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Identification and evaluation of success factors for public construction projects

S.Z.S. TABISH and KUMAR NEERAJ JHA*

Department of Civil Engineering, IIT DELHI, New Delhi, India

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Achieving success in public construction projects is difficult because it requires economy, efficiency, quality, fairness and transparency. Such projects are taken up on the requisition of owners/clients and almost always involve multiple entities and are also accountable to external financial audit and vigilance agencies. Identification of the success factors is considered the key to achieving success in these projects. Through an extensive literature review, 36 success attributes were identified and a questionnaire-based survey was undertaken to elicit views of professionals on these success attributes. The responses from 105 professionals with an average of 22 years of experience in public construction projects in India were collected and analysed. The factor analysis yielded four success factors: awareness of and compliance with rules and regulations; pre-project planning and clarity in scope; effective partnering among project participants; and external monitoring and control. These four success factors were also used in multivariate linear regression in order to explore their relative significance for overall performance, and compliance with anti-corruption and financial norms. The most significant factor for overall performance is awareness of and compliance with rules and regulations. The results would be helpful to public construction project professionals in taking proactive measures for successful completion of public projects.

Keywords: Project success, public sector, success factor, India.

Introduction

A growing economy is an indicator of the development of a country's physical infrastructure, such as industries, residential units, roads, bridges, local trains, etc. For sustained future growth, infrastructural development is an important prerequisite (Construction Industry Development Council, 2005). The Government of India has committed an outlay of INR 20 562 billion (US$514 billion at an exchange rate of Rs. 40 for $1) towards infrastructure development in its 11th five-year plan (2007–11). Large investments in infrastructure have almost ensured the growth prospects of businesses.

But the performance of Indian construction projects has not been very encouraging due to time and cost overruns. According to the Ministry of Statistics and Programme Implementation (Infrastructure and project monitoring division), Government of India report, time and cost overruns have been a major problem affecting the public projects (Project Implementation Status Report of Central Sector Projects, 2007). The analysis shows that 301 delayed projects accounted for a cost overrun of Rs. 300.58 billion (US$7.5 billion at an exchange rate of Rs. 40 for $1), i.e. 26.09% with respect to their original sanctioned cost during the first quarter (January–March) of 2007.

Public sector projects involve public money, have to follow set procedures, and almost always involve multiple entities, from contractors and subcontractors to project management firms and government agencies. Achieving success in public projects is difficult because it requires economy, efficiency, quality, fairness and transparency (GFR, 2005). Kling (2008) states that public projects demand a high level of transparency and accountability and therefore are accountable to external financial audit and vigilance agencies. The project manager (PM) in charge of public construction projects sometimes tries to avoid

*Author for correspondence. E-mail: knjha@civil.iitd.ac.in

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taking decisions due to the existence of these agencies (Mahalingam, 2006). The hesitation in decision-making causes not only delay but also cost overruns. The earlier research on project success factors includes the perceptions of respondents from either the private sector or both private and public sectors uniformly. Since public sector projects are different from private sector ones, the success factors are also different. The existence of differences in perceptions about the relative importance of success factors in private and public sector projects has been reported (Divakar and Subramanian, 2009; Yang *et al.*, 2009). Hence, the uniformity of respondents (employees of the public sector) rather than diversity of respondents involved (from both private and public sectors) in projects is also very important. So, only public sector construction projects and the perceptions of their engineers are used in this study. This can be usefully employed in achieving success in future public construction projects.

Objectives

The objectives of the study are as follows:

- To determine the success factors for public construction projects.
- To identify the relative importance of these success factors in overall performance, compliance with anti-corruption and financial norms.

Owing to the non-availability of documented and structured data on completed projects with professional organizations for the study, a questionnaire-based survey method was used for data collection. The responses received were statistically analysed.

The literature review, research method, analysis of survey results, and application of research to construction projects are explained in the following sections.

Literature review

One of the major areas of research has been the attributes that help to make a project successful. The studies have been based on the assumption that the project success is repeatable and it is possible to find certain success attributes (Ashley *et al.*, 1987). The projects being complex and dynamic, their success or failure cannot be measured with a simple test like the strength of a concrete mix. Despite the availability of literature, it is very difficult to identify certain universal attributes which when present in a project would guarantee a successful outcome. This is for a number of reasons explained below.

First, what makes it difficult to assess whether a project has achieved success or has failed is the lack of a universally accepted definition of project success and the fact that the concept of success remains vague among stakeholders. For those involved in a project, project success is normally thought of as the achievement of some predetermined project goals (Lim and Mohamed, 1999) while the general public has different views of success, which are commonly based on user satisfaction. According to de Wit (1988, p. 165):

> the project is considered an overall success if the project meets the technical performance specifications and/or mission to be performed, and if there is a high level of satisfaction concerning the project outcome among: key people in the parent organization, key people in the project team, and key users or clientele of the project effort.

These definitions are applied to private sector projects but no standardized definition is available for public sector projects.

Second, the perception of success or failure is also time-dependent. The Denver airport project in the USA reveals that something that was viewed as a failure during the construction phase is now treated as a success due to a high inflow of revenue and the improved lifestyle of local inhabitants (Griffith *et al.*, 1999).

Third, there are just too many variables influencing the performance of a project. Geographic location and management style, among other matters, have a role to play in the outcome of a project (Boynton and Zmud, 1984).

Criteria for success and critical success factors are two important keywords used in project and project management contexts. While 'success criteria' are the standards on which a judgment or decision regarding project success are based (Gibson and Hamilton, 1994), 'critical success factors' (CSFs) are the few key areas of activity in which favourable results are absolutely necessary for a particular manager to reach his or her goals (Rockart, 1982).

A construction project is commonly acknowledged as successful when it is completed in time, without cost overruns and in accordance with specifications. A number of researchers have used these three criteria to measure project success (White and Fortune, 2002). The three criteria collectively are also referred as the '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 any dispute(s) which

have been used by some researchers (Munns and Bjeirmi, 1996; Crane *et al.*, 1999) to measure the project performance. These criteria are undoubtedly applicable to both private and public projects. Since public projects involve public money, they are therefore accountable to financial regulation and vigilance agencies. Moreover, since public procurement is most prone to corruption (Søreide, 2002), some additional criteria such as transparency and accountability are also required (Kling, 2008) for performance measurement. Thus, in addition to the criteria mentioned, public projects should also comply with anti-corruption and financial norms. In other words, for projects to be completed in a fair and transparent manner, they should honour anti-corruption norms, and the expenditure should be as per financial regulations.

Prior to Schultz *et al.* (1987), and Pinto and Slevin (1989), most of the authors, for example Baker *et al.* (1983), Cleland and King (1983), and Hughes (1986) presented the success factors based on their experiences. Schultz *et al.* (1987) classified critical success factors into strategic and tactical groups. The strategic group consisted of factors such as project mission, top management support and project scheduling while the tactical group consisted of factors such as client consultation and personnel selection and training. Taking the work of Schultz *et al.* (1987), Pinto and Slevin (1989) evaluated the relative importance of tactical and strategic groups of factors on the project life cycle. They concluded that when measures for external success are employed, planning factors dominate tactical factors throughout the project life cycle. Subsequently, a number of researchers developed lists of issues, practices or factors, which either positively or negatively affect project outcomes (Songer and Molenaar, 1997; Chua *et al.*, 1999; Chan *et al.*, 2004; Nguyen *et al.*, 2004). These factors were identified by using various methods, ranging from formally structured research investigations at one end to simply drawing on extensive years of work experience at the other. A more detailed investigation of the relationships between project execution strategies and project performance can be found in the works of Jaselskis and Ashley (1991) and Alarcon and Ashley (1996).

There were other studies conducted on specific aspects of construction projects. These included: project partnering (Larson, 1995), the influence of management and labour on construction productivity (Lim, 1993), construction contracting methods (Gordon, 1994), as well as contract disputes (Diekmann and Girard, 1995). Some of the researches addressed project management success instead of the success of the project as a whole (Might and Fisher, 1985; Pinto and Slevin, 1988). Tiong *et al.* (1992) studied the concept of CSFs for BOT projects. Zhang (2005) studied CSFs for public–private partnerships in infrastructure development while Abraham (2003) studied CSFs for the construction industry. Khandekar and Sharma (2006) found that organizational learning, which is largely reflected through human resource management (HRM) activities, has a positive correlation to organizational performance. Jha and Mishra (2007) found that 'regular monitoring of critical path activities'; 'monitoring the budget on all activities and taking corrective action'; 'application of sound technical practices'; 'implementation of all contractual commitments' are the most important coordination activities corresponding to schedule, cost, quality and no-dispute performance criteria, respectively. Despite their emphasis on a limited facet of project success, these works undoubtedly contribute to the overall model of project success.

While a number of studies have been conducted to understand the success factors for private projects using some of the aforementioned criteria, the same is not true of public projects especially in light of criteria suggested by Kling (2008). Wirick (2009) mentioned that 'overlapping oversight mechanism' is a distinguishing characteristic of public sector projects. The constraints of these overlapping oversight agencies are embedded in statutes, rules, executive orders and required processes. This overlapping oversight represents, at the operational level, the system of checks and balances that limits the power of government agencies to operate outside the bounds of public authorities. These constraints are, in fact, designed to limit the agencies' discretion and operation so that the public sector employee remains accountable. In addition, the penalties on public sector agencies for violating these constraints are so severe that public sector agencies turn very risk-averse, even to the extent of choosing compliance over the attainment of business objectives.

Songer and Molenaar (1997) studied public sector projects to identify 15 characteristics of successful projects but their study was limited to design-build (DB) projects. Songer and Molenaar (1997) found that the top five important project characteristics are well-defined scope, shared understanding of scope, owner construction sophistication, adequate owner staffing, and established budget.

These examples represent only a partial list of the many factors identified in the reviewed articles. However, it is recognized that research on project success factors needs further efforts. Too general or too specific success factors in previous studies present certain difficulties when practically applied. In addition, the

Table 1 Recent studies on project success attributes and the type of respondents considered

Researcher(s) and year of publication	Type of respondents considered	Methods of analysis	Number of variables considered	Key success attributes/variables identified
Sanvido *et al.* (1992)	Mixed type respondent (private and public)	Ranking the closeness of fit and the success of each project and computing Spearman's rho, conducting pair-wise analysis	35	Well-organized facility team, contract that allows and encourages the team chemistry without conflict of interest and differing goals, experience in project management, planning, design, construction, and operations of similar facilities, and timely, valuable optimization information from the owner, user, designer, contractor, and operator in the planning and design phases of the facility.
Songer and Molenaar (1997)	Representative from public sector agencies having experience in DB projects.	Regression analysis	44	Well-defined scope, shared understanding of scope, owner's construction sophistication, adequate owner staffing and established budget.
Chua *et al.* (1999)	Experts from private and public firms	Analytical hierarchy process (AHP)	67	Adequacy of plans and specifications, constructability, PM competency, PM commitment and involvement, economic risks, adequacy of funding, budget updates, schedule updates, site inspections.
Schaufelberger (2003)	Contractor of DB projects	Interview-based approach from seven contractors	7	Well-defined project scope, mutual understanding of the scope of work between the owner and the contractor, owner had sufficient experience with the design-build project delivery method.
Nguyen *et al.* (2004)	Mixed type respondents (public and private)	Factor analysis	20	Competent project manager, adequate funding throughout the project, multidisciplinary/competent project team, commitment to project, and availability of resources.
Andersen *et al.* (2006)	Mixed type respondents	Factor analysis and regression analysis	60	Strong project commitment, early stakeholder influence, stakeholder endorsement of project plans and rich project communications, a well-structured and formal project approach and well-understood and accepted project purpose.
Jha and Iyer (2007)	Mixed type respondents (public and private)	Factor analysis and multi-nominal logistic regression	55	Top management support, owner's competence, commitment of the project participants, conflict among project participants, coordination among project participants, favourable working conditions, project manager's competence, interaction between project participants—internal, and interaction between project participants—external.
Lam *et al.* (2008)	Contractor, client, and consultant	Factor analysis and multiple regression analysis	42	Project nature, effective project management action, adoption of innovative management approaches.

researches on success factors done earlier include perception of respondents from both private and public sectors without any difference and most of the studies are for private sector projects, as can be seen from Table 1.

Public sector projects have been a neglected area of study and research (Thai, 2008). Thai (2008) mentioned that four interrelated cornerstones to promote an efficient, effective and accountable acquisition function for public sector projects are organizational alignment and leadership, policies and processes, human capital and knowledge and information management. Similarly, Wirick (2009) mentioned common critical success factors for public sector projects such as: project management methodology, interactive dialogue among stakeholders, management support, and a detailed process of identifying users, supplementary requirements and capable project managers. It is clear from above that public and private sector projects are different in many ways and there exist differences in perceptions on the relative importance of success factors in the private and public sectors (Divakar and Subramanian, 2009; Yang *et al.*, 2009).

Thus, the present study considers only public sector projects and public sector respondents (employees of the public sector) and the success attributes relevant to public sector projects only.

Research method

The focus of this research is to identify and evaluate the success attributes for successful completion of public sector construction projects. This involves a literature review to capture the existing body of knowledge about success attributes and success criteria. Then, a questionnaire-based survey was conducted to draw the views of experienced public sector professionals on these success attributes. Finally univariate and multivariate data analyses like ANOVA, factor analysis and regression analysis were applied. Through ANOVA, significant attributes for highly successful projects were identified. Then these attributes were grouped into small factors through factor analysis and finally regression analysis was done to identify the important factors. The steps involved are briefly explained below.

Step 1: Preliminary interview

All reported success attributes of public construction projects were considered in order to develop a list of items for empirical testing. The identified attributes were scrutinized and verified through a series of face-to-face interviews with a number of select professionals with sufficient experience in public construction projects, including senior management representatives in India. A total of 10 key target project participants were interviewed to elicit their perceptions on the contribution of attributes to the success of public construction projects. The interviews were conducted in the respondents' head offices, and lasted for one to two hours, depending on the time allocated by the respondents and the degree of detail in their answers. A pilot study questionnaire was drafted to test the attributes and criteria adopted when assessing the success of a public construction project. The draft of the main empirical research questionnaire was reviewed by the participants during face-to-face interviews. Because no major adverse comments were received from the respondents, the pilot study questionnaire after slight modifications was taken as the final empirical questionnaire for the investigation. Finally, 36 success attributes were determined as given in Table 2, and these constituted the basis for the empirical survey questionnaire.

Step 2: Questionnaire development

The attributes listed above were presented to the respondents. The respondents were requested to rate the success attributes for the project in which they were currently involved then (case project). The rating for each attribute was sought on a nine-point Likert scale in which '1' represented 'strong disagreement' and '9' represented 'strong agreement'. If the respondent had no idea about a given attribute they were asked to state 'don't know'. A typical question of the questionnaire is given in Table 3 along with the rating scale. Since only success attributes were to be rated, the maximum scale sensitivity was required. Hence, a nine-point scale was used to measure such differential levels of intensity. The nine-point scale includes immediate values between adjacent values and helps the experts express their judgments subjectively and in a better way. Since some respondents are biased towards placing themselves in the middle of the scale (Schwarz *et al.*, 1985), the middle of the scale is further divided with adjacent values. As reported by Lissitz and Green (1975), reliability increases as the number of points increase to five and continue to increase. The authors conclude that increasing the number of scale points creates opportunities for response sets to arise and provides sufficient sensitivity to detect small significant differences. It is also interesting to note that an increasing number of authors (e.g. Hooker and Siegler, 1993; Watkins *et al.*, 1998) are using 10-point scales. Russell and Bobko (1992) found that the data from a 15-point scale increased regression analysis effect sizes by 93%

Table 2 List of attributes

Sl. No.	Attributes	Source
1	Owner's need thoroughly understood and defined	Chan *et al.* (2001); Chan *et al.* (2004)
2	Regular monitoring and feedback by owner	Dunnam (1984)
3	Clearly articulated scope of work	Songer and Molenaar (1997); Chan *et al.* (2004); Nguyen *et al.* (2004)
4	Adequate staff for planning	Songer and Molenaar (1997)
5	Availability of land without dispute	Diekmann and Girard (1995)
6	Comprehensive pre-tender site investigation	Chan *et al.* (2001)
7	Project manager with proven track record	Macomber (1989)
8	Project manager with similar project experience	Jaselskis and Ashley (1991); Sanvido *et al.* (1992); Nguyen *et al.* (2004)
9	Project manager's ability to coordinate with the owner, contractors, top management, and his team	Jha and Iyer (2007)
10	Thorough pre-qualification for potential bidders	Chan *et al.* (2001)
11	Adequate staff for execution	Songer and Molenaar (1997)
12	Timely and valuable decision from top management	Nguyen *et al.* (2004)
13	Timely and valuable decision by project manager and staff	Nguyen *et al.* (2004)
14	Availability of resources (fund, machinery, materials, etc.) as planned throughout the project	Songer and Molenaar (1997); White and Fortune (2002); Nguyen *et al.* (2004)
15	No major changes in the scope of work during construction	Chan *et al.* (2001)
16	Competent design consultant of the contractor	Chan *et al.* (2001)
17	Contractual motivation/incentive clause	Chua *et al.* (1999); Kog *et al.* (1999)
18	Thorough understanding of scope on the part of project manager and contractor	Songer and Molenaar (1997)
19	Timely finalization of detailed engineering plans and drawings	Jaselskis and Ashley (1991)
20	Regular design and construction control meetings	Chua *et al.* (1999)
21	Regular schedule and budget updates	Jha and Iyer (2007)
22	Regular quality control and quality assurance activities	Chung (2007); ISO (2007)
23	Full cooperation of all project participants	Chan *et al.* (2001); Jha and Iyer (2007)
24	Adequate communication among all project participants	Zimmerer and Yasin (1998); Chan *et al.* (2001); Nguyen *et al.* (2004); Jha and Iyer (2007)
25	A high degree of trust shared by project participants	Zimmerer and Yasin (1998); Chan *et al.* (2001)
26	Quick conflict resolution by participants of the project	Chan *et al.* (2001)
27	No social and political interference	Hadipriono and Chang (1988); Jha and Iyer (2007)
28	No bureaucratic interference	Nguyen *et al.* (2004); Jha and Iyer (2007)
29	No labour problem during construction	Jha and Iyer (2007)
30	Utilization of up-to-date technology by contractor	Nguyen *et al.* (2004)
31	Top management's support	Munns and Bjeirmi (1996); Nguyen *et al.* (2004); Jha and Iyer (2007)
32	Regular monitoring and feedback by top management	Munns and Bjeirmi (1996); Chua *et al.* (1999);
33	Awareness of all anti-corruption rules and regulations	Thai (2008)
34	Compliance with anti-corruption rules and regulations in decision-making process	Kassel (2008); Thai (2008)
35	Awareness of all audit/financial rules and regulations	Kassel (2008)
36	Compliance with audit/financial rules and regulations in decision-making process	Kassel (2008)

over those from a five-point scale. This also encouraged the authors to use nine-point scales.

In addition to being asked the above questions, the respondents were also requested to rate the compliance of the case project with anti-corruption norms and financial norms, and overall performance on a scale of 1 to 9. In the scale, '1' represented 'very low compliance' (i.e. norms were followed in a very limited manner) while '9' represented 'very high compliance' (i.e. all norms followed). The questionnaire-based survey dealt with several issues regarding major and medium construction projects, but issues related to only project success factors are presented.

Step 3: Selection of respondents

A list of completed or ongoing public construction projects was developed on the basis of information obtained from the website of the Ministry of Statistics and Programme Implementation (Infrastructure and project monitoring division), Government of India (http://www.mospi.gov.in), which monitors all the public projects of value more than 20 crore

Table 3 Extract of questionnaire

Sl. No.	Project success attributes	Level of endorsement								
1	Owner's need was thoroughly understood and defined	1	2	3	4	5	6	7	8	9
2	Regular monitoring and feedback taken by owner	1	2	3	4	5	6	7	8	9
3	Other attributes as listed in Table 2	1	2	3	4	5	6	7	8	9

Legend

1	2	3	4	5	6	7	8	9
Strongly disagree	Disagree		Neither agree nor disagree			Agree		Strongly agree

(Rs. 1 crore = Rs. 10 million). Projects costing between Rs. 100 crore and Rs. 1000 crore are called major projects and projects costing between Rs. 20 crore and Rs. 100 crore are called medium projects. All major and medium projects were considered. Representatives of all 813 major and medium projects were contacted. Several means such as e-mail, postal services, and personal delivery were employed to deliver the questionnaires and to receive responses. In our study, the owner is the government agency, local authority, a utility or any organization on whose behalf the engineer/project manager (PM) of the public sector is executing the project. The uniformity of respondents' perceptions (public sector employees) was maintained by selecting only professionals involved in public construction projects.

One hundred and five responses from project managers/engineers were received. The average response rate was 12.92%, which can be regarded as reasonable considering the length of the questionnaire and the target respondents (Krosnick, 1999). Respondents have minimum seven years and maximum 36 years of experience in construction business, the average experience being of 22 years.

Step 4: Analysis method

The analysis included identifying the significant success attributes. Two statistical tools, viz. factor analysis and multiple regression, were used to analyse data from the survey questionnaire. Factor analysis was used to identify the underlying dimensions and multiple regression was used to find the importance of success factors.

Factor analysis is a statistical technique used to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables (Norusis, 2002). It is conducted using a two-stage process: factor extraction and factor rotation. The goal of factor extraction is to determine the factors, using principal components analysis, whereas that of the second stage, factor rotation, is to make the factor more interpretable. Factor analysis addresses the problem of analysing the structure of correlations among a large number of variables by defining a set of common underlying dimensions, known as factors (Hair *et al.*, 1998). Several tests are required to determine the appropriateness of factor analysis for factor extraction. These include the Bartlett test of sphericity—a statistical test for the presence of correlations among the variables; the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (MSA), etc. Details of the factor analysis process and the test procedures can be found in Hair *et al.* (1998).

A regression model is a mathematical model that can relate a number of independent variables to a dependent variable. The models are developed using traditional regression techniques. In this research, the independent variables are the success factors obtained after factor analysis as defined above. For each model, the dependent variable is one of the performance criteria.

Data analysis

Univariate analysis

Analysis of variance is a procedure used for comparing sample means to see if there is sufficient evidence to infer that the means of the corresponding population distribution also differ. Based on the literature survey results, the following hypotheses were proposed:

> H_0: There is no significant difference in the perception of these attributes of a successful project.
>
> H_1: There is a significant difference in the perception of these attributes of a successful project.

The one-way ANOVA model is employed for testing the hypotheses. The significance level is set to 0.05. The respondents were asked to rate the overall performance on a nine-point scale, wherein 1 represents 'very low performance' and 9 represents 'very high performance'. Projects rated more than 6 on the scale were considered 'high' performing ones. The projects which were 'high' and 'very high' performing were rated as 'successful projects' whereas other projects with a value/rating less than 6 on the scale were rated 'not successful'. Table 4 shows that 20 success

attributes out of 36 are significant for successful projects. So, these 20 attributes were only considered for factor analysis for the projects rated as 'successful'.

Application of factor analysis

Prior to factor analysis and multiple regression analysis, all attributes and personal perceptions of success were tested for potential outliers and normality. It was found from the test results that they all satisfied the basic assumptions of normality and were confirmed to be acceptable and reliable. The reliability of the nine-point scale used in the survey was determined using Cronbach's coefficient alpha, which measures the internal consistency. The test value was 0.950 (F statistic = 14.67; p = 0.00) which was greater than 0.5, indicating that the nine-point scale measurement was reliable at the 0.05 significance level.

Factor analysis was applied to reduce the 20 success attributes to a small number of 'underlying' factors. Hair *et al.* (1998) suggested a case to variable ratio of 5:1 to guarantee a reliable factor analysis. However, some researchers have worked with ratios as low as 2:1, though in our study the ratio is more than 5:1. As recommended in Hair *et al.* (1998), factor loading of each factor should exceed 0.50 with sample size around 100. Additionally, at least one-half of the variance of each variable must be taken into consideration. Therefore, each variable's communality, representing the amount of variance accounted for by the factor solution for the variable, should be equal to, or more than, 0.5 to have sufficient explanation (Hair *et al.*, 1998).

The responses on the success attributes were subjected to principal component analysis. The value of the Bartlett test of sphericity is 1441.375 and the associated significance level is small (p = 0.000) which suggests that the population correlation matrix is not an identity matrix (Hair *et al.*, 1998). The correlation

Table 4 Different projects rating on attributes

Sl. No.	Attributes	F	Sig*
1	Owner's need thoroughly understood and defined	2.329	0.130
2	Regular monitoring and feedback by owner	4.798	**0.031**
3	Clearly articulate scope of work	4.331	**0.040**
4	Adequate staff for planning	2.196	0.141
5	Availability of land without dispute	3.558	0.062
6	Comprehensive pre-tender site investigation	19.164	**0.000**
7	Project manager with proven track record	1.752	0.189
8	Project manager with similar project experience	0.753	0.388
9	Project manager ability to coordinate with the owner, contractors, top management and his team	1.947	0.166
10	Thorough pre-qualification for potential bidders	0.002	0.968
11	Adequate staff for execution	1.216	0.273
12	Timely and valuable decision from top management	2.208	0.140
13	Timely and valuable decision by project manager and staff	5.315	**0.023**
14	Availability of resources (fund, machinery, materials, etc.) as planned throughout the project	6.928	**0.010**
15	No major changes in the scope of work during construction	10.025	**0.002**
16	Competent design consultant of contractor	0.101	0.751
17	Contractual motivation/incentive clause	0.002	0.961
18	Thorough understanding of scope on the part of project manager and contractor	18.693	**0.000**
19	Timely finalization of detailed engineering plans and drawings	0.983	0.324
20	Regular design and construction control meetings	0.527	0.470
21	Regular schedule and budget updates	2.514	0.116
22	Regular quality control and quality assurance activities	4.778	**0.031**
23	Full cooperation of all project participants	4.275	**0.041**
24	Adequate communication among all project participants	4.343	**0.040**
25	A high degree of trust shared by project participants	15.707	**0.000**
26	Quick conflict resolution by participants	12.136	**0.001**
27	No social and political interference	16.547	**0.000**
28	No bureaucratic interference	9.378	**0.003**
29	No labour problem during construction	6.486	**0.012**
30	Utilization of up-to-date technology by contractor	2.435	0.122
31	Top management's support	8.038	**0.006**
32	Regular monitoring and feedback taken by top management	15.068	**0.000**
33	Awareness of all anti-corruption rules and regulations	1.747	0.189
34	Compliance with anti-corruption rules and regulations in the decision-making process	4.758	**0.031**
35	Awareness of audit/financial rules and regulations	4.285	**0.041**
36	Compliance with audit/financial rules and regulations in the decision-making process.	9.842	**0.002**

Note: * Values in bold show the significant success attributes ($p < 0.05$).

matrix shows that all variables have significant correlation at the 0.05 significance level. It implies that the deletion of any other success attribute is not necessary. The value of the KMO MSA is 0.869, which is greater than 0.6 and hence the responses were considered appropriate for factor analysis (Kim and Mueller, 1978).

For the analysis, the varimax orthogonal rotation of principal component analysis was used to interpret the components. The factor labels, percentage of the variance explained by them (in parentheses), and the attributes emerging under them are shown in Table 5. The details of the factor loading and communalities are also given in Table 5. The values shown in Table 5 are compared with the values recommended by Hair *et al.* (1998) and found to be appropriate. Four factors were extracted that accounted for 73.18% of the variance. In general, loading and interpretation of the factors extracted were reasonably consistent. The factors are discussed in the following sections.

Factor 1: Awareness of and compliance with rules and regulations

Four attributes have emerged under this factor accounting for a variance of 21.97%. Compliance with rules and regulations helps in the successful completion of projects (Kassel, 2008). A sound public procurement system needs to have good procurement laws and regulations (Thai, 2008). It may be observed that most of the regulations for labour are part of the contract document and must be complied with. Problems arise with such violations as not adhering to the Minimum Wages Act, not providing adequate shelter, or other facilities as stipulated under labour laws. It justifies the grouping of this attribute in this factor.

Factor 2: Pre-project planning and clarity in scope

Six attributes have emerged under this factor accounting for a variance of 21.85%. The importance of these attributes—clear articulation of the scope of work, comprehensive site investigation, absence of major changes during construction, thorough understanding of scope by the PM and contractor, lack of social, political and bureaucratic interference is well established. It may be observed that the attributes under this factor pertain to the pre-project planning stage and their appraisal is possible only when a comprehensive pre-tender site investigation is carried out. This results in clear articulation of work and helps in developing a thorough understanding of the scope by the PM and contractor. This also prevents any major changes during construction. Bureaucratic, social and political interference could be avoided by involving all the stakeholders from the beginning and ensuring good planning. Otherwise, such interference will only result in delays. In many instances, such interference is meant to change the scope of the project, a phenomenon which happens due to lack of sound pre-project planning and, to a certain extent, this can be avoided by sound pre-project planning.

Factor 3: Effective partnering among project participants

This factor has eight attributes accounting for 21.41% variance and pertaining to partnering. This comprises valuable timely decisions by staff and PM, adequate communication among all project participants, full cooperation of all project participants, top management support, quick conflict resolution by project participants, trust shared by project participants, monitoring and feedback by top management and availability of adequate resources. Here, 'partnering' denotes partnering among project participants. It is more effective than teamwork as it involves effective working relationships between project participants. The term 'partnering' is often confused with partnership. The basic difference between a partnering arrangement and a partnership is that former refers to members of a project teamed together for a particular purpose or project, while the members of a partnership have joined together to run a business in common (Ward and Chapman, 2003). The effective partnering allows the participants to understand the requirements of owners and enables them to participate with new ways of remuneration, and also bring about innovation and reduction in cost (Pau, 2005). The fundamental principles of partnering include commitment, trust, respect, communication and proper consideration of interest. There are many studies which have established partnering as a success factor for construction projects (Mohr and Spelman, 1994; Larson, 1995; Cheng *et al.*, 2000; Bayramoglu, 2001; Chan *et al.*, 2004; Jacobson and Choi, 2008).

Factor 4: External monitoring and control

Two attributes have emerged under the factor accounting for 7.96% variance. The owner, for the purpose of this study, is considered as an outsider. As mentioned earlier, 'owner' in this study is the government agency, local authority, a utility or any organization, on behalf of which the engineer/project manager in the public sector is executing the project. Similarly, quality control and assurance are also done by some external agency. This explains the name of the factor. Dunnam (1984, p. 162) reported that

Table 5 Factor structure for success attributes

Factor and attributes description	Communalities	Factor loading
Factor 1. Awareness of and compliance with rules and regulations (21.965%)		
You had complied with anti-corruption rules and regulations in the decision-making process	0.812	0.864
You had awareness of the audit/financial rules and regulations	0.889	0.856
You had complied with the audit/financial rules and regulations in the decision-making process	0.849	0.864
There was no labour problem during construction	0.663	0.667
Factor 2. Pre-project planning and clarity in scope (21.845%)		
There was thorough understanding of scope on the part of project manager and contractor	0.771	0.833
Comprehensive pre-tender site investigation was carried out	0.699	0.804
No major changes were made in the scope of the work during construction	0.730	0.755
There was no social and political interference	0.823	0.697
There was no bureaucratic interference	0.827	0.627
The scope of work was clearly articulated	0.511	0.621
Factor 3. Effective partnering among project participants (21.408%)		
Project manager for the project and staff had taken timely valuable decisions	0.844	0.900
There was adequate communication among all project participants	0.786	0.771
There was full cooperation among all project participants	0.845	0.756
Your team got top management's support	0.624	0.701
Conflict was resolved quickly by project participants	0.625	0.601
A high degree of trust was shared by project participants	0.777	0.574
Regular monitoring was conducted and feedback taken by top management	0.594	0.560
The resources (fund, machinery, materials, etc.) as planned throughout the project were available	0.513	0.486
Factor 4. External monitoring and control (7.963%)		
Regular monitoring was conducted and feedback taken by owner	0.763	0.798
Regular quality control and quality assurance activities were conducted	0.720	0.584

> one way of successfully dealing with the many constraints that can arise during the life of the project is to keep the owner so close to the project status and involved in the decision-making process that he understands the impact of each deviation and, with full understanding, accepts the necessary adjustments.

Application of multivariate analysis

This technique is chosen as the principal tool in this study to identify the important factors for the success of public construction projects. Multivariate regression analysis has been used to explore the relative importance of the factors extracted from factor analysis on the criteria for the success of public construction projects.

Initially, since there was a large number of attributes and a limited sample size, there was a need to reduce the number of attributes before embarking on regression analysis. So, factor analysis was used to group the attributes.

Regression analysis is an iterative process. The responses of participants in public projects were used as inputs and results are shown in Tables 6, 7 and 8. The analysis was done by stepwise procedures. The regression analysis techniques include maximizing the coefficient of determination (R^2) value, minimizing model variances, and only including variables in the model that have been proven to be statistically significant through *t*-tests, *F*-tests, and stepwise selection procedures. The coefficient of determination (R^2), is a measure of the goodness of fit. However, when more independent variables are introduced into the model, R^2 automatically increases. A better estimate of the goodness of fit is *adjusted* R^2. Unlike R^2, it does not inevitably increase as the number of included explanatory/independent variables increases. In Tables 6, 7 and 8 B represents Regression coefficient, σ, Standard error of variable regression coefficient and b, Standardized regression coefficient. The regression analysis has been used here to explore relative significance of success factors for success of overall performance, and compliance with anti-corruption and financial norms.

The stepwise multiple regression results, when 'overall success' was treated as dependent variable with the four factors as independent variables, are shown in Table 6. The 'awareness of and compliance with rules and regulations' (Factor 1), 'effective partnering among project participants' (Factor 3) and 'pre-project planning and clarity in scope' (Factor 2), were found to be significant at $p < 0.05$ for the overall success of public construction projects.

Regression results were consistent with the findings of various previous studies. The most important factor contributing to the overall public project success was found to be the 'awareness of and compliance with rules and regulations'. Compliance with rules and regulations helps in the successful completion of projects (Kassel, 2008). This factor demands fulfilling certain responsibilities. In order that the responsibilities be fulfilled, the extent of the decision-making powers of the project participants and the areas of their authority should also be clearly specified (Chan and Kumaraswamy, 1996). Similarly, absence of labour problems, which can only be possible if labour regulations are complied with, also helps in the successful completion of projects (Jha and Iyer, 2007).

The second factor contributing to the overall public project success was found to be the 'effective partnering among project participants'. Bennett and Jayes (1998, p. ii) have defined partnering as:

> a set of strategic actions that deliver vast improvements in construction performance. It is driven by a clear understanding of mutual objectives and cooperative decision-making by a number of firms which are all focused on using feedback to continuously improve their joint performance.

Partnering requires that all parties be committed to improving communication within the project team and provide support from all level of management (Moore *et al.*, 1992). Also, communication among participants plays an instrumental role in problem identification and conflict resolution. Thus, a control and resolution mechanism should be developed to deal with problems and disputes (Bates, 1993). In fact, conflicting parties should work out a mutually satisfactory solution, and this can be achieved by joint problem-solving mechanism in order to seek alternatives for problematic issues. Such a high level of participation among parties may help them to secure a commitment to a mutually agreed solution (Cheng

Table 6 Stepwise multiple regression results for overall success

Independent variables	B	σ	b	t-value	p-value
Dependent variable: overall success; $R^2 = 0.168$, adjusted $R^2 = 0.137$					
Constant	7.906	0.063	NA	124.732	0.000
Factor 1: Awareness of and compliance with rules and regulations	0.156	0.064	0.248	2.449	0.016
Factor 3: Effective partnering among project participants	0.153	0.064	0.243	2.398	0.019
Factor 2: Pre-project planning and clarity in scope	0.137	0.064	0.218	2.148	0.035

Table 7 Stepwise multiple regression results for compliance with anti-corruption norms

Independent variables	B	σ	b	t-value	p-value
Dependent variable: compliance with anti-corruption norms; $R^2 = 0.453$, adjusted $R^2 = 0.426$					
Constant	7.953	0.108	NA	73.445	0.000
Factor 2: Pre-project planning and clarity in scope	0.610	0.109	0.463	5.599	0.000
Factor 1: Awareness of and compliance with rules and regulations	0.426	0.109	0.323	3.909	0.000
Factor 3: Effective partnering among project participants	0.395	0.109	0.299	3.622	0.001
Factor 4: External monitoring and control	0.279	0.109	0.211	2.558	0.012

Table 8 Stepwise multiple regression results for compliance with financial norms

Independent variables	B	σ	b	t-value	p-value
Dependent variable: compliance with financial norms; $R^2 = 0.274$, Adjusted $R^2 = 0.237$					
Constant	7.741	0.100	NA	77.128	0.000
Factor 1: Awareness of and compliance with rules and regulations	0.340	0.101	0.321	3.367	0.001
Factor 2: Pre-project planning and clarity in scope	0.294	0.101	0.278	2.917	0.005
Factor 3: Effective partnering among project participants	0.248	0.101	0.234	2.454	0.016
Factor 4: External monitoring and control	0.209	0.101	0.197	2.066	0.042

et al., 2000). Also, a thorough understanding of scope on the part of contractor and project manager helps in avoiding conflicts.

The third factor contributing to the overall public project success was found to be the 'pre-project planning and clarity in scope'. For the success of a public construction project both contractor and project manager must have a thorough understanding of the scope of the work, which is only possible when the scope itself is clearly articulated and there is no social, political and bureaucratic interference in this regard. Major changes during construction should also be avoided as they disturb the planning and delay the completion of projects and at a later stage create disputes during settlement of variations. Comprehensive site investigation helps in sound planning, resulting in minimum changes during construction and thereby avoiding delays and reducing bureaucratic, social and political interference. Clarity of scope also helps in developing a thorough understanding between PM and contractor, which in turn helps in the early completion of work.

Jacobson and Choi (2008) also found 10 success factors for public works: specific plan/vision; open communication and trust; political support; expert advice and review; high degree of commitment; clear role and responsibility; willingness to compromise/collaborate; respect; risk awareness; and community outreach and shared vision between the client, architect and contractor; these also validate our findings. Toor and Ogunlana (2009), while studying critical success factors for large-scale projects, also found project planning and control, project personnel and involvement of client as critical success factors, which, again, is in line with our finding.

The stepwise multiple regression results when 'compliance with anti-corruption norms' is treated as dependent variable with the four factors as independent variables are shown in Table 7.

All the four factors were found to be significant at $p < 0.05$ for compliance with anti-corruption norms for public projects. The factor 'pre-project planning and clarity in scope' is the most important factor when the objective is compliance with anti-corruption norms. Manipulation only occurs when the scope is not well defined and planning is poor. However, if the scope is defined to the best possible extent, chances of manipulation are slight. The other factors are 'awareness of and compliance with rules and regulations', 'effective partnering among project participants' and 'external monitoring and control'. Simplified procedures reduce the opportunity for corruption (Pope, 2000). There is a need to have simple rules and regulations so that compliance with them is easy and everyone in the organization is aware of the rules. 'Behaviour of superiors' is ranked as the topmost factor associated with unethical decisions (Baumhart, 1961; Brenner and Molander, 1977). The commitment to combating corruption is required from the top for effective partnering to comply with anti-corruption norms. These factors certainly will help in adopting fair and transparent practices.

The stepwise multiple regression results when 'compliance with financial/audit norms' is treated as dependent variable with the four factors as independent variables shown in Table 8.

In this case also, all the four factors were found to be significant at $p < 0.05$ for compliance with financial norms for public projects. The factor 'awareness of and compliance with rules and regulations' is the

most important when the objective is compliance with financial/audit norms. Thai (2008) emphasizes the importance of good procurement laws and regulations for a sound public procurement system. Effective partnering promotes openness, trust and efficient communication, which, to a certain extent, help avoid disputes and litigation (Li *et al.*, 2001). In addition, all other factors are also important as most of the time variations, extension of time, etc., which are due to poor planning and badly defined scope are sources of financial irregularities.

Conclusions

The public sector has been a neglected area of study and research (Thai, 2008). Public sector projects are different from private sector projects in many ways, the distinguishing characteristics being 'overlapping oversight mechanism' (Wirick, 2009). Government funding, accountability and public welfare are the key features of public sector projects, but in contrast the private sector only looks at profits yielded from project completion. All earlier studies on success factors do not recognize these aspects. A comprehensive investigation of the success factors for public construction projects is initiated in the Indian construction industry. Responses were collected from the engineers involved in public sector projects. Four success factors, viz. 'awareness of and compliance with rules and regulations', 'effective partnering among project participants', 'pre-project planning and clarity in scope', and 'external monitoring and control' were extracted by the application of factor analysis on 36 attributes developed through a synthesis of empirical studies and opinions from industry practitioners on public construction projects. The first three factors were identified as the most important for explaining the overall success of public construction projects. Of these, the most important factor for overall performance is found to be 'awareness of and compliance with rules and regulations'. The reason could be the fear of penalties for violating the constraints (Wirick, 2009). Frequent training of public sector employees on rules and regulations can generate confidence. Establishing a steering committee or senior management group can be helpful in the decision-making process. It is very important to avoid major changes during construction as not only do these cause cost and time overruns but also doubts are raised about the genuineness of these changes. This can only be avoided with sound planning. But public sector agencies have shorter planning horizons because of the electoral cycle (Wirick, 2009). Hence, more sincere and focused efforts are needed. Upfront planning should be done for risk management in case changes/variations become necessary. Project participants should work as partners to stay close and focused on achieving goals. Public sector projects require management of all stakeholders, but this can also be used as an opportunity and a source of resources and support, justifying the emergence of 'external monitoring and control' as one of the success factors. All the four factors are essential when the objective is compliance with anti-corruption and financial norms. 'Pre-project planning and clarity in scope' becomes the most important when the objective is compliance with anti-corruption norms whereas 'awareness of and compliance with rules and regulations' is most important when the objective is compliance with financial/audit norms. The results would help public construction project professionals in taking proactive measures for successful completion of projects.

A series of in-depth case studies on various public projects should be undertaken in future in other countries as well in order to verify the applicability and reliability of the success factors identified in this study. Effective strategies can also be suggested for enhanced project performance and improved compliance with anti-corruption and financial norms.

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