.206	0.233	0.405	0.141
C5	**0.840**	0.221	0.194	0.391	0.169
D1	0.268	**0.836**	0.185	0.402	0.202
D2	0.210	**0.849**	0.230	0.387	0.205
D3	0.112	**0.754**	0.171	0.101	0.157
D4	0.191	**0.708**	0.167	0.204	0.134
M1	0.218	0.185	**0.784**	0.363	0.223
M2	0.196	0.197	**0.828**	0.369	0.200
M3	0.192	0.179	**0.774**	0.362	0.198
M4	0.231	0.219	**0.847**	0.425	0.208
M5	0.105	0.178	**0.768**	0.359	0.159
SAT1	0.417	0.288	0.341	**0.776**	0.248
SAT2	0.348	0.260	0.375	**0.766**	0.273
SAT3	0.430	0.295	0.397	**0.900**	0.374
SAT4	0.412	0.351	0.426	**0.838**	0.410
SH1	0.152	0.142	0.210	0.303	**0.754**
SH2	0.207	0.199	0.217	0.415	**0.848**
SH3	0.188	0.194	0.163	0.227	**0.844**
SH4	0.165	0.181	0.206	0.341	**0.758**

Note: Bold values are loadings for items, which are above the recommended value of 0.7.

determination (R^2) of the endogenous latent variables, is important. Other useful approaches used for measuring the inner structural model included path coefficient and t-statistic value, effect size (f^2), goodness of fit (GoF), and the model's predictive relevance (Q^2).

Measuring the Value of R^2

The R^2 is a measure of the variance explained in the endogenous variables and is thus a measure of the model's predictive accuracy (Sarstedt et al. 2014). In order to determine model validity, Cohen (1988) sorted the endogenous latent variables weak, moderate, and substantial depending on the R^2 values. An R^2 greater than 0.26 is considered substantial, R^2 between 0.13 and 0.26 is regarded as moderate, and R^2 between 0.02 and 0.13 is viewed as weak. The R^2 of the final model in this study was 0.454, indicating that 45.4% of the variance in client satisfaction is explained by the lack of quality. Hence, client satisfaction can be explained as moderate. Falk and Miller (1992) proposed that R^2 should be higher than 0.10 for the model to have predictive accuracy. If the value of R^2 is lower than that, the conceptual model is considered unable of describing the endogenous variables.

Path Coefficient and T-Statistics

The path coefficients in a PLS model can be acquired as a standardized beta coefficient (β) (Hair et al. 2011). The path coefficient denotes the possible variation in the endogenous variables for a unit variation in exogenous variables. The conceptual model is compared using the β values of each path; a greater β value has a more substantial influence on endogenous variables. The significance of path coefficient(s) is computed through a t-test. For evaluating the significance of hypothesis, a bootstrapping process is used (Chin 1998). The t-statistics values must be equal to or greater than cutoff value 1.96 at the 5% level of significance (Hair et al. 2011). Table 6 provides the β and t-statistics values.

Table 6 demonstrates that quality and satisfaction have a standardized coefficient of 0.674 and t-value 30.439. Thus, lack of quality has a significant influence on client satisfaction, which demonstrates that it has the most substantial effect on client satisfaction in public infrastructure projects. It can be concluded that the findings clearly support the hypothesis. Therefore, the hypothesis that lack of project quality significantly affects client satisfaction is accepted and proven.

Table 6. Path coefficient and t-statistics

Hypothesized path	Standardized beta	T-statistic	*P*-value
Construction-related factor > quality	0.491	17.098	0.000
Design-related factor > quality	0.274	12.413	0.000
Material-related factor > quality	0.444	15.192	0.000
Stakeholder-related factor > quality	0.298	10.919	0.000
Quality > satisfaction	0.674	30.439	0.000

Effect Size of the Model

The strength of the model is measured by the R^2 value of an endogenous latent variable. Meanwhile, f^2 indicates the degree of the effect of individual latent exogenous constructs on the latent endogenous construct. A variation in R^2 is measured by removing the individual latent exogenous constructs from the conceptual model and can be used to calculate whether the excluded latent construct has a significant impact on the latent endogenous constructs. The effect size f^2 can be calculated (Chin 1998) by

$$f^2 = \frac{R^2 \text{ included} - R^2 \text{ excluded}}{1 - R^2 \text{ included}} \quad (1)$$

where R^2 included and R^2 excluded = R^2 values by including and excluding an exogenous latent construct in the model. According to Cohen (1988) the effect size is large if $f^2 = 0.35$, medium if $f^2 = 0.15$, and small if $f^2 = 0.02$. The results of this analysis are provided Table 7.

Goodness of Fit

GoF of the model explains how well it fits a set of observations that globally validate the PLS path model (Tenenhaus et al. 2005) for the outer measurement model and inner structural model to validate that the model satisfactorily clarifies the observed data. The GoF

Table 7. Results of effect size f^2

Exogenous latent variable	R^2 included	R^2 excluded	f^2	Effect
Construction-related factor	0.454	0.358	0.176	Medium
Design-related factor	0.454	0.427	0.049	Small
Material-related factor	0.454	0.374	0.147	Small
Stakeholder-related factor	0.454	0.409	0.082	Small

index is the geometric mean of the average R^2 of endogenous latent variables and the average communality (i.e., AVE). The GoF is calculated by

$$\text{GoF} = \sqrt{\text{Average } R^2 \times \text{Average communality}} \quad (2)$$

The cutoff values are between 0 and 1 for global validation of PLS model, where 0.1, 0.25, and 0.36 are considered as a small, medium, and large GoF, respectively (Wetzels et al. 2009). In this model, the GoF index is 0.54, which indicates the model fits the data very well and has suitable predictive power.

Predictive Relevance of the Model

The Stone-Geisser's Q^2 can be used to the quality of PLS model and model's predictive relevance, which is calculated by a blindfolding procedure (Tenenhaus et al. 2005). Based on blindfolding, the Q^2 criterion proposes that the values confirm the model's predictive relevance in respect of a particular construct. Q^2 values higher than zero for the endogenous construct means the model has predictive relevance for that particular construct, and Q^2 values lower than zero denotes a lack of predictive relevance in the model (Hair et al. 2011). Q^2 can be obtained using cross-validated redundancy procedures as suggested by Vinzi et al. (2010). Therefore, this procedure was applied in evaluating the Q^2 of this study's model. The result shows that the Q^2 value of 0.29 is higher than zero in this study model, which indicates the model is considered as having predictive relevance.

The results of this study have revealed a clearer picture of the effect of lack of quality on client satisfaction and can help in improving a set of appropriate guidelines and actionable information for sustainable infrastructure projects.

Discussion and Implications

This study was conducted to apply the PLS-SEM method to examine how the lack of quality factors affect the client satisfaction in the Pakistani public construction industry. By employing this method, factors affecting the quality and its direct impact on client satisfaction can be understood. The hypothetical paths established in the proposed model were significant. By analyzing and evaluating all the standardized beta coefficients in the SEM, it was determined that lack of project quality was a significant cause of client dissatisfaction. The structural model results revealed that about 45.4% of quality factors affect client satisfaction in a public construction project. It can be concluded that the construction-related factor, design-related factor, material-related factor, and stakeholder-related factor were the dominant factors that directly affect the quality of construction projects, and Table 3 demonstrates that these have a significant relationship with client satisfaction. In terms of relative importance of these four quality factors, the construction-related factor (beta = 0.491) has the strongest effect on the quality. The construction-related factor contains five subfactors: low level of skill and labor experience (factor loading = 0.850), contractors' poor technical knowledge (factor loading = 0.782), inadequate site supervision by contractor (factor loading = 0.799), obsolescent construction technology and equipment (factor loading = 0.841), and limited construction time imposed by project clients (factor loading = 0.840). A contactor's capability and performance play a vital role in the successful delivery of a project (Doloi et al. 2011). To get better quality in construction projects, the contractor needs to examine these factors and determine the extent to which these can affect the construction projects with regard to client satisfaction.

Because the construction-related factor has the highest path coefficient (beta = 0.491) affecting quality, it can be inferred as the most dominant predictor influencing client's satisfaction. Uncoordinated construction could cause a substandard quality project, which leads to a dissatisfied client. To deal with this dilemma, contractors or service providers should be involved in the project planning phase. They have the experience, skills, knowledge, competency, and expertise regarding construction methods and techniques, so their involvement in the preconstruction/planning phase of the project process could lead to better quality construction projects. This would substantially increase client satisfaction. Similarly, the contractors' or service providers' effective planning, control, and technical skills positively influence the quality of a construction project and hence enhance client satisfaction. The contractor or service provider should normally manage their consideration regarding the technical knowledge or supervision by providing adequate resources and also improve services in response to problems that would previously have happened. Obviously, the construction-related factor is a vital element that all participants should consider because during the construction phase, the plan applies to bring the concept into reality and is the most risky phase of the project.

Also, quality was not only affected by construction factors, but also the other factors in the model, and this impact was validated by examining the relationships. This factor was followed by material (beta = 0.444), stakeholders (beta = 0.298), and design (beta = 0.274), which were revealed in Fig. 2. The design-related factor had the lowest path coefficient in the model, and one possible reason why this factor was the least important is that all the participants were from the public construction industry. Practitioners in construction projects presume that the construction designs are better as per standard and are more suitable for construction/execution.

The predictive accuracy of the model was ascertained by R^2 value. In the analysis of the PLS path model, it was observed that a lack of project quality had a substantial impact on client satisfaction in public construction projects. The R^2 value was 0.454, suggesting that 45.4% of the variance in client satisfaction was explained by lack of quality factors of construction, material, design, and stakeholders. Lack of project quality was directly related to client satisfaction at $T = 30.439$ and $p = 0.000$, indicating that a lack of project quality was a significant predictor of client satisfaction. The influence of each independent construct on the dependent construct was determined by effect size. The effect size of the construction-related factor on client satisfaction was 0.176, indicating that the construction-related factor has medium to large effect on the R^2 for client satisfaction. The suggested model GoF ensures that the empirical data used fit the model and have a predictive power of 54%. The model also demonstrated predictive relevance because the Q^2 value was substantially greater than zero.

To confirm the effectiveness of this study, the findings were presented to construction professional experts for confirmation and validation. Six experts agreed to participate. The selected experts participated in the pilot study, and they were informed of the importance and background of this study given that this is not a testing process but instead validation of the study. The experts held senior

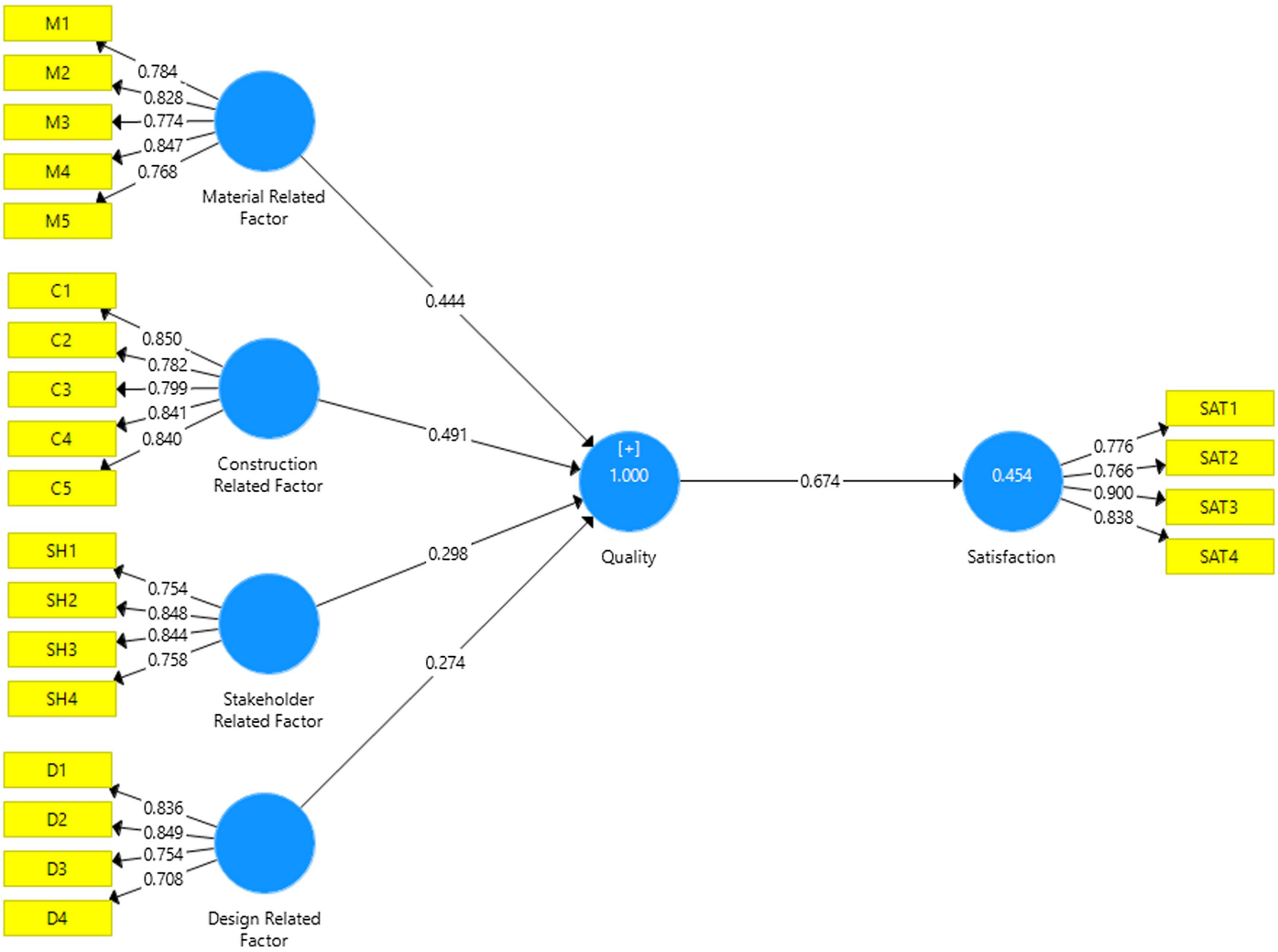

Fig. 2. Estimation of the structural equation model.

positions and had more than 20 years of working experience in public construction industry. All experts were of the opinion that the findings were suitable and appropriate and thought the findings were valuable and useful for the public construction industry. It is believed that the findings can help provide much greater understanding for construction practitioners as well as researchers. Thus, this will support practitioners in making suitable management preferences and taking remedial action regarding the most dominant factors. This study tested the hypothesis and verified that lack of quality in projects was directly affecting client satisfaction. Client satisfaction with and success, and sustainability of a project are usually measured by project quality. Therefore, lack of quality in construction projects often leads to client dissatisfaction, thus causing the failure of the construction project.

Conclusion

The public construction industry is primarily project based, and quality is one of clients' major concerns regarding their construction projects to ensure project success and sustainability. Clients need clear collaboration, flexibility, teamwork, joint effort, cooperation, and clear performance from service providers or contractors. Determining client satisfaction has numerous benefits for the construction industry, for example, in assessing progress toward the goals and objectives, ensuring better communication between parties, efficiently meeting their requirements, and empowering shared agreements. For the sake of accomplishing client satisfaction, the contractor or service provider must realize what the client needs and how to meet those needs.

The primary aim of this study was to explore the influence of the lack of project quality on client satisfaction through PLS-SEM. Through a detailed literature review, a total of 18 factors affecting the quality and four client satisfaction factors were identified. Data were collected through a survey, then the PLS-SEM technique was used to analyze the data and test the hypothesis. A framework was presented to assess construction client satisfaction, which was influenced by four quality constructs, namely construction, design, material, and stakeholder factors, and four client satisfaction variables. The findings from the conceptual model calculation confirmed the hypothesis. The result of the PLS-SEM analysis revealed that lack of project quality directly affects client satisfaction (beta $= 0.674$ and $R^2 = 0.454$) and indicated that the construction-related and material-related factors were the two most significant factors with the highest standardized path coefficient. The goodness-of-fit index of the conceptual model was measured to be 0.54, which showed that the conceptual model has appropriate reliability and validity and fits the data as supported by the SEM model. However, the study also revealed that these factors do not only affect project quality; client satisfaction is also affected

by a lack of quality in construction projects. The results of the validated conceptual model will help the client and service provider to determine areas where quality improvement is necessary.

This study provides key implications for both theoretical and practical views. In terms of theoretical aspects, this study contributes to the body of knowledge on lack of project quality and client satisfaction, particularly in the perspective of the public construction industry, which has not been empirically tested in previous studies. In particular, this study verified that lack of project quality, which contains the four factors of construction, material, design, and stakeholders, has a significant relationship with client satisfaction. This study, therefore, bridged this knowledge gap by giving empirical evidence that endorsed that lack of project quality directly impacts client satisfaction. Moreover, this study explored public industry practitioners' perceptions regarding these variables through a survey-based research and provided empirical evidence of a meaningful connection between these variables that may be revealing of a causal effect. Finally, the study adds a key methodological contribution by applying PLS-SEM, which could be the first such empirical tested in the public construction industry.

In terms of practical contributions, this study likely provides solutions for the challenges faced by the construction industry. In particular, it is the authors' hope that this study will benefit the public construction practitioners, who can benefit from the results by focusing more attention on the important factors that impact project quality. Succeeding in providing client satisfaction is becoming a primary objective of successful completion of construction projects. The findings can be used as a source for strategic options by policymakers and service providers. It is vital to comprehend the implications of these findings in practice. For a client (owner), the authors suggest that the contractor or service provider should be involved in the preconstruction phase of the project to offer opinions and allow clients to obtain benefits from their experience on the issues of buildability and constructability. For the contractor or service provider, this study suggests that contractor should have an effective quality management team, skilled laborers, and better quality of materials and equipment. The evaluation of client satisfaction is based on the quality of the end projects. This assessment is used to support service providers or contractors to better their performance to a prerequisite level and to confirm that the projects are handed over as expected in terms of quality.

The study was conducted in the context of the construction industry in Pakistan. From a statistical perspective, the threshold for generalizability (i.e., a minimum sample size of 10 times the largest number of input vectors to a construct) was met; hence, the results are statistically generalizable. However, no attempts were made to generalize the findings to other nations than Pakistan because this would only be speculative in the absence of empirical data. However, the high level of standardization in the construction industry worldwide implies that very little can be expected in terms of national differences. To that end further studies are suggested as future research using the same constructs and measurements to test and validate the findings in other countries and develop a validated global model.

Scientific Contribution

The main contribution of this study to the body of knowledge is to fill the gap in the existing literature by empirically investigating how the lack of quality in public projects impact client satisfaction in the context of the public construction industry. The relationships between lack of quality factors and client satisfaction have not been explored in previous literature, and this is the first study to empirically explore this relationship in the public construction industry. This relationship is conceptually intriguing because it bridges two important domains of quality and satisfaction research in public infrastructure projects. The present study is therefore intended to make contributions to the literature on lack of quality, and impact on client satisfaction in a single study and provide essential support for industry policies and decision making to facilitate the understanding of the desired outcomes.

The present study also proposed a model and applied advance statistical method, PLS-SEM, which is previously missing in the literature. This study adopted the latest PLS-SEM approach to solve the problem and hence adds to the body of knowledge. The conceptual framework and hypothesis, are valid and result-oriented, definitely add to existing knowledge on the subject.

Data Availability Statement

Data generated or analyzed during the study are available from the corresponding author by request. Information about the *Journal*'s data-sharing policy can be found here: http://ascelibrary.org/doi/10.1061/(ASCE)CO.1943-7862.0001263.

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