A Post Construction Evaluation to Study the Impact of Contractors' Attributes on Construction Project Success

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Abstract

The success of construction projects is a fundamental issue for most governments, users and communities. In the literature that deals with construction project success and causes of time and cost overruns in the construction industry, there is some literature that highlights the role of contractors in project success. While most studies rank contractors' success attributes from tendering, prequalification, and a long term historical perception perspective, this research aims to study the impact of contractors' attributes on project success from a post construction evaluation perspective to identify what went right and what went wrong. In an attempt to understand and investigate this impact, a questionnaire survey is used to establish construction professionals' perception of critical success factors (CSFs) of contractors that greatly impact on the success of construction projects. Factor analysis reveals nine underlying clusters namely- (i) safety and quality; (ii) past performance; (iii) environment; (iv) management and technical aspects; (v) resources; (vi) presence; (vii) experience; (viii) past projects; and (ix) finance. Logistic regression techniques were used to develop models that predict the probability of project success. Factors such as turnover history, quality policy, adequacy of labour resources, adequacy of plant resources, waste disposal, size of past projects completed, and company image are the most significant factors affecting projects success. Assuming that project success is repeatable; these findings provide a clear understanding of contractors' performance and could potentially enhance existing knowledge of construction project success.

Keywords: construction project success, project performance, contractor selection.

1. Introduction

According to Ye et al. (2009), the construction industry is one of the most significant industrial contributors to the European economy in terms of gross product and employment. As a result, the success of a construction project is a fundamental issue for most governments, users and communities.

In modern construction projects there are significant challenges for both clients and contractors to deliver the project successfully due to increasing complexity in design and the involvement of a multitude of stakeholders (Doloi, 2009). In addition to the above stated complexity of construction projects, defining project success itself is a complex issue (Toor and Ogunlana, 2010; Lame et al. 2008; Wang and Huang, 2006). Chan and Chan (2004) reported that the concept of project success is developed to set criteria and standards to aid project participants to complete projects with the most desirable outcomes. However, this concept remains somewhat of an enigma as there is no agreement on what should be the critical success criteria on construction projects despite several studies (Ahadzi et al.2008).

The iron triangle (on time, under budget, according to specifications) has been the widely accepted criterion for project success during the last couple of decades. However, Toor and Ogunlana (2010) reported that the same old-fashioned performance criteria can no longer be the sole determinant of project success due to a change in demands of users, evolving environmental regulations, and shifting functions of buildings.

Scholars make a distinction between project management success and project success when attempting to measure success as the two, although related, may be very different (de Wit 1988; Cooke-Davies, 2002; Baccarini, 1999). Pheng and Chuan (2006) pointed out that the successful accomplishment of cost, time, and quality objectives were regarded as project management success. Alternatively, project success deals with the final project objectives. De Wit (1988) concludes that good project management can contribute towards project success but is unlikely to be able to prevent project failure.

Pinto and Covin (1989) pointed out that many of the reasons behind project success can be found in the existence, or lack, of several CSFs. In addition, Belassi and Tukel (1996) asserted that one thing of prime importance in determining project success or failure is the existence of groups of success factors and their interactions.

There are many factors that contribute to project success. Construction projects and their success are highly dependent on contractors (Yaweli et al.2005; Ng et al.2009; Banki et al.2009; Palaneeswaran and Kumaraswamy, 2001). The appointment of the right contractor will not only ensure the overall quality of the project but also offer the opportunity of saving on costs (Yaweli et al.2005). The main contractors start their main duties which impact on the success of a project, when the project reaches the construction or execution stage. During this life cycle the actual work of the project is accomplished. Hence, the aimed of this paper is to investigate the impact of objective and subjective success attributes (criteria) of contractors on construction projects, as they play the main role in project management success which can contribute towards project success.

Over the past few decades, numerous studies have highlighted success criteria and CSFs of contractors. These studies have been expanded by both the industrial and academic worlds. While these criteria and their influencing CSFs have been discussed from tendering, prequalification, and a long term historical perception perspective, the approach in this research is to investigate those criteria from an immediate post construction delivery perspective to identify what went right and what went wrong and record lesson learnt before moving to the next project. An attempt is made to capture the perception of construction project practitioners, in a post construction evaluation, regarding CSFs of contractors that greatly impact on the success of projects, as they play the main role in project success.

Using factor analysis and logistic regression analysis, this research also aims to provide the industry with predictive models that can measure the probability of project success. Assuming that project success is repeatable; the findings from this research seek to provide a clear understanding of contractors' performance and could potentially enhance existing knowledge of construction project success.

2. Methodology

2.1 Research Framework

The approach undertaken for this research comprised two components, a literature review, discussed in the previous section, and an exploratory self-administered survey.

2.2 Survey Questionnaire

The exploratory survey was designed to ask the respondents to rate the impact of contractor CSFs on the success of construction projects. The impact level is measured on a 5-point Likert scale, where 5 denotes strongly agree, 4 agree, 3 neutral, 2 disagree, and 1 strongly disagree. The respondents were required to answer the questions according to actual situations that they had experienced on projects they were working on or had recently completed.

The first part of the survey include some items for collecting background information of the respondents and their projects, such as the respondent's position, experience in the construction industry, type of firm/organisation, procurement type and main project type in the organisation. In the second part of the survey the respondent was asked to rate the impact of CSFs shown in Table 1 on the success of projects. The third part of the survey required participants to comment on the outcome of the completed project. A blank space was provided for the participants so they could suggest their own CSFs that were not been mentioned in the survey. A web based survey using the Survey Monkey website was also developed to increase the return rate.

A pilot study was undertaken to pre-test the survey which was subsequently modified before a final version was produced. The survey targeted client, consultant and contractor organisations involved mostly in infra-structure, residential and commercial projects in the UK. The survey was mailed or hand delivered to 512 participants. One hundred and sixty four completed surveys were returned representing a 32% response rate. The valid dataset was then analysed using the Statistical Package for the Social Sciences (SPSS) version 19.0 for Windows.

3. Data analysis and results

Two statistical tools, factor analysis and logistic regression, were used to analyse data from the survey questionnaire. The main purpose of the factor analysis is to establish which of the variables could be measuring aspects of the same underlying dimensions (Field, 2005). Using SPSS 19.0, the survey opinions of the 35 CSFs were subjected to principal component analysis. Table 2 and Fig.1 present the results.

The results of factor analysis show that the Bartlett test of sphericity is 2283.362 and the associated significance level is 0.000 suggesting that the population correlation matrix is not an identity matrix (Table 2). The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.708 (Table 2), which is considered good (Kaiser, 1974). The average communality of the variables after extraction was above 0.6. Cronbach's alpha of 0.865 suggested the reliability of the research instrument used was also acceptable (Table 2).

The principal component analysis generated nine clusters with eigenvalues greater than 1 explaining 64.6% of the variance (it should be noted that factor (component) 10 was dropped from the analysis as there is no common theme between variables). The factor clustering based on varimax rotation is shown in Table 2. Only factors with loading exceeding 0.50 were selected to evaluate the factor patterns and this reduced the number of factors from 35 to 29. Fig.1 is a scree plot of the total variance associated with each factor. The plot shows a distinct break between the sleep slope of the large factors and the gradual trailing off of the rest.

4. Regression Analysis of Underlying Success Factors

Ordinal logistic regression was selected for this research because the dependent variables were ordinal on a scale from strongly disagrees to strongly agree. Ordinal logistic regression results in more accurate and valid results as it is designed to fit the inherent order or ranking of the dependent variable (Norusis, 2010). The application of logistic regression requires no assumptions about the predictor variables. Hence, the independent variables do not have to be normally distributed, linearly related or of equal variance (Field, 2005).

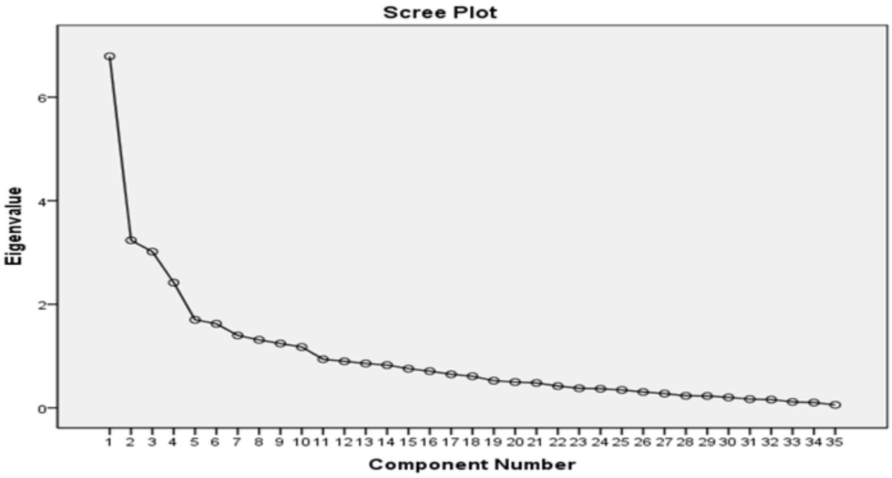

Figure 1: Scree plot for factor analysis

The objective of using logistic regression is to predict the probability that an event will occur. In this study the event is the agreement that the contractors' attributes have an impact on the success of projects. The construction professionals respond to the survey by agreeing or disagreeing with the survey statements. The model then estimates the probability that a contractor with a given set of attributes will impact on a certain project and turn it in to a successful project. The relationship can be expressed in the form of

$$\text{logit}(p) = a + b_1x_1 + b_2x_2 + \ldots + b_ix_i$$

where p is the probability of project success and x_1, x_2 ... x_i are the explanatory variables.

The twenty nine variables that resulted from varimax rotation were entered into the model as independent (covariate) variables to determine which might have predictive ability in relation to project success. The general method of estimating the model parameters is called maximum likelihood (Field, 2005). Log likelihood (LL) represents the probability that the observed values of dependents may be predicted from the observed values of the independents.

Similar in intent to R-Square in a linear regression model, the Pseudo R-Square attempts to quantify the proportion of explained variation in the logistic regression model. In logistic regression analysis, there are two types of R-Square. The first one is Cox and Snell R-Square which cannot reach the maximum value of 1 and the second one is Nagelkerke R-Square which can reach the maximum value of 1. Nagelkerke R-Square is the most widely reported when interpreting logistic regression model (Field, 2005). A deviance statistics test is preferred for assessing model goodness of fit over classification tables.

5. Models Development

Factor analysis reveals nine underlying clusters. However, there is no direct relationship that can be shown by simply applying factor analysis. Hence, logistic regression analysis was conducted to estimate the probability of project success and assess the impact of contractors' attributes on project success.

Using the entire dataset, four logistic regression models were built in SPSS 19.0 to estimate the probability of project success based on the 29 independent variables listed in Table 2. Four dependent variables were used to develop logistic models namely: (1) The probability that a project has been completed on schedule, (2) The probability that a project has been completed within budget, (3) The probability that a project achieved the necessary quality, (4) The probability that the contractors' attributes have an impact on the success of a project. These four measures have been rated by respondents in the third part of the survey that asks respondents to comment on the outcome of a completed project. The analysis was based on the 'enter' method which is the default method of conducting logistic regression in SPSS 19.0 for Windows. The models' summary statistics in Table 3 shows that all models, except quality where the level of significance for the model fit is > 0.05, perform adequately and permit the rejection of the null hypotheses that the independent variables are not related to the dependent variable.

6. Discussion of Regression Results

From the results of logistic regression (Table 3), it was found that the success of a project is significantly associated with seven of the advocated variables. The findings indicate that contractors with adequate labour resources have a great impact on project success. *The* a*dequacy of labour resources* variable was a statistically significant predictor of project success in the scheduling, budget, and contractors' impact models. This is consistent with Belout and Gauvrean (2004), Nguen et al. (2004), Hubbard (1990), and Todryk (1990) who asserted that people are responsible for creating, managing, operating and utilising projects and play a decisive role regarding the success or failure of a project.

The results also show that contractors with adequate plant resources are an important and statistically significant factor affecting project success. The scheduling model reveals that the *adequacy of plant resources* factor is a statistically significant predictor of project success. This result is in accordance with Wong et al. (2003) as they found that on-site productivity can be affected by the availability and suitability of a plant needed for construction activities.

Logistic regression tests also revealed that examining *(company) image* and *turnover history* of a contractor appears to impact on the success of a project. These two variables turned out to be statistically significant in the scheduling model. The model shows a positive relationship between those two predictors and timely project delivery. The result of this finding is similar to findings reported in previous literature such as Holt et al. (1994) who pointed out that insolvency is more likely to occur in the construction industry than in others and confidence from an established trading history needs to be relied upon as a measure of future performance. Isik et al. (2011) and Holt et al. (1994) also reported that financial resources show a company's credibility and reputation and turnover history mirrors company trading with an increase in turnover representing growth.

Although the findings indicate that the overall test of quality model is not statistically valid, the *size of past projects completed* predictor appears to be statistically significant. This finding is consistent with Holt et al. (1994) who asserted that contractors who have the requisite experience from a similar project tend to have a greater impact on project success.

The results show that *quality policy* and *waste disposal* are significant predictors of project success in the contractors' impact model. These findings are in line with previous studies by Attalla et al. (2003) and Chan and Chan (2004) which conclude that quality is a specific issue that needs to be prioritised for a 21st century construction site. The results also indicate that contractors who meet environmental obligations and implement waste disposal programmes during construction tend to have a greater impact on project success.

7. Conclusions

There is considerable debate in project management research practice about what determines project success. While the topic has been discussed for a long period of time, an agreement has not been reached. In addition, when it comes to a definition of project success, there is no single list that is totally comprehensive. However, the concept of CSFs presents a smarter way to identify certain factors which when present or absent in a project are likely to make the project successful.

Construction projects and their success are highly related to contractors. They start their main duties and impact project management success that can contribute towards project success, when the project reaches the construction or execution stage where the actual work of the project is accomplished. In addition, identifying what went right and what went wrong in a post construction evaluation before moving to the next project, proved to be a valuable exercise in construction projects.

This paper reports the statistical results of a survey aimed at collecting perceptions of construction practitioners, in post construction evaluation, about the CSFs of contractors that greatly impact on the success of a project. Based on the available literature, 35 CSFs were selected for this study. By employing a factor analysis approach, the 35 critical factors identified in this study are further categorised into nine underlying clusters namely: *(i) safety and quality; (ii) past performance; (iii) environment; (iv) management and technical aspects; (v) resources; (vi) presence; (vii) experience; (viii) past projects; and (ix) finance.*

*F*our logistic regression models were built to examine the impact of contractor attributes on project success and identify the significant association between the success criteria and the nine underlying clusters. From the results of logistic regression, it was found that the success of a project is significantly associated with seven of the advocated variables. They were: *turnover history, quality policy, adequacy of labour resources, adequacy of plant resources, waste disposal, size of past* *project completed, and company image.* The goodness of fit of the models was confirmed by the -2LL, pseudo R-squared, deviance and parallel lines tests, suggesting that the models are statically robust.

The findings showed that new and emerging criteria such as safety and environment are becoming measures of success in addition to the classic iron triangle's view of time, cost and quality.

Assuming that project success is repeatable; these findings provide a clear understanding of contractors' performance and could potentially enhance existing knowledge of construction project success.

8. References

Ahadzie, D. K., Proverbs, D. G., and Olomolaiye, P.O. (2008) Critical success criteria for mass house building projects in developing countries, *International Journal of Project Management*, 26, 675-687.

Attalla, M., Fetaih, A., Hegazy, T., and Elbeltagi, E. (2003) Delivering projects with quality and safety, *Proceedings of the 31st Annual Conference-Canadian Society for Civil Engineering*, 193-201.

Baccarini, D. (1999). The logical framework method for defining project success, *Project Management Journal*, 30(4), 25-32.

Banki, M.T., Hadian, S., Niknam, M., and Rafizadeh, I. (2009) Contractor selection in construction projects based on a fuzzy AHP method, *Proceedings of the Annual Conference-Canadian Society for Civil Engineering.*

Belassi, W., and Tukel, O.I. (1996) A new framework for determining critical success/failure factors in projects, *International Journal of Project Management*, 14(3), 141-151.

Belout, A., and Gauvreau, C. (2004) Factors influencing project success: the impact of human resource management, *International Journal of Project Management*, 22, 1-11.

Chan, A.P.C., and Chan, A.P.L. (2004) Key performance indicators for measuring construction success, *Benchmarking: An International Journal*, 11(2), 203-221.

Cooke-Davies, T. (2002). The "real" success factors on projects, *International Journal of Project Management*, 20, 185-190.

De Wite, A. (1988). Measurement of project success, *International Journal of Project Management*, 6(3), 164-170.

Doloi, H. (2009) Analysis of pre-qualification criteria in contractor selection and their impacts on project success, *Construction Management and Economics*, 27, 1245-1263.

Field, A. (2005) *Discovering Statistics Using SPSS*, 2nd Edn. SAGE publications, London.

Holt, G. D., Olomolaiye, P. O., and Harris, F. C. (1994) Evaluating prequalification criteria in contractor selection, *Building and Environment*, 29(4), 437-448.

Hubbard, D. (1990) Successful utility project management from lessons learned, *Project Management Journal*, 11(3), 19-23.

Isik, Z., Arditi, D., Dikmen, I., and Birgonul, M.T. (2011) Impact of corporate strengths/weaknesses on project management competencies, *International Journal of Project Management*, 27, 629-637.

Kaiser, H. F. (1974) An index of factorial simplicity, *Psychometrika*, 39(1), 31–36.

Ng, S. T., Tang, Z., and Palaneeswaran, K. (2009) Factors contributing to the success of equipment-intensive subcontractors in construction, *International Journal of Project Management*, 27, 736-744.

Lam, E., Chan, A., and Chan, D. (2008) Determinants of successful design-build projects, *Journal of Construction Engineering and Management*, 134(5), 333-341.

Ng, S. T., Tang, Z., and Palaneeswaran, K. (2009) Factors contributing to the success of equipment-intensive subcontractors in construction. *International Journal of Project Management*, 27, 736-744.

Nguyen, L., Ogunalana, S., and Lan, D. (2004). A study on project success factors in large construction projects in Vietnam, *Engineering, Construction and Architectural Management*, 11(6), 404-413.

Norusis, M.J. (2010). *SPSS 16.0 Advanced Statistical Procedures Companion*. Prentice Hall.

Palaneeswaran, E., and Kumaraswamy, M. (2001) Recent advances and proposed improvements in contractor prequalification methodologies, *Building and Environment*, 36, 73-87.

Pheng, L., and Chuan, Q. (2006). Environmental factors and work performance of project managers in the construction industry, *International Journal of Project Management*, 24, 24-37.

Pinto, J. K., and Covin, J. G. (1989) Critical factors in project implementation: a comparison of construction and R&D projects, *Technovation*, 9, 49-62.

Todryk, L. (1990) The project manager as a team builder: creating an effective team, *Project Management Journal*, 16(4), 17-21.

Toor, S., and Ogunlana, S. (2010) Beyond the iron triangle: stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects, *International Journal of Project Management*, 28, 228-236.

Wang, X., and Huang, J. (2006) The relationships between key stakeholders' project performance and project success: Perceptions of Chinese construction supervising engineers, *International Journal of Project Management,* 24, 253-260.

Wong, C.H., Nicholas, J., and Holt, G.D. (2003) Using multivariate techniques for developing contractor classification models, *Engineering, Construction and Architectural Management*, 10(2), 99-116.

Yaweli, L., Shouyu, C., and Xiangtian, N. (2005) Fuzzy pattern recognition approach to construction contractor selection, *Fuzzy Optimization and Decision Making*, 4, 103-118.

Ye, J., Hassan, T. M., Carter, C. D., and Kemp, L. (2009) Stakeholders' requirements analysis for a demand-driven construction industry, *Electronic Journal of Information Technology in Construction*, 14, 629-641.

Table 1: Success attributes and critical success factors

Number	*Success Attributes*	*Critical Success Factors (CSFs)*
1	*Financial Attributes*	*Turnover history* *Credit history* *Bonding capacity* *Cash flow forecast*
2	*Management Attributes*	*Staff qualification* *Management capability* *Site organisation* *Documentation*
3	*Technical Attributes*	*Contractor's IT knowledge* *Knowledge of particular construction method* *Work programming* *Experience of technical personnel*
4	*Past Experience Attributes*	*Type of past project completed* *Size of past project completed* *Length of time in business* *Experience in the region*
5	*Past Performance Attributes*	*Failure to have completed a Contract* *Contract time overruns* *Contract cost overruns* *Past record of conflict and disputes*
6	*Organisation Attributes*	*Size of the company* *Company image* *Age in business* *Litigation tendency*
7	*Environmental Attributes*	*Waste disposal during construction* *Environmental plan during construction* *Materials and substances used in the project*
8	*Health and Safety Attributes*	*Health and safety records* *Occupational safety and health administration rates (OSHAIR)* *Experience Modification Rating (EMR)*
9	*Quality Attributes*	*Quality control* *Quality policy* *Quality assurance*
10	*Resource Attributes*	*Adequacy of labour resources* *Adequacy of plant resources*

Table 2: Factor analysis and total variance explained

Description of clusters	*Factor loading*	*Variance explained*
***Cluster 1**: Health, Safety and Quality*		*19.4*
Quality policy	*0.755*	
Quality assurance	0.733	
Occupational safety and health administration rate (OSHAIR)	0.680	
Health and safety records	0.627	
Quality control	0.625	
Experience Modification Rating (EMR)	0.589	
***Cluster 2**: Past Performance*		9.2
Contract cost overruns	0.896	
Contract time overruns	0.916	
Past record of conflict and disputes	0.848	
Failure to have completed a contract	0.793	
Cluster 3: Environment		8.6
Waste disposal during construction	0.870	
Environmental plan during construction	0.879	
Materials and substances used in the project	0.828	
Cluster 4: Management and Technical Aspects		6.9
Management capability	0.605	
Site organisation	0.586	
Knowledge of particular construction method	0.755	
Work programming	0.727	
Cluster 5: Resources		4.8
Adequacy of labour resources	0.908	
Adequacy of plant resources	0.811	
Cluster 6: Presence		4.6
Size of the company	0.743	
Company image	0.645	
Age in business	0.659	
Cluster 7: Experience		3.9
Experience in the region	0.677	
Length of time in business	0.774	
Cluster 8: Past projects		3.7
Type of past project completed	0.853	
Size of past project completed	0.897	
Cluster 9: Finance		3.5
Turnover history	0.650	
Credit history	0.857	
Cash flow forecast	0.694	
Cumulative variance explained= 64.6%		

Note: Kaiser–Meyer–Olkin measure of sampling adequacy=0.708
Bartlett test of sphericity=approx. chi square 2283.362; *Df 595*; and Sig=−0.000.
Cronbach's Alpha= 0.865
Extraction Method: Principal Component.

						Model fit information			Goodness-of-fit:		Pseudo R-square	
Model	*Predictor*	*B*	*S.E.*	*Wald*	*Sig*	*-2 Log Likelihood*	*Chi-square*	Sig.	*Deviance chi-square*	Sig.	*Cox and Snell*	*Nagelkerke*
Scheduling	*Adequacy of labour resources*	-1.284	.494	6.756	.009*	267.451	50.885	.007*	267.451	1.000♀	.312	.345
	Adequacy of plant resources	1.016	.429	5.615	.018*							
	Company images	.612	.279	4.804	.028*							
	Turnover history	1.081	.318	11.533	.001*							
Budget	*Adequacy of labour resources*	-1.224	.491	6.203	.013*	267.131	44.398	.034*	267.131	1.000♀	.279	.310
Quality	*Size of past project completed*	-.893	.413	4.687	.030*	203.269	29.868	.421	203.269	1.000♀	.198	.241
Contractors' Impact	*Quality policy*	1.103	.451	5.978	.014*	220.469	54.587	.003*	220.469	1.000♀	.333	.382
	Waste disposal	1.208	.519	5.414	.020*							
	Adequacy of labour resources	1.229	.531	5.345	.021*							

* Significant *at $p < 0.05$*
♀ *Sig> 0.05, so the model fits well*
S.E.: *Standard Error*
df (degree of freedom)=1

Table 3: Logistic regression results