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Total quality management practices and its impact on Indian construction projects

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Abstract:
Introduction: The current competitiveness in the business arena of the construction industry has forced players to improve and optimise, forcing them to adopt the iterating process of continuous improvement that ensures the adequate quality of projects, in addition to moderating the cost and time involved in their implementation, the three of which have collectively been recognised as the primary factors causing the client's approval or disfavour in relation to a project.
Purpose: The primary intention of the current study is to analyse the effects of total quality management (TQM) practices for construction projects and their impact on productivity, cost reduction, quality of service, customer satisfaction and Timeliness of Service by conceptualising a model using second-generation partial least squares (PLS) structural equation model (SEM) approach in Tamil Nadu.
Design/Methodology: The primary data have been gathered through a sample survey collected from 94 respondents from Chennai, Kanchipuram, Coimbatore, Trichy, Karur and Tirunelveli districts of Tamil Nadu through the questionnaire. The responses were collected from various professionals in the field, such as project managers, contractors, engineers, consultants and supervisors.
Findings: This study also confirmed a significant and positive relationship between TQM practices and the performance of construction projects. TQM factors such as Benchmarking (BM), Employee Involvement and Empowerment (EMPINV), Innovation (INNOV), Supplier Quality Management (SPQM) and Technical (TECHN) are significant in determining the project's outcome by 79.5%.
Practical implications: The study's finding is of utmost importance because it helps build strategies and policies for the construction industry in the global competitive scenario, in promoting credibility and in increasing customer satisfaction.

Keywords: construction productivity, structural equation model, total quality management, visual PLS

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1 Introduction

Although the construction industry projects a semblance of being highly organised, it is in fact mostly fragmented. So, it is a little tedious for new methodologies to penetrate up to the local level instantaneously, be it technologically or managerially. However, the construction industry has been widely criticised for lacking quality in the processes used during the project design and execution phase, as well as in the finished product. In recent years, the construction industry's awareness and acceptance of quality management have become vital (Acıkara et al., 2017). Also, snags and errors are commonplace, and additional money, human resources, machinery and materials are put into resolving issues that often result in time overrun, cost overrun or both.

Moreover, projects' quality, cost and time have been recognised as the primary factors concerning the client. Various seminal factors act as overall determinants for the characteristics of the final product, including workmanship quality, durability, timely handing over and finish quality. Total quality management (TQM) has not been considered a destination; it is a journey (Burati and Oswald, 1993). In reality, institutionalising TQM has been observed to be difficult for both small and middle-sized firms (Ansah, 2018).

To withstand the current scenario of intense competitiveness, organisations are forced to adapt and improve the reiterating continuous improvement process. This ensures that they utilise their resources to the maximum and plan accordingly. The competition has also

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made the companies more quality-conscious and customer-oriented. This quality consciousness has resulted in careful planning and sound management of quality practices, which has ensured the regular availability of high-quality service and a reasonable degree of certainty in meeting the requirements of the customer. The business, as a whole, can be looked upon as an attempt to capitalise on organisational rewards through a continuous upgradation of products, services, workforce, process improvement and the environment. Due to this movement, quality management systems (QMSs) came to the fore. Guermazi and Mbarek (2016) define a QMS as 'all activities of the overall management function that determine the quality policy, objectives, and responsibilities, and implement them by means such as quality planning, quality control, quality assurance and quality improvement within the quality system'.

QMSs or techniques are often coupled with quality assurance systems, such as ISO9000. In 2020, construction industry has to improve its quality by following ISO9000 in Malaysia (Othman et al., 2020). Quality assurance may also be referred to as quality control. However, quality management and quality control are diametrically different processes. Quality management is deliberated to avoid defects from doing the job right, whereas quality control elaborates on inspecting and checking the finished products. Quality management is not an easy process in the construction industry, where human resources and machinery are equally important. Quality management is a procedural aspect that must involve every level of the workforce, from manual labour to inspection level officers to the top management.

Hence, quality management must involve complex and fail-proof mechanisms that ensure output and productivity. There are numerous methods devised to frame quality management. Some of them include the Six Sigma method, Deming's model, Lean Production System, Kaizen and Total Quality Management.

TQM is a predominantly used and largely unbeaten management method since it involves using problem-solving techniques technically and interpersonally. Though TQM is a time-tested process, it cannot be overlaid in the construction field due to outright rejection of change. This is because of the numerous interpersonal dealings and organisational and human behavioural factors. However, it can be done by introducing a few quality improvement teams on several issues or projects and then expanding to other areas. TQM members also build self-assurance, communication skills and conflict resolution skills. In its quest for incessant effort directed at improvement in quality, TQM continually and naturally institutes an atmosphere of quality consciousness; and thus TQM implementation also improves customer and employee satisfaction.

The construction industry has many challenges, and it lagged behind other industries in executing new policies and reforms to enhance quality management (Kudva et al., 2106). The accomplishment of the TQM philosophy in manufacturing and related industries compels the construction industry to concentrate on TQM. Based on the previous studies, the ten vital factors of TQM are identified (Table 1) as a framework or collection of perspectives of TQM in the Tamil Nadu-based construction sector. Similar research has been done in different places in the world, and each analysis shows different results at different levels, even though each has adopted TQM frameworks. Since there is no single universal cookbook approach, it is essential to study the local industry, its influencing factors, peoples' approaches and outlooks, requirements, local practices and viable options. Hence, the study is highly required for the applications of many TQM processes that need at least a prior feasibility report. Researchers have confirmed that introducing such a change within an organisation concerning quality is done from top to bottom.

Tab. 1: Apparent elements included in the study and its reliability statistics.

S No.	Factors	Author	Cronbach's α
1	BM	Saraph et al. (1989) and Nwabueze (2001)	0.939
2	COMMU	Delgado et al. (2005)	0.939
3	INNOV	Juran (1974) and Nwabueze (2001)	0.938
4	EMPINV	Oakland (1993) and Zhang (2000)	0.940
5	QO	Saraph et al. (1989)	0.940
6	QSS	Saraph et al. (1989)	0.940
7	SPQM	Delgado et al. (2005)	0.938
8	TEAM	Delgado et al. (2005)	0.939
9	TECHN factors	Delgado et al. (2005)	0.937
10	TPMGT	Juran (1974) and Motwani (2001)	0.939
11	Project Outcome (Productivity, Cost Reduction, Quality of Service, Customer Satisfaction, Timeliness)	Delgado et al. (2005)	0.940

BM, Benchmarking; COMMU, Communication; EMPINV, Employee Involvement and Empowerment; INNOV, Innovation; QO, Quality Objectives; QSS, Quality Supervision; SPQM, Supplier Quality Management; TEAM, Team Effectiveness; TECHN, Technical, TPMGT, Top Management Commitment.

1.1 Review of literature

TQM has evolved from the modem management theory, which grew as a separate discipline over the past 100 years. TQM is developed in many other disciplines such as production, marketing, strategy and engineering. TQM also contributes to sub-functional domains such as construction. Various studies forming part of the literature define the concept of TQM using various perspectives; for instance, the Deming approach (1986) stressed the importance of the responsibilities of top management; Juran's approach (1993) placed emphasis on QC circles and self-managing teams; Feigenbaum's approach stressed on setting quality standards; and Ishikawa's approach (1985) studied cause and effect relationship using statistical approaches. TQM has been widely accepted as a winning management philosophy that can be successfully implemented in the construction industry (Elghamrawy and Shibayama, 2008). The TQM approach needs to be emphasised in the construction sector (Harrington et al., 1992) for improved quality and productivity and to eliminate high levels of waste. By implementing and quantifying TQM techniques, substantial economic benefits can be achieved (McIntyre et al., 2000). In the opinion of Ngowi (2000), TQM is an integrated approach that considers cultural values and assumptions that can successfully host cultural values to organisational practices. It mostly entails strengthening commitment, developing a solid quality strategy plan, improving customer attention, paying attention to project process management and paying attention to and analysing quality data (Liao et al., 2018).

TQM has also been acknowledged as a flourishing management philosophy in the services and manufacturing industries. TQM techniques facilitated diminution in quality costs and better customer and employee job satisfaction. TQM embraced quality and productivity through appropriate QMSs (Bajaj et al., 2018) and improved relationships with subcontractors and suppliers (Pheng and Teo, 2004). TQM can develop routine practices and norms that facilitate domestic operations in day-to-day work (Abdul-Aziz, 2002). In Japan, contractors have successfully implemented TQM practices in their domestic operations. The impact that TQM practices have had on the organisational culture has been studied based on the values framework in construction projects, but has received less attention. However, some scholars, such as Low et al. (2020) in Malaysia, Atuahene and Baiden (2018) in Ghana and Worrall (2012) in the United Kingdom, have looked into the culture associated with TQM procedures in building projects. Construction projects are more prominent, complex and multifaceted in the current century, where clients increasingly demand superior quality, efficiency and delivery. TQM has been approved as an affluent and winning management philosophy in the manufacturing sector (Farooqui and Ahmed, 2009). The role of TQM in the construction industry can mainly be looked upon as a facilitator of an organisational culture that elevates quality and productivity to the highest level of priority possible. This study attempts to initiate the fundamental factors determining construction-related companies' success in accomplishing their goal of total quality through Productivity, Cost Reduction, Quality of Service, Timeliness of Service and Customer Satisfaction (Delgado et al., 2005). The constructability of construction projects under TQM is linked to the four primary pillars, namely contractor organisation systems, teamwork, client commitment and process control (Bouranta et al., 2017).

Smith et al. (2003) tried to empirically establish a linkage between the interaction of new management practices such as TQM, team-working, lean production, reengineering and training. From his empirical analysis, he propounded a significant relationship between the two. Construction companies can efficiently employ TQM and experience titanic payback, such as lessening quality costs (Delgado et al., 2005), enhanced employee job satisfaction and greater industry recognition resultant to harbouring better relationships with clients, suppliers and subcontractors (Delgado et al., 2005). Performance excellence is achieved through top management dedication (Motwani, 2001), employee involvement (Zhang, 2000), customer participation in team effectiveness (Delgado et al., 2005; Mathieu et al., 2008), empowerment, customer–supplier relationships and enhanced process management and improvement (Alanazi, 2020). Thus, the TQM structure is implemented in the organisation. Contractors must comprehend the promising benefits of quality implementation despite the existence of numerous barriers to the implementation of TQM (Hoonakker et al., 2010). As part of the organisation's excellent aims involving achievement of customer satisfaction, the TQM method focuses on improving the efficacy of processes and responsiveness in satisfying customer requirements (Ramlawati and Putra, 2018; Phan et al., 2019). To deliver the mounting construction projects on time and within the budget, there is an imperative need to enhance the industry's productivity (Javed et al., 2018), which necessitates quality to minimise customer dissatisfaction and rework. When faced with a changing environment, organisations must consider how to make the best decision at the right moment, modify their approach style appropriately and execute scientific management (Wu and Zhang, 2021).

The current study's focus or area of interest is of great importance in the modern era because of growing infrastructure development in all developing economies. TQM has both long-term and short-term benefits. Due to competition and development, organisations are implementing reengineering processes. However, it is vital to readdress TQM before reengineering (Love et al., 2000). The fragmented nature of construction projects, the dynamic nature of site management and the highly transient approach of labour, have, in conjunction with other factors, resulted in the construction industry's increasing relevance to organisational culture (Teravainen et al., 2018) and project performances (Busu, 2019). The quality factors are highly independent of each other, and the TQM is one of the quality management philosophies that facilitates comfortable change or development (Kharub and Sharma, 2018).

1.2 Problem statement and rationale

Quality is an essential aspect of construction. Directly and indirectly, it affects the timely completion of projects, customer satisfaction, cost reduction, health and safety of the worker and the work and life of the users or occupants. So, quality must be given primary importance. Quality also impacts the different players involved in the construction process. Thus, fixing time, quantity and human resources around quality is crucial. So, an efficient QMS is imperatively necessary to monitor and optimise operations in the construction field.

Quality is a very commonplace term in the construction lingo. Quality is one of the most discussed virtues by civil engineers, contractors and clients alike. Furthermore, payment at each step is heavily influenced by the quality of the work that ensues. Quality is the critical factor that decides the life of the building and that of the builder; as far as previous literature reviews refer, there are not many papers discussing quality management at a grassroots level. Moreover, the lack of tight regulation and a dearth in the enforcement of quality measures in all areas and buildings make it challenging to study quality.

1.3 Research methodology

The current study analyses the factors influencing total quality in the construction industry. The construction industry of Tamil Nadu is taken for the study. The data collected has been received from 94 respondents from Chennai, Kanchipuram, Coimbatore, Trichy, Karur and Tirunelveli. Stratified and purposive random sampling method was the statistical method followed for the current study. The questionnaire had been distributed, and the data were collected from various professionals in the field, who include: project managers, contractors, engineers and consultants. Their responses were obtained, and the data were fed into SPSS 20 and Visual PLS version 2.0 for further analysis. The data were subjected to a correlation analysis using factor loading matrix and partial least squares (PLS) method-based structural equation model (SEM), and the entire research process is shown in Figure 1.

The primary objectives of the study are:

- To identify the factors (Benchmarking (BM), Communication (COMMU), Innovation (INNOV), Employee Involvement and Empowerment (EMPINV), Quality Objectives (QO), Quality Supervision (QSS), Supplier Quality Management (SPQM), Team Effectiveness (TEAM), Technical (TECHN), Top Management Commitment (TPMGT)) affecting the quality of construction projects in Tamil Nadu.
- To study the influence of each factor in determining the project outcome (Productivity, Cost Reduction, Quality of Service, Customer Satisfaction, Timeliness of Service).

Using indicators from the existing literature, a research instrument (Table 1, Figures 1 and 2) was developed to assess the influences of the various factors determining the extent to which TQM implementation was successful. The questionnaire was developed using the 5-point Likert scale for the vital factors affecting construction projects' quality. A small-scale pilot experiment or feasibility study was conducted with 30 samples to check the reliability of the questionnaire. The Cronbach's α value (0.939) for various factors determining TQM can be considered an excellent score for a survey-based study.

2 Results

2.1 Respondent's demographic analysis

Out of the 94 samples taken for the current study to determine the vital factors of TQM practices in construction projects, 74.5% are male respondents and 25.5% are female respondents. Among the respondents, 43% belong to the age group of 26–35 years, 20% belong to the age group of 36–50 years, 19.5% belong to the age group of 51–65 years and 17.5% belong to the age group of >65 years.

The study's respondents have been selected from construction sites and the professionals selected include

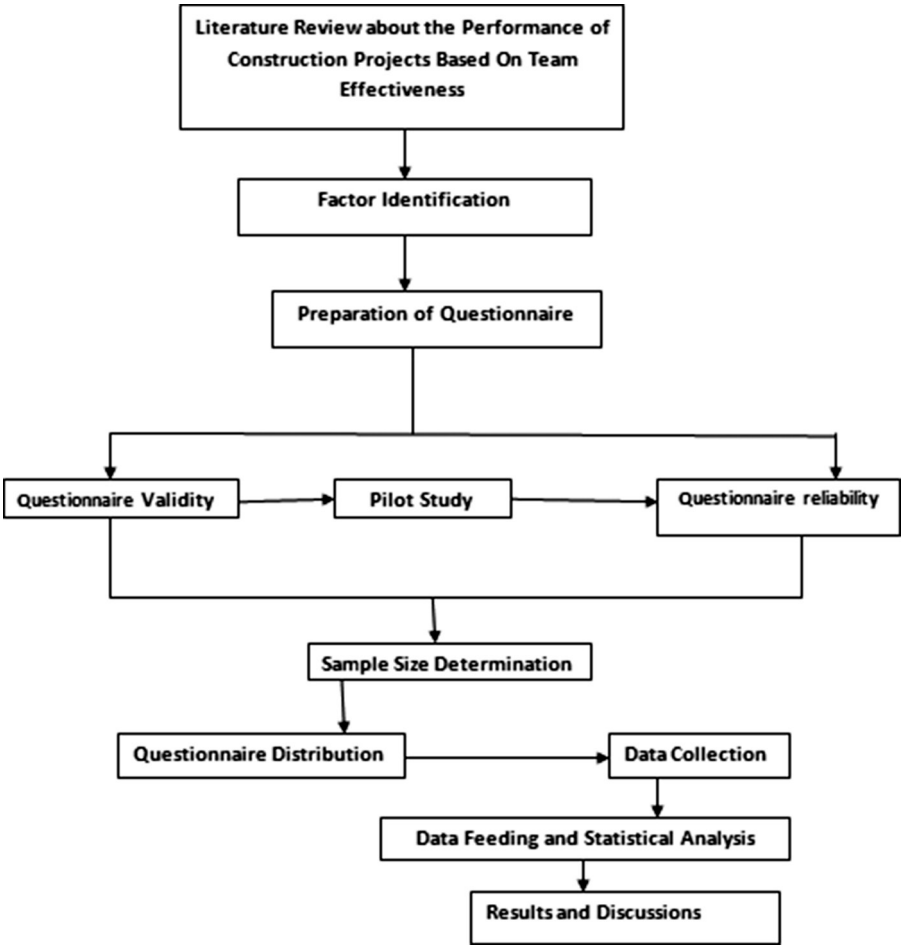


Fig. 1: Research process.

those with the designations of project manager, contractor, engineer and consultant. Among the respondents, 34% are project managers, 23% are engineers, 36% are contractors, 5% are consultants and 2% are supervisors. Further, 41% of the respondents have 5–10 years of experience and 39% have 15–20 years of work experience. Also, 51% of respondents have worked in private construction works and 49% have worked in public construction works. The samples were collected from project managers, contractors, engineers and consultants working in high net-worth projects (ranging from ₹10 crores to ₹100 crores) in Tamil Nadu. PLS can be computed even for very small samples (e.g. <20) (Rigdon, 2014; Ringle et al., 2013).

2.2 PLS analysis

The PLS-based SEM used in the current study is based on the Visual PLS approach. It is a second-generation multivariate analytical method used in management and survey-based research. It can test the theoretical hypothesis and build linear and additive causal models (Chin, 1998a,b). Thus, the Visual PLS SEM has been used in the current study to understand the association between the elements determining the total quality of construction projects and their outcome projects, namely Productivity, Cost Reduction, Quality Service, Customer Satisfaction and Timeliness of Service.

The distinctiveness of the model is that it consists of two sub-models. The inner mode analyses the relationship between the endogenous and exogenous variables, whereas the outer model identifies the association between the latent variable and manifest or observed variables (Wong, 2010). The current study is a survey-based explorative study that analyses the factors determining TQM in the construction sector. Thus, PLS-SEM was considered a good choice for the present study because the sample size is small and the method would therefore be applied where greater predictive accuracy is expected. PLS-SEM has been followed in many disciplines, such as social and behavioural studies (Bass and Avolio, 2003), consumer behaviour (Henseler et al., 2009), marketing

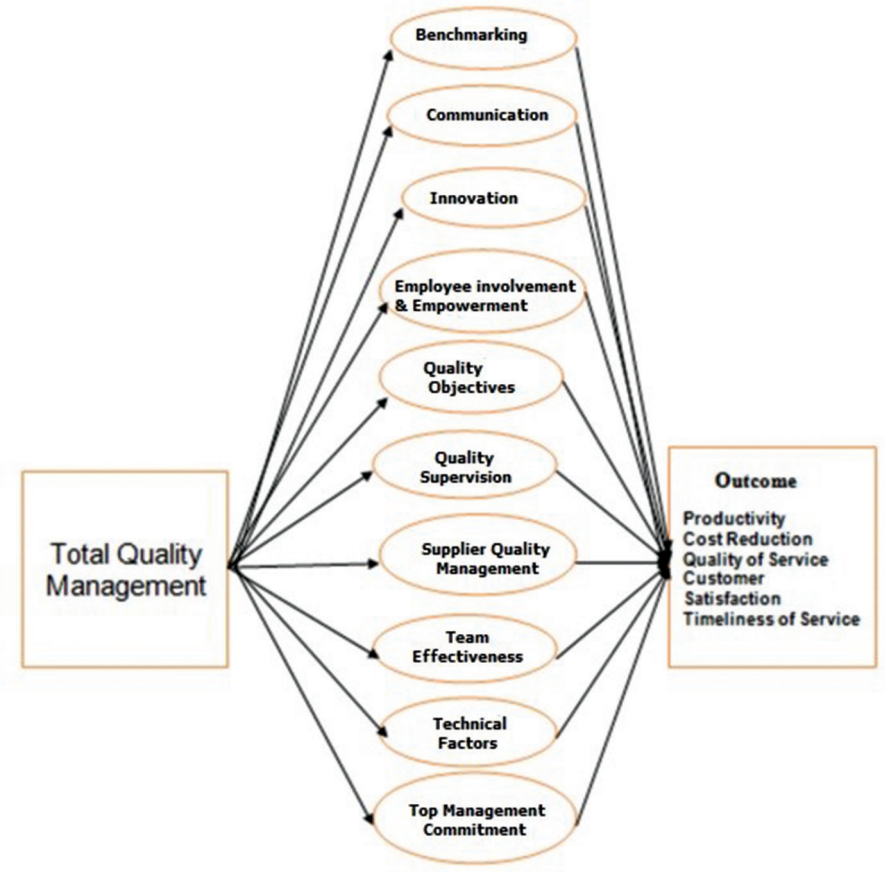


Fig. 2: Conceptual research model – factors determining TQM. TQM, Total quality management.

management, information and decision support systems (Chin et al., 2002), business strategies (Hulland, 1999) and construction management (Vijayabanu and Vignesh, 2018). The model used in the study needs to be assessed, and this is necessary because it ensures the validity and reliability of the constructs used in the study (Loehlin, 1998). Reliability provides the quantity to which a set of indicators used for determining the total quantity (independent factors) in the present study are internally consistent and reliable. This also confirms how the study instrument gives the same results on repetitive trials.

2.3 Reliability of the construct

Reliability is essential, but reliability alone is insufficient because a study with a high-reliability measure may not be valid (Hair et al., 2006). It is clear from Table 2 that the Cronbach's α value for the current study ranges from 0.6 to 0.9, confirming an acceptable reliability level. The computation of internal consistency is understood through the composite reliability (CR), which facilitated the researcher to evaluate the reliability of the total variables of the measurement tool used in the study. Table 2 confirms that the CR values for the current study range from 0.76 to 0.94 and surpass the threshold value of 0.70 (Hair et al., 2016; Rossiter, 2017). The Cronbach's α and CR values were calculated for the constructs of the TQM facets of the present study using the Visual PLS approach, thus confirming that the instrument used has excellent reliability, as shown in Table 3.

The convergent validity should be confirmed for the measurement tool because it is indispensable in ensuring that the items used for evaluating various total quality factors of the construction project are valid, and thus the following decisive factor was considered. The item loadings for each factor determining the total quality of the construction project were ascertained, and the factor loadings >0.50 were retained, as suggested in the literature (Streiner, 1994; Hair et al., 2010), and deemed acceptable. The CR for each construct should go beyond 0.70. Finally, the average variance extracted (AVE) for each variable should be above the suggested cut-off of 0.50 (Fornell and Larcker, 1981). Convergent validity indicates that items included in the construct have higher variances (Hair et al., 2013). It is confirmed from Table 2 that, for the current study, the factor included has loadings that are

Tab. 2: Accuracy analysis statistics for factors determining the total quality of construction projects.

Factors	Items	Factor loadings	CR	AVE	Cronbach's α
QSS	The supervisor gives credit to people when they do a good job.	0.78	0.79	0.51	0.68
	The supervisor gives feedback on the work I have done.	0.50			
	Quality improvement is their responsibility.	0.73			
	My supervisor rewards being cooperative and a good team player.	0.85			
COMMU	Top Management information and interaction	0.85	0.86	0.67	0.74
	Middle management support	0.90			
	Periodic Feedback	0.69			
BM	Best practices	0.81	0.86	0.60	0.78
	Material comparison	0.79			
	Cost Comparison	0.69			
	Quality of the supplies	0.80			
QO	Statutory provisions	0.53	0.77	0.47	0.64
	Proper prior testing with sample materials	0.72			
	Workmanship quality	0.87			
	Quality of the supplies	0.57			
TPMGT	Quality as primary objective	0.90	0.94	0.74	0.93
	Quality as being more important than deadlines	0.91			
	Frequent performance evaluation	0.89			
	Timely allocation of resources	0.84			
	Clear quality goals objectives	0.85			
	Quality is the primary agenda in all the company meetings.	0.76			
INNOV	Creative and innovative suggestions for work improvements	0.77	0.87	0.69	0.77
	Autonomy to use new methods	0.90			
	Contemporary methods are encouraged	0.81			
SPQM	Quality is a more important criterion than the price in selecting suppliers	0.76	0.87	0.57	0.80
	The supplier's delivery performance is considered before ordering	0.86			
	The supplier's market stability is considered	0.77			
	Maintenance of long-term supplier relationship management	0.81			
	Supplier audit and evaluation	0.54			
EMPINV	Participative work culture	0.85	0.86	0.56	0.79
	Employee suggestion schemes	0.73			
	Employees are encouraged to give more suggestions.	0.86			
	Awards (financially or otherwise) are provided to individuals for their excellent suggestions.	0.79			
	Employee participation in quality audit	0.50			
TEAM	Team work	0.73	0.91	0.68	0.87
	Team Problem solving	0.85			
	Team skills and knowledge	0.92			
	Synergy and team effectiveness	0.85			
	Cohesive team	0.76			
TECHN	Initial cracks' visibility	0.51	0.77	0.47	0.67
	Plumb checking is always done before and after concreting	0.85			
	Honeycomb structures' visibility	0.51			
	Platform vibrator is used during the compaction of roof slab	0.64			
	Cutting of rebars is done using machinery	0.68			
OUTPU	Productivity	0.81	0.82	0.50	0.73
	Cost Reduction	0.51			
	Quality of Service	0.73			
	Timeliness of Service	0.61			
	Customer Satisfaction	0.83			

AVE, Average Variance Extracted; BM, Benchmarking; COMMU, Communication; CR, Composite Reliability; EMPINV, Employee Involvement and Empowerment; INNOV, Innovation; OUTPU, Outcome due to Quality Improvement Efforts; QO, Quality Objectives.; QSS, Quality Supervision; SPQM, Supplier Quality Management; TEAM, Team Effectiveness; TECHN, Technical; TPMGT, Top Management Commitment.

Tab. 3: Latent variable correlations for factors determining the total quality of construction projects.

Factors	QSS	COMMU	BM	QO	TPMGT	INNOV	SPQM	EMPINV	TEAM	TECHN
QSS	**0.75***									
COMMU	0.7	**0.82***								
BM	0.2	0.3	**0.77***							
QO	0.4	0.2	0.4	**0.69***						
TPMGT	0.6	0.8	0.3	0.1	**0.86***					
INNOV	0.3	0.5	0.6	0.3	0.3	**0.83***				
SPQM	0.4	0.6	0.6	0.2	0.6	0.4	**0.76***			
EMPINV	0.2	0.3	0.6	0.4	0.4	0.6	0.5	**0.75***		
TEAM	0.2	0.3	0.7	0.3	0.3	0.8	0.6	0.6	**0.82***	
TECHN	0.7	0.6	0.3	0.3	0.4	0.2	0.5	0.2	0.3	**0.68***
OUTPU	0.5	0.6	0.7	0.3	0.5	0.6	0.7	0.6	0.6	0.6

BM, Benchmarking; COMMU, Communication; EMPINV, Employee Involvement and Empowerment; INNOV, Innovation; OUTPU, Outcome due to Quality Improvement Efforts; QO, Quality Objectives; QSS, Quality Supervision; SPQM, Supplier Quality Management; TEAM, Team Effectiveness; TECHN, Technical; TPMGT, Top Management Commitment.
*Discriminant validity.

above the standard cut-off of 0.50. The high factor loading is an important indicator that determines the importance of the factor.

The AVE for all the constructs except QO (AVE: 0.47) and TECHN (AVE: 0.46) are above the suggested cut-off of 0.50 (Fornell and Larcker, 1981). AVE measures the level of variance acquired by the construct, and an AVE above 0.7 is considered excellent, whereas the level of 0.5 is average and acceptable. For the current study, all factors determining total quality have an adequate level of AVE. The AVE is a widespread method of analysing the discriminant validity (Gerbing and Anderson, 1988).

The subsequent phase in the construct validation procedure is the estimation of discriminant validity. Discriminant validity replicates the quantity up to which the study measurement tool is unique and not merely a manifestation of added variables (Petter et al., 2007). Discriminant validity was evaluated by investigating the cross-loadings of each item in the constructs, and the square root of AVE is deliberated for each construct. All the items ought to have superior loading on their similar construct than the cross-loadings on the other constructs in the model (Chin, 1998a, 1998b). Even though there are multiple ways to estimate discriminant validity, AVE is a widespread and universal method (Fornell and Larcker, 1981) of testing discriminant validity (Gerbing and Anderson, 1988). Table 4 shows the correlation matrix with inter-construct correlation among the constructs and the square root AVE on the diagonal, discriminant validity.

It is clear from Table 4 that all the diagonal elements are more significant than the off-diagonal elements in the equivalent rows and columns, thus authenticating that discriminant validity undeniably subsists in the current study. The discriminant validity test acknowledges that the square root of the relevant AVE of each variable should surpass the correlation between the factors. As shown in Table 4, all the variables have good discriminant validity. The diagonal numbers (shown with *), which are the square root of AVE, are superior to the equivalent rows and columns (Chin, 1998a, 1998b). The inter-construct of the correlation between variables and the discriminate validity of the instrument are highly adequate for the present study (Chin, 1998a, 1998b). So, it is validated from the results demonstrated in Table 4 that, overall, the tool has obtained an adequate and satisfactory level of reliability and construct validity.

Tab. 4: Results of SEM analysis using bootstrap.

	Entire sample estimate	*T*-Statistic	Result
QO ⇒ OUTPU	0.13	1.65	Supported by 10%
TPMGT ⇒ OUTPU	0.17	1.84	Supported by 10%
INNOV ⇒ OUTPU	0.38	2.20	Supported by 5%
QSS ⇒ OUTPU	0.15	1.65	Supported by 10%
COMMU ⇒ OUTPU	0.16	1.71	Supported by 10%
BM ⇒ OUTPU	0.27	2.82	Supported by 1%
TECHN ⇒ OUTPU	0.43	3.87	Supported by 1%
TEAM ⇒ OUTPU	0.21	1.8	Supported by 10%
SPQM ⇒ OUTPU	0.23	2.13	Supported by 5%
EMPINV ⇒ OUTPU	0.25	2.39	Supported by 5%

BM, Benchmarking; COMMU, Communication; EMPINV, Employee Involvement and Empowerment; INNOV, Innovation; OUTPU, Outcome due to Quality Improvement Efforts; QO, Quality Objectives; QSS, Quality Supervision; SEM, Structural equation model; SPQM, Supplier Quality Management; TEAM, Team Effectiveness; TECHN, Technical; TPMGT, Top Management Commitment.
The significance is ascertained at 1.65 for 10%, 1.96 for 5% and 2.58 for 1% (all two-tailed), and at >0.98 for 5% (one-tailed).
*Significant at 95%; **Significant at 99%; ***Significant at 90%.

2.4 Assessment of the structural model

The PLS structural model was developed using Visual PLS software, which is a second-generation model that can detail the outline of the associations among the constructs (Loehlin, 1998), and the model evaluates the following three aspects:

(a) Path coefficients, which are assessed by β value;
(b) Path significance, which is denoted by p-value; and
(c) Variance that is explained by various factors determining construction project quality output (R2).

The rationale of the structural model was evaluated in the current study by using Visual PLS 2.0. The model was deliberated in PLS as per the guidelines specified in the Visual PLS Guide (Ringle et al., 2005). Following the assessment pattern of Chin (1998a, 1998b), the bootstrap resampling method was also engaged to investigate the statistical significance of the output of each path coefficient *d* functioning as a determinant in the evaluation of the construction projects. Using randomly selected subsamples, a total of 500 iterations were employed to estimate the theoretical model and formulate hypothesised relationships between the quality and outcome factors. The software Visual PLS does endow with the goodness-of-fit (GoF) for the model, and thus the global GoF developed by Tenenhaus et al. (2004) and this method together explain both the superiority of the measurement model and that of the structural model (Tenenhaus et al., 2005).

The average of AVE deliberated the variables' global GoF and R^2 value. The global GoF for the current study is 0.56, which surpassed the threshold-recommended value of 0.36 (Wetzels et al., 2009). Thus, it is concluded that the conceptual model of research in the current study is endowed with overall GoF. The SEM is shown in Figure 3.

Hypothesis: There is no significant relationship between the factors determining TQM and the outcome of the construction project.

The current study is based on multivariate data analysis, which is in turn based on the second-generation method known as SEM for construction quality research, focusing on PLS, an up-and-coming or emerging path modelling method. The stated hypothesis was tested with the structural model. The model's factor loadings and path coefficients are significant (they specify the potency of associations between independent variables and dependent ones). The R^2 value explained the total variance (which is the variance explained by the independent variables). The significance of each path coefficient was predicted statistically using a Visual PLS bootstrapping method, and the t-values were obtained (Chin, 1998a, 1998b). Table 4 presents the final results of the PLS structural model analysis with the path estimates and t-values.

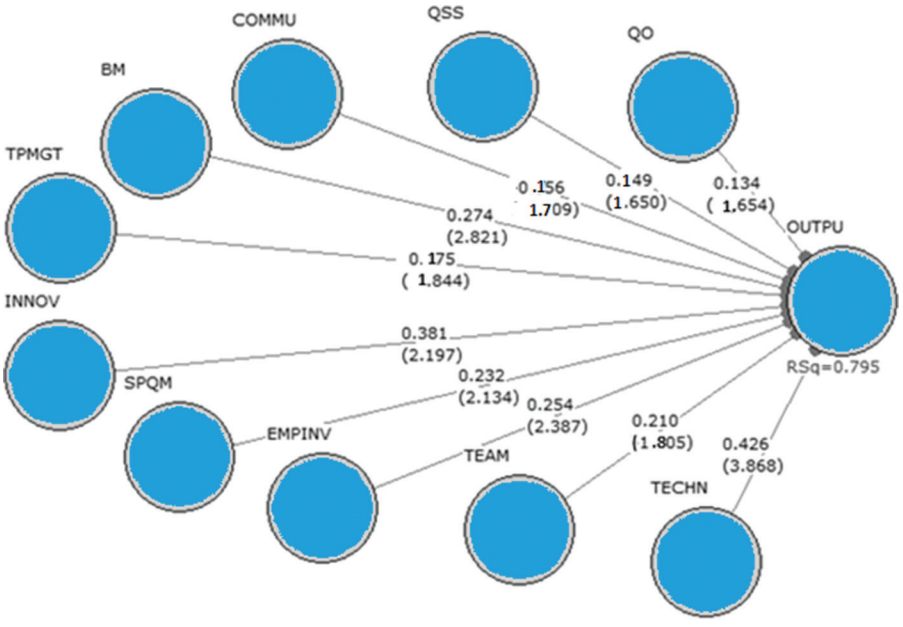


Fig. 3: PLS-SEM Model. BM, Benchmarking; COMMU, Communication; EMPINV, Employee Involvement and Empowerment; INNOV, Innovation; OUTPU, Outcome due to Quality Improvement Efforts; PLS, Partial least square; QO, Quality Objectives; QSS, Quality Supervision; SEM, Structural equation model; SPQM, Supplier Quality Management; TEAM, Team Effectiveness; TECHN, Technical; TPMGT, Top Management Commitment.

Visual PLS can generate *T*-statistics for significant variables using bootstrapping based on the inner and outer models. In this process, a massive number of subsamples (e.g. 5,000) are acquired from the original sample and are substituted to give standard bootstrap errors, which provide estimated *T*-values for testing the significance of structural path significantly.

It is concluded from Table 4 that TECHN knowledge (path coefficient: 0.426; t = 3.868, significant at 99%) and INNOV (path coefficient: 0.381; t = 2.197, significant at 95%) go together and determine the quality of the projects. Next in line are EMPINV (path coefficient: 0.232; t = 2.134), BM Practices (path coefficient: 0.274; t = 2.821) and SPQM (path coefficient: 0.232; t = 2.134). It is further concluded that all the significant variables determining the total quality outcome of the construction project are also positive in directionality. The standardised path coefficients are anticipated to be at least 0.2 (Chin, 1998a, 1998b).

In the current study, the TQM factors BM, EMPINV, INNOV, SPQM and TECHN are significant in determining the project's outcome. BM the best practices and TECHN support for the project are substantial factors; and taken together, these are significant at 99%, confirming the importance of world-class standards and technology in the current construction industry.

Several types of research have demonstrated the role of improved tools in the manufacturing industry as an essential aspect of continuous improvement activities. The use of benchmarked practices in quality control, performance measures and technology tools is common in the construction industry. The customer needs can be identified at various stages through these advanced quality practices. The current study results, which have determined the significance of the factors BM and TECHN support at 99%, have provided excellent confirmation for existing results in the literature (Metri, 2005).

TQM is progressively being followed by the construction companies as a scheme to resolve quality-related tribulations in the construction industry, to meet the needs of the final customer and to integrate the quality management activities through employee involvement, supplier relationship and innovative practices (Wong, 1999).

3 Discussion

The rationale of the present study is to recognise the TQM factor, among Productivity, Cost Reduction, Quality of Service, Customer Satisfaction and Timeliness of Service, that influences construction projects' outcome to the maximum extent. Using a survey—which was based on input collected through a questionnaire from individuals employed in various capacities in high net-worth construction projects in Tamil Nadu, including project manager, engineer, supervisor, contractor and consultant—and Visual PLS to analyse the data obtained, SEM of the critical factors leading to TQM were identified.

This research identifies that BM, EMPINV, INNOV, SPQM and TECHN are significant in determining the project's outcome. Among the significant factors, BM, Best practices, and TECHN support for the project are considered vital factors, and combined, they have a considerable effect, with a significance of 99%. The project manager should carefully monitor these factors to determine the means to maximise the success of construction projects.

Meanwhile, it is also revealed that QO, QSS, TPMGT and TEAM are also indicators of construction projects' success. Except for QSS, all these factors (i.e. QO, TPMGT and TEAM) have a negative path coefficient, which confirms that transparency of communication with the support of top management needs to be considered, and this determines the strength and positive direction in the total quality dimension of the construction project.

The analysis of the inner model shows that various TQM factors explain the perceived successful outcome of the construction project by 79.5%. It is a significant finding because it confirms that the project manager should consider these factors in determining the modus operandi by which the success of construction projects may be maximised. The project manager should pay attention to these TQM indicators because TQM factors that are predictive of project success, such as Productivity, Quality of project and Timeliness of project, have higher outer weights (Hoonakker et al. 2010). This leads us to the conclusion that they are the imperative features of the construction project that should be focused on by the construction industry. The study results regarding TQM factors and their significance in construction project outcome or performance confirm the findings of several previous studies (Rumane, 2016; Panuwatwanich and Nguyen, 2017).

This study has discussed the effects of the TQM factors that influence the outcome of construction projects based on SEM of second-generation multivariate data analysis method with a focus on PLS, which is an emerging path modelling approach for determining the relationship between independent and dependent factors. TQM practices have gained much importance among business people, managers, practitioners and research scholars over the last 20 years due to a more significant impact on the business performance of the construction industry (Bajaj et al. 2018).

The results of this study could have real-time applications, which include:

- Providing an optimised work plan, i.e. setting priorities and optimising the project's available resources.
- Helping project managers in the decision-making process.
- Assisting those responsible for requisitioning materials and other resources to make precise calculations regarding requirements.
- Estimating the overall effectiveness of the project in the whole end-to-end process and choosing the most desired route.
- Enabling contractors and civil engineers to determine the economic, time and resource availability constraints that apply to the project and to overcome them.
- Developing a holistic, total quality process to ensure maximum output in each aspect of the project.

4 Conclusions and implications

Considering in aggregate the applications mentioned at the end of the preceding section, we see that employing TQM in the construction industry could benefit everyone involved in the project, from the workforce to the financiers to the end-users. For future extensions of this line of study, a few more critical success factors can be added to the respective area or region of the survey. Also, apart from TQM, the introduction of other management techniques such as Kaizen, Lean, Six Sigma, etc., can be explored and documented. This project's scope can also be extended to other output factors involving human resources, machinery and the allocation of funds. Also, due to limited resources, the researchers have chosen to survey projects in urban and semi-urban areas only. The rural construction industry can be tapped, and a wider gamut of projects and professionals can be surveyed for better diversification and more accurate results.

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