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Modeling success factors for public construction projects with the SEM approach: engineer's perspective

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Abstract

Purpose – The study of the success factors of a project is a means of improving the effectiveness of the project. Hence, the purpose of this paper is to identify various determinants and validate their effects on the success of public construction projects in Ethiopia.

Design/methodology/approach – The study uses a questionnaire survey to collect data and structural equation modeling (SEM) to empirically examine the effect of determinants, namely, project manager's competence, owner's competence, management support and updates, scope clarity (SC), effective partnering, and monitoring and feedback on success of public construction projects which has been measured by performance on cost, schedule, quality and no-dispute parameters. Out of 407 questionnaires distributed among the selected respondents, a total of 200 completed questionnaires were received. The response rate was 49.1 percent.

Findings – The results depict that the investigated factors have a significant positive influence on the success of public construction projects with path coefficient of 0.82, the model is substantial in representing the relationship of the factors on the success of public construction projects and the factor "SC" plays a decisive role in the success of a project as it has a path coefficient of 0.98, and it is followed by "effective partnership, and owner's competency" having equal path coefficients of 0.96.

Research limitations/implications – The proposed model was validated by collecting data from many senior construction executives in Ethiopia only, hence may induce certain bias in the outcome of the study.

Practical implications – The significance of six constructs is highlighted to help the project manager in understanding the role of various constructs in public construction projects. The results would enable researchers and industry practitioners to focus on a few factors to take proactive measures and get the optimum result in the successful delivery of public construction projects. Utilization of SEM in the understanding of the significance of various success determinants is an important contribution to the body of theoretical literature in construction management. Since the model includes constructs, SEM has been used for construct validation.

Social implications – The implications of this study are not limited to researchers and construction industry practitioners alone. The Ethiopian Government could adopt the results of this study to reduce/avoid additional cost incurred due to the poor performance of public construction projects which results in poor utilization and increased social and economic costs. Furthermore, the study may also help the government efforts to enhance efficiency and effectiveness in the use of public funds for construction projects which are an ongoing concern of government and of the international development community.

Originality/value – This work is original and has neither been published nor under consideration for publication elsewhere. This study can add value to the construction professional in public construction project management as well as the Government of Ethiopia.

Keywords Construction, Methodology, Project management, Interview, Questionnaire survey

Paper type Research paper

Introduction

Construction projects are the central core of the economic growth of a country. It is obvious that the performance of these projects plays an important role. Because of the dynamic nature of the construction industry, construction projects are continuously facing uncertainties that make the management of these projects challenging and subsequently cause poor performances (Sugumaran and Lavanya, 2014). Hence, it is imperative to ensure that the construction projects are completed to satisfy and meet the predetermined objectives.

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Construction industry entails many stakeholders at various stages. The stakeholders such as client, designer, contractor, subcontractors, specialists, construction managers and consultants, etc. are involved from the start till completion of the project. Each stakeholder has his/her own definition of success, and it needs not to be the same even in a given project. Success is the relative term, and it is highly subjective (Parfitt and Sanvido, 1993). Success definition changes from project to project. Success for one stakeholder may be a failure for others (De Wit, 1988). Therefore, it becomes a very complex process to measure the performance of any construction project in terms of success. Success can be defined in terms of the attributes or the variables that influence the outcome of a project in a positive manner. The dimensions of these attributes can be people oriented (stakeholders and their qualities and traits), resource based, technology dependent, working environment, and system, or task.

A construction project is considered as successful when it is completed in time, without cost overruns, and within the specified quality parameters. In the past, many researchers have used these three criteria to measure project success (White and Fortune, 2002). These three criteria collectively are also referred to as the "iron triangle" in the project management parlance (Atkinson, 1999). There are certain other criteria such as safety performance, the satisfaction of stakeholders and the status of the dispute, which have been used by some researchers (Tabish and Jha, 2011) to measure the success of public construction projects. In this study, we have used time, cost, quality and no dispute to assess the success of the public construction project.

This study has focused on the identification of the success factors (SFs) of the public construction projects in Ethiopia. A questionnaire survey approach was adopted for this study and the viewpoints of Ethiopian industry experts were utilized to identify and to evaluate the SFs for public construction projects. It is evident from the literature that many researchers identified different SFs for construction projects in a country which may or may not be applicable in other countries (Tripathi and Jha, 2018b). Some of the researchers have attempted to identify SFs for construction projects in Ethiopia, but their study was either limited to the building construction projects or they only identified the factors affecting time and cost overrun in road construction projects. Very few researchers have drawn attention to identifying the SFs, which can be applied to the public construction projects in Ethiopia. The authors of this study have tried to identify the factors that will increase the chances of success for construction projects in Ethiopia, as well as other African countries, due to the similarities in their working environments and socioeconomic conditions.

In the present study, a hypothesis was made that SFs affect project success. SFs were defined as a second-order construct composed of six constructs: project manager's competence (PMC), owner's competence (OC), management support and updates (MSU), scope clarity (SC), effective partnering (EP), and monitoring and feedback (MF). This study uses the SEM technique to test the hypothesized significant positive relationships between SFs and project success.

Literature review

Success has always been the ultimate goal of every activity of a project, and the construction project is no exception. There are a considerable number of journal papers explaining factors impacting the success of construction projects in general, but very few have focused on determining the critical factors for the success of public construction projects (Amade *et al.*, 2015).

Critical success factors (CSFs) and criteria to define success are keywords in the field of project management. According to Rockart (1982), CSFs are those few key areas of activity in which favorable results are necessary for a manager to reach his or her goals. Furthermore, Boynton and Zmud (1984) explain that CSFs represent those managerial or enterprise areas that must be given special and continual attention to bring about high performance. Kerzner (1998) found that CSFs help in identifying the absolutely necessary factors to meet the desired deliverables of the customer.

Normally time, cost and quality have been used by many researchers as criteria to measure success. The three criteria collectively are also referred as "iron triangle" in the project management parlance (Atkinson, 1999). There are certain other criteria such as: safety performance, satisfaction of stakeholders and the status of dispute which have been used by some researchers (Crane *et al.*, 1999) to measure the project performance. These criteria are undoubtedly applicable to both private and public projects. In this research cost, schedule, quality and no-dispute parameters have been used as criteria to measure the performance of the public construction projects. The factors that are critical to the success of a project have been discussed by several researchers in different industries including construction. In one such study related to management information systems (MIS), Boynton and Zmud (1984) identified the suitability and weaknesses of the CSFs as a methodology and finally recommended guidelines for the effective application of the CSF method. The aim of the current study is to identify the factors that affect the success of a public construction project. Earlier studies reported in the literature in this area are based on delivery system, organization or specific aspect of construction management. These are briefly mentioned below.

Bing *et al.* (2005) used the CSF methodology in the context of PPP/PFI construction projects in the UK. They evaluated the relative importance of 18 potential CSFs using a questionnaire survey and identified a strong and good private consortium, appropriate risk allocation and available financial market as the three most important factors. The 18 CSFs were broadly part of effective procurement, project implementability, government guarantee, favorable economic conditions and available financial market. On the other hand, Iyer and Jha (2005) conducted a study on Indian construction projects and identified the following six CSFs: top management support, PMC, MF by the participants, project manager's coordinating and leadership skill, coordination among project participants and OC. Similarly, the study conducted on design and build delivery system by Chan *et al.* (2001) identified six project SFs using factor analysis in Hong Kong. These are client's competencies, contractor's competencies, end-users' needs, project team commitment, risk and liability assessment and constraints imposed by end-users. They found project client's competencies, contractor's competencies and team commitment, to be important to bring a successful project outcome. To understand the interrelationships between success traits and project success particularly for public sector projects in India, Tabish and Jha (2012) utilized SEM in their study. They concluded that human factors play an important role in making a project successful. Further, Pakseresht and Asgari (2012) employed CSF methodology to identify the CSFs for a construction organization in Iran. The study was carried out in two stages. In the first stage, using a questionnaire survey, sets of high priority SFs were identified. Subsequently, on the selected high priority factors, the analytical hierarchy process (AHP) was implemented to obtain the weight of these factors. Based on the weights, the CSFs are: a technical and economic assessment of the required project resources, experience and track record of the project manager for the projects executed in the past, project strategic planning, and the contractor's team experience in project execution. However, their study was for a construction organization and not for a project.

In order to discover the interrelationships among the CSFs, Chen *et al.* (2012) established CSFs system for construction projects in China using structural equation modeling (SEM). The CSFs system consisted of three categories and ten subcategories such as participant-related factors (owner's ability, owner's preference, owner's expectations, contractor's characteristics and sub-contractors characteristics; project-related factors (projects characteristics, and project delivery characteristics; and environment-related factors (economic, political and natural). Memon and Rahman (2013) developed a hierarchal model for assessing causative factors and cost overrun in Malaysia and analyzed using the SEM. They found that the contractor's site management-related factors had a strong effect on cost overrun. Samee and Pongpeng (2015) used SEM to determine the causal relationships among the three components: construction equipment management, project performance and corporate performance. The result of their research work in Thailand indicates that four factors of construction equipment management, namely, selection management, operations management, maintenance and repair management, and retirement and replacement management affect the project and corporate performance. Chandra (2015) identified the factor that causes risk and the factor of project success. Based on the result of the SEM, he investigated the natural risks, design risks, resource risks, financial risks, legal and regulatory risks, and construction risks affecting the project success in Surabaya, Indonesia.

Kog and Loh (2012) identified 10 CSFs from 67 factors describing aspects of project characteristics, contractual arrangements, project participants and interactive processes using AHP in Singapore. The factors identified were project manager competency, adequacy of plans and specifications, constructability, realistic obligations/clear objectives, project manager commitment and involvement, construction control meetings, contractual motivation/incentive, technical approval authorities, constructability program and modularization. Alzahrani and Emsley (2013) used a questionnaire survey to understand the impact of contractors' attributes on project success from a post-construction evaluation perspective in the UK. They conducted factor analysis and obtained nine clusters impacting the success of project, namely, past performance, safety and quality, resource, experience, environment, organization, management and technical aspects, finance and size/type of previous projects. Subsequently, these factors were used to predict the probability of project success using the logistic regression analysis.

Molenaar *et al.* (2000) used the SEM to explain how and why contract-related conflict arises between owners and contractors in the construction industry in the USA. Zulu (2007) evaluated the relationship between project management and project performance using an SEM approach in the UK. The study concluded that the application of SEM improves the understanding of the direct and indirect relationship between project management influencing factors and project performance. Wong and Cheung (2005) used the SEM to test the hypothesis that partners' trust level is positively related to the partnering success in Hong Kong. The study concluded that performance, permeability and relational bonding make significant contributions toward parties' trust level.

Mustefa (2015) studied the factors affecting time and cost overrun in road construction projects in Addis Ababa, Ethiopia through a questionnaire survey and found that the most important causes of time overrun were financial problems, delay to furnish and deliver the site and improper planning whereas the most important causes of cost overrun were found to be an inadequate supply of raw materials and equipment by contractors, delay in construction, incomplete design at the time of tender and design changes. Further, Tadewos and Patel (2018) tried to identify the factors influencing time and cost overruns in road construction projects only in Addis Ababa, Ethiopia through review of several papers and concluded that financial problems, fewer materials and equipment supply by contractors, improper planning, design changes, land acquisition and construction delay and incomplete design are the main sources of delay and cost overrun, respectively. Most of the factors were the same as that of the study by Mustefa (2015). Belay *et al.* (2016), on the other hand, investigated the major SFs on building construction projects in Bole sub-city, Addis Ababa, Ethiopia. Based on the analysis of 120 questionnaires using relative importance index (RII), they found that leadership skills of project manager, adequacy of funding project, project monitoring, a clear objective and decision-making effectiveness are the highest significant SFs. The above studies are summarized in Table I to better understand and compare findings of the study highlighting country-specific factors and research area.

Based on an analysis of literature that has been outlined above, it has become apparent that there are plenty of factors with the potential to affect the project success. But the factors affecting the success of the projects are different for different countries, which is supported by Tripathi and Jha (2018b) stating that the factors for a particular region may or may not be applicable to the other region. Also, very few studies have been taken up in the context of public projects, and not enough research work has been reported for Ethiopian public construction projects. The performance of public construction projects in Ethiopia has not been encouraging due to time and cost overruns. For instance, Dessa (2010) in his study examined the performance of 15 completed projects in different regions of Ethiopia and found that the delay encountered in most projects range from 20.66 to 500 percent of original contract time and cost increase is greater than 80 percent of its contractual sum. Some of the researchers have tried to identify the success of construction projects in Ethiopia but their study was limited to the building projects or only identified the factors affecting time and cost overrun in road construction projects. But very little efforts have been made in identifying the factors responsible for the success of public construction projects in Ethiopia. Hence, the necessity was felt to identify the SFs vital for public construction projects in Ethiopia. In this study, factors relevant to public construction projects and responses only from respondents involved in public construction projects have been analyzed. The following objectives were set for this study accordingly:

(1) to test the hypothesis that CSFs influence the success of public construction projects; and

(2) to explore the relative impact of the CSFs in the success of the public construction projects measured against various success parameters.

As it is tough to get the required data on completed public construction projects due to data preservation problem and the confidentiality of the information about the projects, this study considered a questionnaire survey approach as appropriate. The viewpoints of the construction professionals engaged in the Ethiopian public construction projects were used to apply the SEM to test the hypothesis that the CSFs positively influence the success of the public construction projects.

Research method

The various steps involved in the research are presented in the following sections.

Step 1: identification of success attributes

After a thorough review of the literature, a list of 20 project success attributes was identified. The appropriateness of these attributes for Ethiopian scenario was further checked by discussions with the key construction professionals in Ethiopia who had wide experience in the construction industry and were working at senior management positions in their organizations. Subsequently, a questionnaire was designed based on the 20 project success attributes identified. Taking the suggestions made by these professionals, the necessary modification was made to the list of attributes. Despite wider consultations and in-depth literature review, the above-identified attributes cannot be called exhaustive because of the fragmented nature of the construction industry. However, the list covers a large portion of different types of construction projects. A pilot survey was carried out to check the wordings and understanding of the questionnaires. As suggested by the experts, a minor modification was made in the questionnaire. The professionals participated in the pilot survey had more than 25 years of working experience in a public construction project.

Researcher's name	Tools used	Country	Research area	Critical factors identified
Kog and Loh (2012)	AHP	Singapore	Success factors of construction project	(1) Project manager competency, (2) adequacy of plans and specifications, (3) constructability, (4) realistic obligations/clear objectives, (5) project manager commitment and involvement, (6) construction control meetings, (7) contractual motivation/incentive, (8) technical approval authorities, (9) constructability program and (10) modularization
Alzahrani and Emsley (2013)	Questionnaire survey	UK	Success factors of construction project	(1) Past performance; (2) safety and quality; (3) resource; (4) experience; (5) environment; (6) organization; (7) management and technical aspects; (8) finance; and (9) size/type of previous projects
Bing *et al.* (2005)	Questionnaire survey	UK	Success factors of PPP/PFI construction projects	(1) A strong and good private consortium, (2) appropriate risk allocation and (3) available financial market
Pakseresht and Asgari (2012)	AHP	Iran	Success factors of construction organization	(1) Technical and economic assessment of the required project resources, (2) experience and track record of the project manager for the projects executed in the past, (3) project strategic planning and (4) the contractor's team experience in project execution
Chan *et al.* (2001)	Factor analysis	Hong Kong	Success factors of construction project	(1) Client's competencies, (2) contractor's competencies, (3) end-users' needs, (4) project team commitment, (5) risk and liability assessment and (6) constraints imposed by end-users
Iyer and Jha (2005)		India	Success factors of construction project	(1) Top management support, (2) project manager's competence, (3) monitoring and feedback by the participants, (4) project manager's coordinating and leadership skill, (5) coordination among project participants and (6) owner's competence
Chen *et al.* (2012)	SEM	China	Success factors of construction project	(1) Participant-related factors, (2) Project-related factors and (3) Environment-related factors
Memon and Rahman (2013)	SEM	Malaysia	Cost overrun	Contractor's site management related factors
Tabish and Jha (2012)	SEM	India	Success traits of public sector projects	Human factors

(*continued*)

Table I. Summary of literature review

Researcher's name	Tools used	Country	Research area	Critical factors identified
Samee and Pongpeng (2015)	SEM	Thailand	Effect of Construction equipment management on project and corporate performance	(1) Selection management, (2) operations management, (3) maintenance and repair management and (4) retirement and replacement management
Chandra (2015)	SEM	Indonesia	Risk of project success	(1) Natural risks, (2) design risks, (3) resource risks, (4) financial risks, (5) legal and regulatory risks and (6) construction risks
Wong and Cheung (2005)	SEM	Hong Kong	Partnering success	(1) performance, (2) permeability and (3) relational bonding
Mustefa (2015)	Questionnaire survey	Ethiopia	Time and cost overrun in road construction projects	Time overruns: (1) financial problems, (2) delay to furnish and deliver the site and (3) improper planning Cost overruns: (1) inadequate supply of raw materials and equipment by contractors, (2) delay in construction, (3) incomplete design at the time of tender and (4) design changes
Tadewos and Patel (2018)	Literature review	Ethiopia	Cost overruns in road construction projects	(1) Financial problems, (2) fewer materials and equipment supply by contractors, (3) improper planning, (4) design changes (5) land acquisition and construction delay and incomplete design
Belay *et al.* (2016)	RII	Ethiopia	Success factors on building construction projects	(1) Leadership skills of project manager, (2) adequacy of funding project, (3) project monitoring, (4) a clear objective and (5) decision-making effectiveness

Table I.

Responses on the extent of effects of these attributes on the performance of public construction projects were sought on a five-point ordinal scale in which "1" refers to "adversely affect," "2" refers to "significantly affect," "3" refers to "marginally affect," "4" refers to "no effect" and "5" refers to "helps in improving." Similarly, for performance outcome variables, the five-point Likert scale was used in which "1" refers to very low performance and "5" refers to "very high performance. The questionnaire is given in the Appendix.

Step 2: data collection

Target respondents were engineers involved in public sector projects. A list of completed public construction projects (railways, highways, buildings and waterworks) was developed on the basis of information obtained from different government offices responsible for public construction works. A total of 407 questionnaires were distributed through e-mail, post and personally to respondents selected randomly from the list available with these offices. A total of 200 completed questionnaires were received. The average response rate was 49.1 percent, which is considered acceptable (Sekaran, 2003). The respondents were chosen with a wide range of experience and number of years of service. A summary of respondents' profile is given in Table II. From Table II, it can be seen that respondents with 10–20 years' experience form the largest group and the average experience of the respondents was 17 years.

Step 3: data analysis

All the responses were stored and analyzed using statistical package for social science (SPSS) Version 20 and LISREL 8.8, an SEM tool. In this study, both univariate and multivariate statistical analyses were used. Under the assumption of a multivariate normal distribution of the observed variables, maximum likelihood estimates have the desirable asymptotic or large sample properties of being unbiased, consistent and efficient (Kmenta, 1971). Mahalanobis D^2 (d^2) was used to find the outliers from data.

The authors initially found three outliers in the data samples. Analyses were performed with and without these outliers and the results obtained were compared to determine whether the results were more representative and on an expected line with or without the outliers. In the end, it was decided not to include these outliers for further analysis. Then the samples were checked for normal distribution and results show neither outliers nor severely skewed cases. The significant attributes are identified for the projects ranked: "High" and "Very high" on performance. Out of 20 attributes, only 15 attributes were found to be significant and taken for further analysis, as shown in Table III. Statisticians have suggested that the inclusion of irrelevant variables can result in poor model fit and number

Experience in years	Percentage	Contract amount	Percentage
Less than 10 year	20	Less than Birr 100m	36.0
Between 10–20 year	51.5	Between 100–300m	20.5
Between 20–30 year	21	Between 300–600m	33.0
More than 30 year	7.5	Between 600–900m	7.0
		Above 900m	3.5

Note: 1 USD = 20.99 Ethiopian Birr

Table II. Summary of respondent's profile

S. No.	Attributes	Mean	Sig.
1	Availability of resources (fund, machinery, materials, etc.) as planned throughout the project	4.7	*0.00*
2	Regular quality control and quality assurance activities	4.68	*0.00*
3	Adequate communication among all project participants	4.61	*0.03*
4	Regular monitoring and feedback by owner	4.62	*0.02*
5	Clearly articulated scope and nature of work in the tender	4.61	*0.04*
6	Compliance with rules and regulations of anti-corruption	4.48	0.75
7	Adequate design and drawings	4.59	0.10
8	Regular monitoring and feedback by top management	4.64	*0.00*
9	Top management support	4.65	*0.00*
10	Regular schedule and budget updates.	4.63	*0.00*
11	Regular design and construction control meetings	4.72	*0.00*
12	Project Manager with similar project experience	4.42	0.19
13	Coordinating ability and rapport of project manager with his team members and sub-contractors	4.7	*0.00*
14	Understanding responsibilities by various project participants	4.73	*0.00*
15	Thorough pre-qualification for potential bidders	4.69	*0.00*
16	Owners need thoroughly understood and defined	4.63	*0.01*
17	Thorough understanding of scope of work by project manager	4.69	*0.00*
18	Adequate plans and specifications	4.59	0.10
19	Utilization of up- to-date technology by contractor	4.43	0.20
20	No major changes in the scope of work during construction	4.65	*0.00*

Note: Sig. values shown in italic face show the attributes which are significant at 0.05 sig. level

Table III. Significant success attributes based on performance criteria of variables should be restricted (Duda and Whitehead, 1998). Hence, limited attributes have been selected and the model is analyzed.

ANOVA, mean, median, standard deviation and frequency were used to find out summary statistics of responses. Factor analysis and reliability assessment were carried out to determine SFs. A total of six factors were extracted using Varimax rotation. The factor analysis results are shown in Table IV. To understand the causal relations among the various constructs, the SEM approach was adopted, and this has been explained in detail in the following section.

In this study, based on the proposed model, the hypothesis that SFs have a significant positive influence on the success of the public construction project is tested as follows:

H_0. SFs do not have a significant positive influence on the success of public construction projects.

H_a. SFs have a significant positive influence on the success of public construction projects.

Structural equation modeling (SEM)

SEM is among the most useful advanced statistical analysis techniques that have emerged in the social sciences in recent decades. SEM is a class of multivariate technique that combines the aspect of confirmatory factor analysis (CFA) in the form of measurement model and regression or path analysis in the form of the structural model. The advantage of using SEM is that it simultaneously examines the relationship between measured variables (independent variables) and constructs (dependent variables). The measurement model is concerned with how well the variables measure the constructs addressing their reliability and validity and the structural model is concerned with modeling the relationships among the constructs by

Second order construct (Latent variable)	First order construct (Latent variables)	Indicators
Success factors	1. Project Manager's competence (PMC)	Availability of resources (fund, machinery, materials, etc.) as planned throughout the project (PMC1)
		Understanding responsibilities by various project participants (PMC2)
		Regular design and construction control meetings (PMC3)
		Thorough understanding of scope of work by project manager (PMC4)
	2. Owner's competence(OC)	Regular monitoring and feedback by owner (OC1)
		Owners need thoroughly understood and defined (OC2)
		Thorough pre-qualification for potential bidders (OC3)
	3. Management support and updates (MSU)	Top management support (MSU1)
		Regular schedule and budget updates (MSU2)
	4. Scope clarity (SC)	No major changes in the scope of work during construction (SC1)
		Clearly articulated scope and nature of work in the tender (SC2)
	5. Effective partnering (EP)	Adequate communication among all project participants (EP1)
		Coordinating ability and rapport of project manager with his team members and sub-contractors (EP2)
	6. Monitoring and feedback (MF)	Regular monitoring and feedback by top management (MF1)
		Regular quality control and quality assurance activities (MF2)

Table IV.
Constructs and their indicators

describing the amount of explained and unexplained variance which is akin to the system of simultaneous regression models (Wong and Cheung 2005). Unlike other multivariate statistical analysis, such as regression analysis, SEM considers the measurement errors also and explains the entire relationships in a single model (Molenaar *et al.*, 2000). Thus, SEM is a technique which effectively incorporates a whole range of standard multivariate analysis methods, including regression, factor analysis and analysis of variance. Also, because second order and first order constructs have been used, SEM has been found the most appropriate to validate the significance of the relationship. Many researchers Tabish and Jha (2012), Memon and Rahman (2013) and Chen *et al.* (2012) applied SEM in the construction management area.

The wide applicability of the SEM has been made quite evident in the literature review. Besides the advantages and applicability in exploring relationships in wider areas, SEM can be used to recognize complex relationships visually and systematically. Needless to say, it is more useful in understanding performance processes and thus makes SEM the perfect choice for discovering the underlying interrelationships among critical factors (Ng *et al.*, 2010).

Variables and constructs

Variables also known as indicators are the directly measured raw data, whereas constructs are not directly measured. Variables having common variance define constructs (Yong and Pearce, 2013). Therefore, in order to measure the SF of construction projects, based on the result from factor analysis six first-order construct and their variables (indicators) are determined as shown in Table IV. Important determinants of public construction project performance such as PMC, OC, MSU, SC, EP, MF are considered for the model.

Step 4: defining measurement model

This study identified 6 latent variables (constructs) and their 15 measurable variables (indicators) as shown in Table IV, to develop the hypothesized model. The hypothesized model is shown in Figure 1. Second order constructs have been used in the model as they maximize the interpretability (Hair *et al.*, 2010). The direction of the hypothesized influence between two constructs is defined by the dark arrow as shown in Figure 2. The constructs are represented by an oval, and their variables (indicators) are represented by a rectangle. The data were collected based on a questionnaire survey approach and selection of respondents and determination of significant attributes for the analysis has been discussed above.

This study used covariance matrices in the SEM analysis because of distinct statistical advantages (Hair *et al.*, 2010). Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity test were also carried out to check the sample adequacy and multivariate normality. It is a measure of the homogeneity of variables. A higher value of KMO is desired. According to Gorsuch (1983) and Field (2013) for an adequate sample size, the KMO value greater than 0.5 is recommended. The KMO value is found to be 0.65. Therefore, the sample was found adequate for analysis. This study has the sample size of 200 which may be considered enough for conducting SEM (Tabachnick and Fidell, 2001; Tripathi and Jha, 2018a). Measurement model validity is assessed by the comparison of the theoretical measurement model with the reality model and to see how well the data fits.

Reliability (construct and item)

Cronbach's α reliability analysis was performed using SPSS version 21. Construct reliability measures the degree to which an observed variable reflects an underlying factor. It is computed from the squared sum of factor loadings for each construct and the sum of the error variance terms for a construct. A construct reliability value of 0.6 and 0.7 may be acceptable (Hair *et al.*, 2010). Further, item reliability which refers to the amount of variance explained in the underlying constructs rather than to error can be obtained by squaring the factor loadings, and it should be greater than 0.50 (Hair *et al.*, 2010).

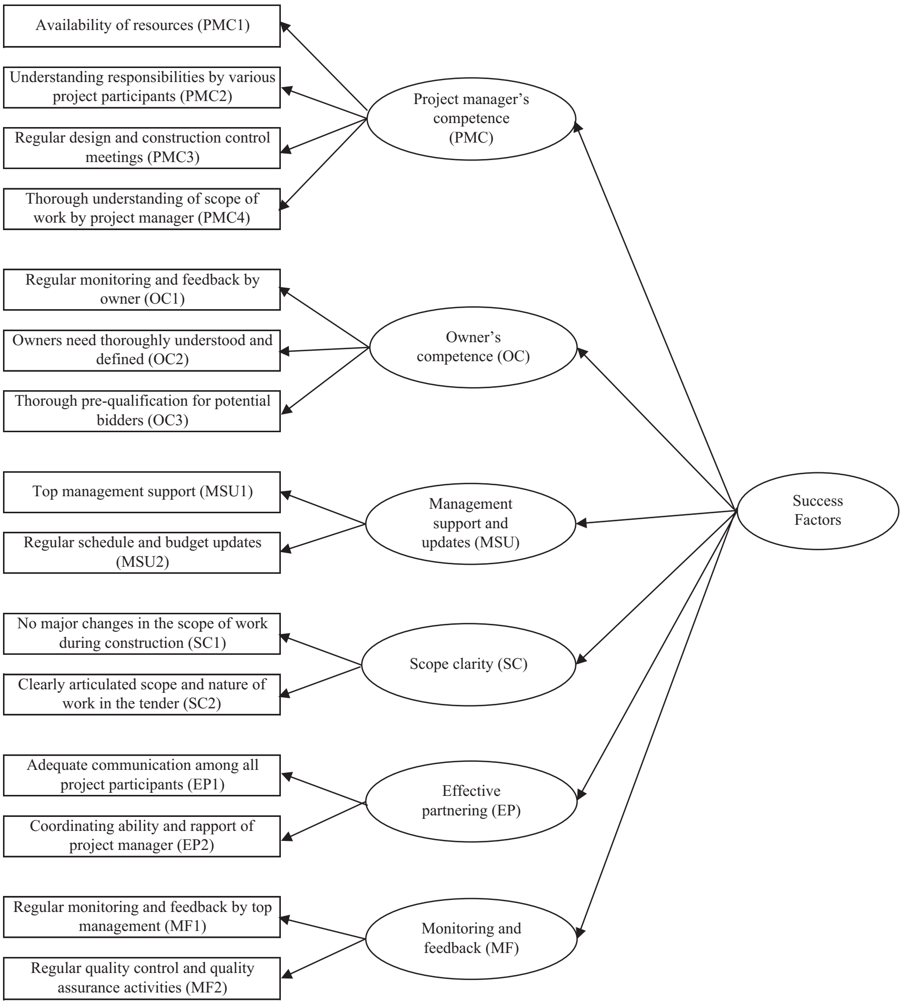

Figure 1.
Hypothesized model of success

Validity (convergent, discriminant, face and nomological)

Validity refers to the extent to which research is accurate. Convergent validity is a way to assess the construct validity of a measurement procedure (Campbell and Fiske, 1959). It refers to the degree to which indicators of the same constructs should converge or share a high proportion of variance in common. Average variance extracted (AVE), factor loading and communality are used to assess convergent validity. The AVE, factor loading and communality should be 0.50, 0.60 and 0.50, respectively, or higher (Fornell and Larcker, 1981; Hair *et al.*, 2010).

Discriminant validity refers to the degree to which conceptually similar concepts are distinct. The measures of theoretically different constructs should have low correlations with each other. According to Fornell and Larcker (1981), discriminant validity can be checked using the AVE. The AVE of each construct should be greater than the squared correlations between the construct and all other constructs in the model. Face validity is the degree to which a test is subjectively viewed as covering the concept supposed to

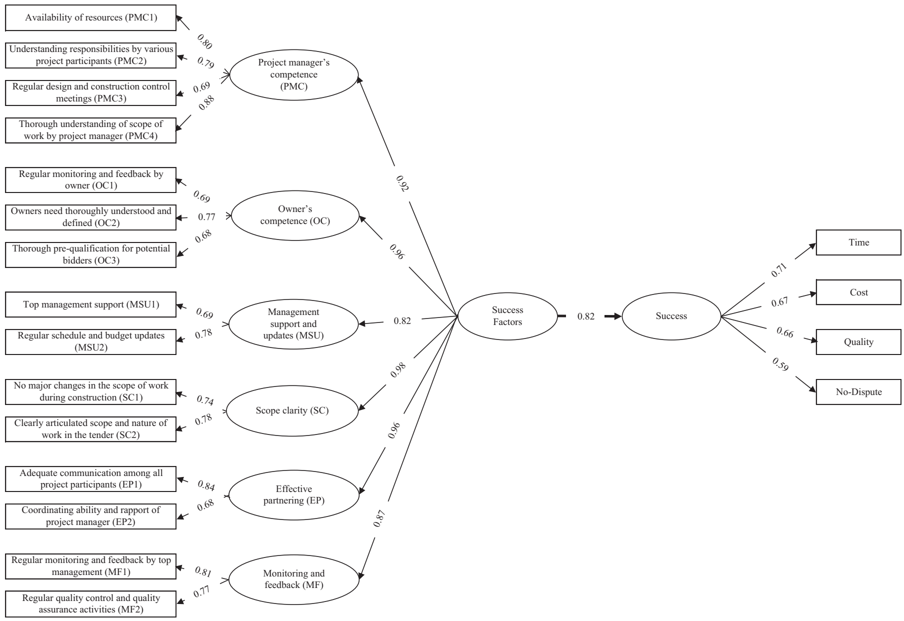

Figure 2.
Structural equation modeling results of linkage between success factors (construct) and success

be measured. Nomological validity is a form of construct validity that refers to whether the correlations among the constructs in a measurement theory make sense. Both face and nomological validity can be checked using existing literature.

Step 5: validation of the hypothesized model

In the CFA, the overall model fit describes the degree to which the attributes denote the hypothesized constructs. The SEM model is tested by assessing its appropriateness. The results of the covariance structural analysis, which is indicated by the goodness-of-fit (GOF) indices, evaluate the adequacy of the model. The model is revised if appropriateness is not good (Tripathi and Jha, 2018a). For assessing the GOF of a specified model, different researchers have proposed different criteria in SEM literature. Different GOF indices measure the appropriateness of a model from different aspects. The GOF used to evaluate the validity of the structural model in this study is shown in Table V. In order to evaluate the validity of the structural model, at least one absolute index, one incremental index and the ratio of χ^2 to DOF (model $\Delta\chi^2$) is required (Hair *et al.*, 2010). Therefore, this study uses multiple GOF indices to assess the overall fit of the structural model. The GOF indices are briefly described in the following paragraph (Tripathi and Jha, 2018a).

The ratio of χ^2 to the degree of freedom (df): this ratio compares the observed covariance matrix with the estimated covariance matrix by assuming that the tested model is true. The GFI: it indicates how well the hypothesized theory fits the data.

The root-mean-square error of approximation (RMSEA): it measures the difference between the observed and the estimated covariance matrices vs the unit degree of freedom.

Standardized root mean square residual (SRMR): it is defined as the standardized difference between the observed correlation and the predicted correlation.

Incremental fit index (IFI): it compares a χ^2 for the model tested to the hypothesized model. It indicates the relative improvement in the fit of the model compared with a statistical baseline model.

Table V.
Goodness of fit indices for the structural equation model

Goodness of fit and indices	Parameters	Permissible range	Overall model
Goodness of fit index	χ^2	As low as possible	306.87
	DOF	As high as possible	145
	Normed χ^2 (χ^2/DOF)	Between 2 and 5	2.12
	p-value	> 0.05 or 0.01	0.00
Absolute fit indices	GFI	0–1	0.87
	Adjusted GFI	> 0.80	0.83
	RMSEA	< 0.08	0.07
	SRMR	< 0.08 or 0.05	0.06
Incremental fit indices	NFI	> 0.90 or 0.95	0.95
	TLI or NNFI	> 0.90 or 0.95	0.97
	CFI	> 0.90 or 0.95	0.98
	IFI	> 0.90 or 0.96	0.98
Parsimony fit indices	PNFI	> 0.50	0.81
	PGFI	> 0.50	0.66

Comparative fit index (CFI): it represents the relative improvement in the fit of the hypothesized model (Chen *et al.*, 2012). It takes sample size into account and performs well even if the sample size is small.

Tucker–Lewis index (TLI): it considers a correlation between model complexity and sample size.

The measurement model validity largely depends on establishing acceptable levels of the GOF for the model and finding specific evidence of construct validity (Hair *et al.*, 2010). To evaluate the measurement model validity, convergent and discriminant validity were assessed. The six factors: PMC, OC, MSU, SC, EP and MF were measured using 15 items. Nomological and face validity were also tested through discussion with construction professionals. The test results are presented in Table VI.

It can be seen from Table VI that the communalities of indicators are greater than 0.5, except OC3 ("Thorough pre-qualification for potential bidders"), MSU1 ("Top management support"), and EP2 ("Coordinating ability and rapport of project manager with his team members and sub-contractors"). The communalities of OC3 and EP2 are in close range of 0.5 and can be accepted. Communality of MSU1 is 0.37 but since its AVE value is more than 0.5 and this indicator is an important indicator, so it has been retained. This shows that the measurement model is capable of describing the average variation among the measured variables and item reliability (Hair *et al.*, 2010). The value of Cronbach's α more than 0.7 is considered to be acceptable (Wong and Cheung, 2005). Cronbach's α values for all groupings in the hypothesized model are greater than 0.7 which indicates the hypothesized model has good internal consistency and reliability.

The values of AVE for each construct was found to be greater than 0.5 (Table VI), which shows that the indicators in each construct converge or share a high proportion of common variance. Content validity was also checked by conducting extensive literature survey to specify the variables that define constructs. Content validity is the degree to which the elements of an assessment procedure are relevant to and representative of the construct that they measure (Haynes *et al.*, 1995).

The ratio of χ^2 to the DOF (2.12) was within the acceptable range. The GFI value was 0.83, and other indices like RMSEA (0.07) and SRMR (0.06) were also in their permissible range, and thus are acceptable. Furthermore, IFI, CFI and TLI values are higher than their cutoff values as shown in Table V.

The hypothesized theory was depicted as a structural (path) model in the path diagram based on the hypotheses shown in Figure 1. The relationship between the constructs can be interpreted similar to the regression coefficient which describes the linear relationship

Constructs	Indicators	Cronbach's α	Factor loading (Indicators)	Factor loading (Constructs)	Unique variance	Communality	AVE	CR	R^2 (Indicators)	R^2 (Constructs)	t-value
PMC	PMC1	0.864	0.80	0.92	0.36	0.64	0.63	0.87	0.64	0.85	12.07
	PMC2		0.79		0.40	0.60			0.61		
	PMC3		0.69		0.50	0.50			0.48		
	PMC4		0.88		0.24	0.76			0.77		
OC	OC1	0.703	0.69	0.96	0.48	0.52	0.51	0.76	0.49	0.92	9.26
	OC2		0.77		0.39	0.61			0.60		
	OC3		0.68		0.55	0.45			0.45		
MSU	MSU1	0.701	0.69	0.82	0.63	0.37	0.51	0.71	0.47	0.68	8.32
	MSU2		0.78		0.40	0.60			0.56		
SC	SC1	0.710	0.74	0.98	0.47	0.53	0.58	0.73	0.54	0.95	11.48
	SC2		0.78		0.45	0.55			0.62		
EP	EP1	0.714	0.84	0.96	0.30	0.70	0.58	0.74	0.71	0.92	8.86
	EP2		0.68		0.53	0.47			0.45		
MF	MF1	0.764	0.81	0.87	0.34	0.66	0.62	0.77	0.66	0.75	10.38
	MF2		0.77		0.42	0.58			0.58		
Success factors				0.82						0.68	7.57

Table VI.
Individual item reliability and construct validity

between the two constructs (Matt and Dean, 1993). The numbers over the paths (Figure 2) are the standardized path coefficients.

All values of different GOF indices of the overall model, shown in Table V, are within the permissible range. The *t*-test result confirms the significance of the path coefficient and indicates whether or not the hypothesized relationship holds. The R^2 (see Table VI) values obtained also confirms a strong linear relationship among constructs. The relative importance of each construct can be expressed in terms of its standardized path coefficients. Accordingly, SC emerges as the most significant SF. H_a, which assumes that SFs have a significant positive influence on the success of public construction projects, is found to be supported because of the significant path coefficient of 0.82.

Discussion

Project success is a foundation to execute, manage and control current projects and to plan and orient future projects. Project SFs need special attention to ensure the project's success; otherwise, if these factors are not handled properly, it could lead to the failure of the project (Kandelousi *et al.*, 2011).

Authors have used the SEM technique in this paper to test the hypothesis that SFs have a significant positive influence on the success of a public construction project. The results were found to be consistent with those determined in previous studies undertaken by Jha and Iyer (2007) and Tabish and Jha (2012). As discussed previously, important determinants for the success of construction projects such as PMC, OC, MSU, SC, EP and MF are considered for this model. As it can be seen from Figure 2, SC was found to be the factor with the highest influence on construction project success followed by EP and OC, while MSU was the factor with the least influence.

In fact, earlier studies by Songer and Molenaar (1997) and Iyer and Jha (2005) have also found "clearly defined goals and objectives" as a factor for project success. Collins and Baccarini (2004) considered "a clearly articulated scope" to be a factor which is essential for meeting the owner's needs and thus ensuring success. Jacobson and Choi (2008) and Chan *et al.* (2004) asserted EP as a key element in ensuring project success. Furthermore, many researchers have identified adequate communication among all project participant as vital for the success of construction projects (Nguyen *et al.*, 2004; Toor and Ogunlana, 2008). Al-Qudsi (1995) also identified team effort by stakeholder: owner, architect, construction manager, contractor and subcontractors, as a crucial factor for the successful completion of a project.

According to Iyer and Jha (2005), PMC plays an important role in making a project successful. The project manager is able to ensure the availability of various resources necessary for the project; this is because project resources provide the means for accomplishing the work objectives. Inayat *et al.* (2012) in their study identified regular design and construction control meetings as an important factor for the successful accomplishment of construction projects. Iyer and Jha (2005) in his study found the OC as one of the major factors for the success of construction projects in India. Iyer and Jha (2005) further discussed that for the successful accomplishment of a project, a competent owner should have its scope of work well defined and explained to the contractor and he/she should closely monitor the project regarding its progress, quality, budget and other aspects.

Lin (2010) and Chae and Poole (2005) emphasize top management support as an important factor for achieving project success. Projects without the support of top management rarely survive. Furthermore, success largely depends on factors like MF (factor loading 0.81) and regular quality control and quality assurance activities (factor loading 0.77). Khan *et al.* (2008) suggested that quality control and quality assurance activities enhance the success of construction projects. These factors are important and must be paid attention to the success of construction projects.

Summary and conclusions

Public construction projects play a vital role in the economic growth of a country. The performance of these projects greatly depends on some critical factors which are responsible for their success/failure. Hence, understanding of the impact of critical factors on performances of public projects is considered to be a means for improving their efficiencies and effectiveness. Hence, a comprehensive investigation of public construction project success is initiated in the Ethiopian construction industry. This study attempts to identify a set of factors affecting the success of a public construction project. A questionnaire survey and SEM technique have been used to empirically validate the proposed hypothesis, that SFs have a significant positive influence on the success of public construction projects and to explore the relative impact of these CSFs in the success of the public construction projects measured against various success parameters. The results point out that all the parameters and indices considered in the study were within the acceptable limits. The final SEM indicated that the hypothesis set for the study was found to be supported with a very strong path coefficient of 0.82 at 0.05 significance level, as shown in Figure 2.

The final SEM model reveals that SC plays the most significant role in making a project successful as it has a path coefficient of 0.98, and it is followed by the effective partnership, and owner’s competency having equal path coefficient 0.96, PMC (path coefficient = 0.92), MF (path coefficient = 0.87) and MSU (path coefficient = 0.82). These SFs have a direct influence on the success of public construction projects while the success attributes have indirect implication on the success of public construction projects through SFs. Hence, it is recommended to pay proper attention to these SFs which may increase the probability of the success of the public construction projects.

Currently, the public sector procurement in construction in Ethiopia is largely based on the traditional procurement method, known as the design-bid-build method. In this method, the client or his representative develops the need into a set of workable activities and estimates the time and cost for executing the set of activities. The client is also responsible for specifying the quality requirement and presents them in the form of a specification and “good for construction” drawings. Thereafter, the process of contractor selection is initiated and a responsible contractor usually the lowest bidder is awarded the contract through the competitive bidding (Hatush and Skitmore, 1998). One of the serious problems faced by government authorities is the poor performance of their projects (Mustefa, 2015). Poor performances of the projects are often caused by a number of issues such as the absence of clearly defined scope and nature of the work in the tender and major changes in the scope of the work during construction. Changes during project execution reflect the uncertainties in the scope of the work during the early stages of the project (Assaf and Al-Hejji, 2006). To reduce these changes, the scope of the work should be well-defined and clearly articulated at the planning stage of the project. Gibson *et al.* (2006) also pointed out that a well-defined and clearly articulated scope stops chances of variation at a later stage which may otherwise negatively affect project outcome. Further, the significant relationships between PMC, OC, MSU, SC, EP and MF and project success with regard to the Ethiopian public construction sector has been observed using SEM. The results would enable researchers and industry practitioners to focus on a few factors to take proactive measures and get the optimum result in the successful delivery of public construction projects. Utilization of SEM in understanding the significance of various success determinants is an important contribution to the body of theoretical literature in construction management.

The questionnaire-based survey has some limitations. The proposed model was validated by collecting data from a large number of senior construction executives involved in public construction projects in Ethiopia only, hence may induce certain bias in the final outcome of the study. The viewpoints of the construction executives engaged in sectors other than public construction projects might be different, and therefore, different sets of success attributes/factors should be identified based on their own focus. The implications of this study are not limited to researchers and construction industry practitioners alone. The Ethiopian Government could adopt the results of this study to reduce/avoid additional cost incurred due to the poor performance of public construction projects which results in poor utilization and increased social and economic costs. Furthermore, the study may also help the government efforts to enhance efficiency and effectiveness in the use of public funds for construction projects which are an ongoing concern of government and of the international development community.

In this study, the importance of understanding the impact of various SFs on public construction project success has been emphasized. Further research is needed to investigate potential improvement in the success of projects using these factors in Ethiopian public construction industry. Similar research may also be conducted with respect to construction projects success in other countries, using the present study findings.

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(The Appendix follows overleaf.)

Appendix. Abstract of the questionnaire used in the study

Question 1.

Listed below are some of the attributes responsible for advantage/hindrances to project success. Please indicate the effects of these attributes on various project success evaluation criteria by marking tick (√) on only one, given alongside the attributes. If you have no idea about the question you can mention, “Don’t know” against the question.

While responding to the questions, following legend may be used.

1	Adversely delay	Adversely affect	Adversely affect	Adversely increase
2	Significantly delay	Significantly affect	Significantly affect	Significantly increase
3	Marginally delay	Marginally affect	Marginally affect	Marginally increase
4	No effect	No effect	No effect	No effect
5	Helps speeding up progress	Helps in saving	Helps in improving	Helps in decreasing

S. No.	Project Success Attributes	Effects on Completion Schedule					Effects on Project cost					Effects on Project Quality					Effects on Project Dispute				
1.	Availability of resources (fund, machinery, materials etc.) as planned throughout the project	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
2.	Regular quality control and quality assurance activities	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
3.	Adequate communication among all project participants	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
4.	Attributes as given in Table III.																				

Question 2.

Listed below are some of the performance outcome variables such as time performance, cost performance, quality performance, and No-Dispute. Please rate the performance of the project selected by you (called choice project) on these variables on a 5-point scale, given alongside the performance outcome variables. If you have no idea about the question you can mention, “Don’t know” against the question.

S. No.	Performance outcome variables	Scale (1–5)				
1	How do you rate the time performance of the project selected by you on a scale of 1 to 5 (please tick √ on one only)	1	2	3	4	5
		1 = Behind schedule by >10%, 2 = Behind schedule by ≤ 10%, 3 = On schedule, 4 = Ahead schedule by < 10%, 5 = Ahead schedule by >10%.				
2	How do you rate the cost performance of the project selected by you on a scale of 1 to 5 (please tick √ on one only)	1	2	3	4	5
		1=Over budget by >10%, 2= Over budget by ≤10%, 3= On budget, 4=Under budget by ≤10%, 5= Under budget by >10%.				
3	How do you rate the quality performance of the project selected by you on a scale of 1 to 5 (please tick √ on one only)	1	2	3	4	5
		1=Very low, 2=Low, 3=Fair, 4=High, 5= Very high.				
4	How do you rate the performance of the project selected by you on No-dispute account you on a scale of 1 to 5 (please tick √ on one only)	1	2	3	4	5
		1=Very low (large disputes), 2=Low, 3= Fair, 4= High, 5= Very high (no dispute)				

Thank you for your valuable contribution.

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