Critical success factors for implementation process of design-build projects in Vietnam

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Abstract

Purpose – Design-build (DB) has become widely prosperous in recent years. This new approach could be applicable to construction projects in either developed or developing countries. However, the implementation process of DB in Vietnam encounters difficulties due to the unfamiliarity and inexperience with the approach. This study aims to identify the correlation and causality between critical success factors (CSFs) and DB project performance measured by key performance indicators (KPIs).

Design/methodology/approach – A questionnaire was used to collect the project data from public and private sector DB projects in Vietnam. The correlation between CSFs and KPIs was identified through correlation analysis. Then, the causality was explored through regression analysis.

Findings – The results of correlation indicate that parties' capabilities play an important role in determining the success or failure of DB projects. In addition, the results of causality highlight six CSFs which significantly affect DB project performance, including resolving conflicts quickly; effective overall managerial actions in planning, organizing, leading and controlling; project participants' satisfaction with the financial return from the project; competent multidisciplinary project team; project team members' good/active attitudes to the job; and adequate funding throughout the project. It was also shown that there is no significant difference about the project performance between public and private sector DB projects.

Practical implications – Identifying the correlation and causality between CSFs and different aspects of DB project performance could help project participants to know the controllable CSFs on which they must focus more. Hence, they could manage these CSFs properly to increase the chance of meeting time, cost and quality objectives of DB projects in which they are involved and achieving the owners' satisfaction.

Originality/value – The findings of this study could provide project participants in Vietnam, as well as similar developing countries, with a better understanding of the impact of CSFs on different aspects of DB project performance. Hence, they could make effective CSFs-based improvements on their management-oriented approaches to enhance different aspects of DB project performance.

Keywords Critical success factors, Project and construction management, Key performance indicators, Procurement management, Design-build

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Introduction

Project success is almost the ultimate goal of all project participants in any construction project. However, in recent years, project participants have had difficulties in achieving the success of construction projects where a conventional way (design-bid-build, DBB) is the widely applied delivery method. Building clients are becoming dissatisfied with the drawbacks of this procurement method (Deakin, 1999). Moreover, the challenges of how to handle a construction project successfully become more difficult due to the increasing complexity, uncertainty and dynamics of most construction projects (Nguyen *et al.*, 2004). If construction projects were delivered by an innovative procurement method, project outcomes could be better.

Design-build (DB), demonstrated to be an effective delivery method, is a project procurement method where one entity or consortium is contractually responsible for both the design and construction to deliver a construction project to a client's satisfaction (Songer *et al.*, 1997). The DB method has been shown to be a leading trend in the construction industry (Songer and Molenaar, 1997) and has become popular in the world in recent years (Xia and Chan, 2010). However, the implementation process of this innovative procurement method in Vietnam, where the construction industry has been criticized for its inefficiency and weakness (Le-Hoai *et al.*, 2010), encounters several difficulties. Little research has focused on the DB method in Vietnam, as well as similar developing countries. So far, the relationships between critical success factors (CSFs) and DB project performance, which could be a useful information to increase the chance of project success (Chan *et al.*, 2004), have not been investigated. Thus, a study, which is carried out to explore the relationships between CSFs and DB project performance, is very useful to project participants in Vietnam, as well as similar developing countries.

This study aims to identify the correlation and causality between CSFs and DB project performance measured by key performance indicators (KPIs). It is expected that this study could help project participants to know which CSFs are controllable to enhance DB project performance. They could also have a better understanding of the effects of CSFs on different aspects of DB project performance.

Literature review

Several research endeavors have focused on DB project success. Many of these were reviewed in the study of Dang *et al.* (2012) to investigate the case of the Vietnamese construction industry. The published work specified and ranked 47 CSFs which could affect the success of DB projects in Vietnam. Lam *et al.* (2004) established a conceptual framework of 32 CSFs for DB projects in Hong Kong. From the framework, it is hypothesized that the project success of a DB project is a function of the interaction among project characteristics, project procedures, project management strategies, project-related participants, project work atmosphere and project environment. Lam *et al.* (2008) developed a project success index (PSI) for DB projects in the Hong Kong context, which was assessed by the KPIs of time, cost, quality and functionality. Forty-two CSFs were reduced into 12 main project success factors (PSFs) by using factor analysis. Then, they used multivariate regression analysis to link the PSFs to the PSI based on the data from the Hong Kong construction industry. Xia *et al.* (2009) and Xia and Chan (2010) used five semi-structured face-to-face interviews and two rounds of a Delphi questionnaire survey to identify the key competences of Chinese DB contractors and clients, respectively. Rankings were assigned to the key competences on the basis of

their relative importance. The key competences that DB contractors and clients should possess to ensure the success of DB projects were identified.

In addition, other researchers have attempted to model DB project performance. Konchar and Sanvido (1998) examined explanatory and interacting variables to predict project performance based on DB, DBB and construction management at risk (CM) procurement systems. Using multivariate regression analysis, some models were developed to predict unit cost, construction speed and delivery speed based on 316 projects in the USA. Molenaar and Songer (1998) developed five models to predict cost growth, schedule growth, conformance to expectations, administrative burden and overall user satisfaction for the US public sector DB project selection. Multi-attribute regression technique was used to develop the models based on 122 projects. Chan *et al.* (2001) constructed several models to predict time performance, cost performance and overall performance for public sector DB projects in Hong Kong. Thirty-one CSFs which may affect project performance were identified. Using 19 DB projects whose information was provided by 53 project participants, factor analysis was used to reduce 31 CSFs to six main PSFs. Then, stepwise multiple linear regression technique was used to construct the models. Ling *et al.* (2004) also used multivariate regression analysis to predict the performance of DB and DBB projects based on 87 building projects in Singapore. Using 59 CSFs, 11 models were developed to predict unit cost, cost growth, intensity, construction speed, delivery speed, schedule growth, turnover quality, system quality, equipment quality, owner's satisfaction and owner's administrative burden. In addition, the performance of DB projects in Singapore was investigated and predicted by Ling (2004) and Ling and Liu (2004), respectively. With 60 CSFs, Ling (2004) used correlation analysis to identify the key factors which affect 11 areas of project performance based on 42 public and private sector DB projects. Using 65 CSFs, Ling and Liu (2004) used artificial neural networks (ANNs) to predict 11 areas of project performance based on 33 public and private sector DB projects.

It can be seen from the literature review that the research area on DB project performance is context-specific. Conducting a study in the current Vietnamese context could derive a few valuable findings contributing to global knowledge. Moreover, in Vietnam and other similar developing countries, the evaluation of the impact of CSFs on DB project performance with regard to different issues of time, cost, quality and owner has still received little attention. Thus, this study will attempt to explore the impact in terms of correlation and causality. This study selects 33 CSFs presented in the previous publication of Dang *et al.* (2012) and 10 KPIs identified from the review of past works for the research (see Table I).

Research methodology

Questionnaire design

A questionnaire was designed based on 33 CSFs and 10 selected KPIs mentioned above to investigate DB projects in Vietnam. Through the questionnaire, respondents were requested to rate the performance of the related qualitative issues in DB projects, in which they had been directly involved, according to a five-point Likert scale. The quantitative information was collected using project documents and contracts. Respondents were requested to rate the performance of 33 CSFs on a scale from 1 = "very bad" to 5 = "very good". Regarding project quality and owner's satisfaction, respondents were requested to rate their assessment on a scale from 1 = "very

Issues	Indicator ref.	Performance metrics	Definition
Cost	Y1	Unit cost ($/m^2)	(Final cost/Area)/Index
	Y2	Cost growth (%)	[(Final cost – Contract Cost)/Contract Cost] × 100
	Y3	Intensity [($/m^2)/month]	Unit cost/Total time
Time	Y4	Construction speed (m^2/month)	Area/[(As-built Construction End Date – As-built Construction Start Date)/30]
	Y5	Delivery speed (m^2/month)	Area/Total Time
	Y6	Schedule growth (%)	[(Total Time – Total As-planned Time)/Total As-planned Time] × 100
Quality	Y7	System quality	Performance of building elements, interior space and environment (1 = very unsatisfactory, 5 = fully satisfactory)
	Y8	Equipment quality	Performance and adequacy of mechanical and electrical equipment (1 = very unsatisfactory, 5 = fully satisfactory)
Owner	Y9	Owner's satisfaction	1 = very unsatisfactory, 5 = fully satisfactory
	Y10	Owner's administrative burden	1 = very heavy burden, 5 = minimum burden

Table I.
Definition of KPIs

Sources: Adapted from Konchar and Sanvido (1998); Molenaar and Songer (1998); Ling (2004) and Ling and Liu (2004)

unsatisfactory" to 5 = "fully satisfactory". Relating to owner's administrative burden, the scale was from 1 = "very heavy burden" to 5 = "minimum burden". Regarding cost and time, specific information about the actual project performance was collected from project documents and contracts to compute cost and time performance metrics (see Table I). Before collecting project data, a pilot study was carried out to minimize or exclude the possibility of missing any information necessary for this study.

Data collection

Surveyed building projects, delivered by DB in recent years and after 2000, were first identified from various contactable companies including owners, consultants and contractors. Both public and private sector DB projects were investigated. Then, key managers, who were directly involved in these projects, were invited to participate. Some of them were not only the key managers of these projects but also the senior managers of the companies involved. Respondents provided project-specific data by answering the questionnaires directly delivered to them after an explanation of related information. Then, they sent the finished questionnaires back to the researchers. Because inertia forces against scientific research are still strong in the Vietnamese culture (Le-Hoai *et al.*, 2010), it is very difficult to contact both contractor and client (owner or consultant) to collect the data information for each project. Thus, in this study, the assessment of owner's satisfaction with the project was not performed thoroughly.

The assessment was based on the invited respondents' perspective. In addition, a respondent was not requested to provide information for more than two projects due to the respondents' subjectivity.

It is very difficult to collect the data about DB projects with a high level of adequacy and accuracy in Vietnam. The data collection process was carried out for about three months, with a reminder after one month from the first contact. The collected data were first checked for appropriateness, adequacy and accuracy. The data of three projects judged to be inappropriate were excluded from the analyzed data. Finally, only 25 projects could be used in this study, following data verification. The data sets of 25 projects were received from 17 respondents including two owners, five project management consultants and ten contractors. Regarding the respondents' position, three of them (17.7 per cent) were senior managers, ten (58.8 per cent) were project managers or project team leaders and four (23.5 per cent) were site managers. In terms of project size, 14 projects (56 per cent) were US$ 0.5-10 million and the remainder (11, 44 per cent) were over US$ 10 million [1 US$ = 20,000 VND (2010)]. About gross area, eleven projects (44 per cent) were 2,500-20,000 m^2, seven (28 per cent) were 20,000-50,000 m^2, four (16 per cent) were 50,000-100,000 m^2 and three (12 per cent) were larger than 100,000 m^2. In 25 projects, more than three-quarters of them (19, 76 per cent) were private sector projects while less than one quarter (six, 24 per cent) were public sector ones. This implies that the results of this study may be more applicable to private sector DB projects.

Data analysis

CSFs having a high degree of correlation with DB project performance (measured by KPIs) were identified from Spearman's correlation analysis where the correlation coefficient could measure the strength of any association between a pair of random variables symmetrically. The correlation between a pair of variables is measured on a scale from -1 = "perfectly negative correlation" to +1 = "perfectly positive correlation" (Ling and Liu, 2004; Ling *et al.*, 2004). In this study, a CSF is considered significantly correlated to a KPI, if the resulted p-value is less than the significance level of 0.05 (p-value < 0.05).

To validate that the CSFs identified from correlation analysis are indeed the key factors significantly affecting DB project performance, stepwise multivariate regression analysis was used to explore the causality between CSFs and KPIs. The causality between a KPI and CSFs could be expressed as Eq. (1) as follows:

$$Y_i = \alpha + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \ldots + \beta_k x_{ki} + \varepsilon_i \quad (1)$$

where, Y_i = value of a KPI (see Table I); α = constant and the intercept at y-axis; $\beta_{1\sim k}$ = estimated regression coefficients; $x_{1\sim k}$ = values of CSFs; ε_i = error term, which is a random variable having the normal distribution with mean 0 and variance σ^2; i = index of KPIs and k = number of CSFs.

The strength of the causality is judged through the coefficient of determination (R^2), which is a descriptive measure of how well the regression line fits the data. However, R^2 automatically increases when more independent variables, which are the CSFs in this study, are introduced into a model. A better measure of the goodness of fit is adjusted R^2. Unlike R^2, the adjusted R^2 increases only if the new variable improves the model. In

addition, the causality between a KPI and CSFs will be proven statistically significant through *t*-tests and *F*-tests.

Results

Tables II and IV present the correlation and causality between CSFs and DB project performance, respectively. The results show that many aspects of DB project performance, such as unit cost (Y1), intensity (Y3), construction speed (Y4), delivery speed (Y5), system quality (Y7) and owner's satisfaction (Y9), could be controlled better by focusing more on many controllable CSFs presented in Tables II and IV. On the other hand, several other issues, such as cost growth (Y2), schedule growth (Y6), equipment quality (Y8) and owner's administrative burden (Y10), have not yet been revealed with regard to how to be controlled better, because no correlation and causality are found significant. It can be seen that it is not easy to achieve a comprehensive success of a DB project in Vietnam, where the construction industry has been criticized for its inefficiency and weakness (Le-Hoai *et al.*, 2010). Further studies should also be conducted to review and analyze more example cases of both successful and unsuccessful DB projects with regard to time, cost, quality and owner issues. Such lessons learned would be useful for enhancing DB project performance in Vietnam and other similar developing countries.

The results also show that 10 CSFs are not significantly correlated to any KPI, including comprehensive pretender site investigation (X2), reasonable tendering system (X3), clear project objectives and scope (X7), advantages of policy management of local government (X9), availability of resources (X10), resolving structure failures in the construction process quickly (X12), owner's emphasis on time, cost and quality of the project (X19), owner's overall contribution to the project (X20), contractor's experience with similar DB projects and good reputation in the construction market (X23) and project management consultant's competence and experience (X28). The implication of this finding is that project participants would not need to pay much attention to these CSFs when managing DB projects, because they would have a small impact on DB project performance. A possible explanation for this finding is that, so far, project participants in Vietnam have still focused more on "how possible they may implement a DB project" than "how well they can manage it", due to their unfamiliarity and inexperience with DB projects.

On the other hand, several CSFs have a significant impact on some issues of DB project performance, because they are correlated to many KPIs significantly, such as adequate funding throughout the project (X27) (four KPIs, three issues), consultant's/owner's quick response to contractor's requests and instructions (X30) (three KPIs, three issues), resolving conflicts quickly (X13) (three KPIs, two issues), effective monitoring and approval mechanisms for design changes (X16) (three KPIs, two issues) and effective overall managerial actions in planning, organizing, leading and controlling (X18) (three KPIs, two issues) (see Table III). It can be seen that these CSFs are very important for DB project performance in terms of time, cost, quality and owner. Thus, project participants should focus more on these CSFs to manage DB projects better.

Some tests are performed to confirm whether the results from regression analysis are reliable. The scatter plots of the standardized residuals against the standardized predicted values show that there is no relationship between the residuals and predicted values. Thus, the assumptions of linearity and homogeneity of variance are met. In

Table II. Results of correlation

Indicator ref.	Performance metrics	Variable ref.	Success factors	*p*-value	r	Rank
Y1	Unit cost	X13	Resolving conflicts quickly	0.007	−0.641	1
Y2	Cost growth	✓	✓	✓	✓	✓
Y3	Intensity	X13	Resolving conflicts quickly	0.029	−0.546	1
		X1	Market exploration research	0.047	−0.503	2
Y4	Construction speed	X18	Effective overall managerial actions in planning, organizing, leading and controlling	0.002	0.675	1
		X16	Effective monitoring and approval mechanisms for design changes	0.013	0.556	2
		X27	Adequate funding throughout the project	0.014	0.553	3
Y5	Delivery speed	X18	Effective overall managerial actions in planning, organizing, leading and controlling	0.001	0.750	1
		X16	Effective monitoring and approval mechanisms for design changes	0.001	0.746	2
		X17	Effective control mechanisms of subcontractors' works	0.010	0.681	3
		X27	Adequate funding throughout the project	0.010	0.640	4
		X15	Appropriate organizational structures, cultures, roles and levels of authority	0.012	0.628	5
		X22	Contractor's good combination of design expertise and building techniques	0.014	0.618	6
		X30	Consultant's/Owner's quick response to contractor's requests and instructions	0.024	0.579	7
		X24	Contractor's strong design and construction management capability	0.048	0.517	8
		X33	Project participants' satisfaction with the financial return from the project	0.048	0.517	8
Y6	Schedule growth	✓	✓	✓	✓	✓

(*continued*)

Table II.

Indicator ref.	Performance metrics	Variable ref.	Success factors	*p*-value	r	Rank
Y7	System quality	X31	Competent multidisciplinary project team	0.000	0.757	1
		X32	Client's project manager's competence and experience	0.007	0.583	2
		X29	Design consultant's thorough understanding of the construction process to develop a cost-effective design on time	0.008	0.574	3
		X25	Contractor's project team leader's competence, experience and delegated authority	0.005	0.559	4
		X14	Adequate systems for quality, risk, safety and more human-related conflict management	0.005	0.555	5
		X26	Contractor's project team leader's commitment to time, cost and quality	0.006	0.548	6
		X5	Thorough understanding of project complexity	0.005	0.546	7
		X33	Project participants' satisfaction with the financial return from the project	0.007	0.535	8
		X18	Effective overall managerial actions in planning, organizing, leading and controlling	0.009	0.514	9
		X4	Comprehensive contract documentation	0.010	0.513	10
		X17	Effective control mechanisms of subcontractors' works	0.016	0.507	11
		X6	Well-planned project schedule	0.010	0.504	12
		X21	Owner's/His representative's decision-making power	0.011	0.498	13
		X11	Project team members' good/active attitudes to the job	0.013	0.492	14
		X22	Contractor's good combination of design expertise and building techniques	0.013	0.491	15
		X30	Consultant's/Owner's quick response to contractor's requests and instructions	0.016	0.486	16
		X27	Adequate funding throughout the project	0.017	0.482	17
		X8	Appeal of the project to end-users	0.022	0.476	18

(*continued*)

Table II.

Indicator ref.	Performance metrics	Variable ref.	Success factors	*p*-value	r	Rank
		X24	Contractor's strong design and construction management capability	0.030	0.435	19
		X16	Effective monitoring and approval mechanisms for design changes	0.047	0.401	20
Y8	Equipment quality	✓	✓	✓	✓	✓
Y9	Owner's satisfaction	X31	Competent multidisciplinary project team	0.000	0.717	1
		X13	Resolving conflicts quickly	0.003	0.636	2
		X4	Comprehensive contract documentation	0.003	0.577	3
		X26	Contractor's project team leader's commitment to time, cost and quality	0.008	0.526	4
		X30	Consultant's/Owner's quick response to contractor's requests and instructions	0.012	0.502	5
		X32	Client's project manager's competence and experience	0.027	0.495	6
		X27	Adequate funding throughout the project	0.023	0.463	7
		X21	Owner's/His representative's decision-making power	0.027	0.441	8
		X5	Thorough understanding of project complexity	0.033	0.427	9
		X14	Adequate systems for quality, risk, safety and more human-related conflict management	0.041	0.421	10
Y10	Owner's administrative burden	✓	✓	✓	✓	✓

Notes: r: Correlation coefficient; ✓: NA

Variable ref.	Success factors	Indicator ref.	Performance metrics	Issues involved
X27	Adequate funding throughout the project	Y4	Construction speed	Time
		Y5	Delivery speed	
		Y7	System quality	Quality
		Y9	Owner's satisfaction	Owner
X30	Consultants'/Owner's quick response to contractor's requests and instructions	Y5	Delivery speed	Time
		Y7	System quality	Quality
		Y9	Owner's satisfaction	Owner
X13	Resolving conflicts quickly	Y1	Unit cost	Cost
		Y3	Intensity	
		Y9	Owner's satisfaction	Owner
X16	Effective monitoring and approval mechanisms for design changes	Y4	Construction speed	Time
		Y5	Delivery speed	
		Y7	System quality	Quality
X18	Effective overall managerial actions in planning, organizing, leading and controlling	Y4	Construction speed	Time
		Y5	Delivery speed	
		Y7	System quality	Quality

Table III.
Top five CSFs significantly correlated to many KPIs

probability-probability (P-P) plots, the observed values distribute along the expected line approximately, indicating that the probability distributions of residuals could be assumed to be normal. In addition, all the CSFs in the models, in which the causality between CSFs and DB project performance is shown, have tolerance values more than 0.1, indicating that multicollinearity does not exist among the CSFs (Attalla and Hegazy, 2003). The Durbin-Watson tests consistently yield the values of approximately 2, indicating that there appears to be no auto-correlation in the residuals from regression analysis.

The Mann-Whitney test is also performed to confirm whether there is a difference between public and private sector DB projects with regard to project performance. All the resulted p-values of the Mann-Whitney test are more than the significance level of 0.05 (min p-value = 0.233). It could be concluded that there is no significant difference about the project performance between the public and private sector DB projects. In fact, when construction projects are more complex, it becomes more difficult to satisfy clients in a very competitive high-risk construction market. Due to the highly increasing requirements of clients, the performance of either public or private sector projects must be good enough accordingly.

Discussions

CSFs versus project cost

The results show that resolving conflicts quickly (X13) affects both unit cost (Y1) and intensity (Y3) significantly (see Tables II and IV). While unit cost is expected to be low, intensity is preferred to be high. Surprisingly, both of them have a negative correlation with resolving conflicts quickly. This may be because unit cost is significantly correlated to intensity ($r = 0.798$, p-value = 0.000), indicating that a low unit cost would also tend to lead to a low intensity. As a result, DB projects where conflicts are resolved quickly would have a low unit cost and then, intensity may not be very high. In any

further study, there should be a consideration about using either unit cost or intensity to measure project costs, because intensity is unit cost divided by total time (see Table I).

Nevertheless, conflicts need to be resolved quickly so as to enhance the performance of project costs, because conflicts of interest may always exist between contractors and clients in any project. Moreover, contractors are even exposed to huge pricing risks transferred from clients in DB projects (Lam *et al.*, 2004).

CSFs versus project time

Construction speed (Y4) and delivery speed (Y5) should be maximized. Construction speed and delivery speed are significantly correlated to three and nine CSFs, respectively. The three CSFs which are significantly correlated to construction speed also have high correlations with delivery speed. The implication of this finding is that project participants who need to maximize construction speed and delivery speed should focus on these CSFs (see Table II).

To ensure high project speeds, project participants should focus on some management-related CSFs, such as effective overall managerial actions in planning, organizing, leading and controlling (X18); effective monitoring and approval mechanisms for design changes (X16); effective control mechanisms of subcontractors' works (X17) and appropriate organizational structures, cultures, roles and levels of authority (X15). Good performance of these CSFs could help to reduce several reworks and, therefore, improve project speeds. They should also focus on funding for DB projects adequately (X27) to deliver them as scheduled. In addition, contractors who possess good combination of design expertise and building techniques (X22) or strong management capability of design and construction (X24) should be employed to implement DB projects. Undoubtedly, the construction experience and management capability would tend to enable contractors to control the project works' performance better. In general, it can be seen that if a DB project is implemented by competent parties with effective management strategies, then it should be delivered fast.

Further analysis shows that effective overall managerial actions in planning, organizing, leading and controlling (X18) and project participants' satisfaction with the financial return from the project (X33) are two important factors which significantly affect construction speed and delivery speed, respectively (see Table IV). DB projects whose managerial actions are effective should accomplish a high construction speed. In fact, many construction projects in Vietnam have faced some delays of time due to poor performance of managerial actions (Le-Hoai *et al.*, 2008). Thus, project works should be planned well and then controlled effectively to enhance the time performance. In addition, delivery speed will be high if project participants are satisfied with the financial return from the project. Good financial return from the project is important not only for project participants but also for related companies' development in a very competitive high-risk construction market. Construction projects whose financial return would tend to satisfy project participants are frequently provided with the best supports for the project completion, such as adequate funding, adequate resources, adequacy of plant/equipment and good management of either design or construction. Thus, project participants should pay closer attention to these CSFs when managing DB projects so as to ensure high project speeds.

Table IV.
Results of causality

Indicator ref.	Variable ref.	β	σ	b	t-test		R^2	Adjusted R^2	F-test	
					t-value	p-value			F-value	p-value
Y1	Constant	4,350.523	1,078.289	✓	4.035	0.001	0.457	0.418	11.794	0.004
	X13	−1,048.851	305.406	−0.676	−3.434	0.004				
Y2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Y3	Constant	93.827	29.958	✓	3.132	0.008	0.271	0.215	4.834	0.047
	X13	−18.657	8.486	−0.521	−2.199	0.047				
Y4	Constant	−8,157.347	4,144.461	✓	−1.968	0.066	0.274	0.232	6.424	0.021
	X18	2,687.977	1,060.489	0.524	2.535	0.021				
Y5	Constant	−6,436.879	3,756.912	✓	−1.713	0.115	0.338	0.278	5.623	0.037
	X33	2,493.941	1,051.689	0.582	2.371	0.037				
Y6	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Y7	Constant	0.224	0.453	✓	0.495	0.628	0.813	0.788	32.555	0.000
	X31	0.487	0.097	0.589	5.021	0.000				
	X11	0.457	0.102	0.528	4.502	0.000				
Y8	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Y9	Constant	−0.337	0.726	✓	−0.464	0.652	0.747	0.700	16.197	0.001
	X13	0.767	0.154	0.757	4.988	0.000				
	X27	0.343	0.127	0.409	2.697	0.021				
Y10	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: β: Regression coefficient; σ: Standard error; b: Standardized regression coefficient; ✓: NA

CSFs versus project quality

The results show that to achieve a high system quality (Y7), 20 CSFs, which are significantly correlated to system quality, should be performed well (see Table II). Over half of these CSFs relate to parties' characteristics, in which the most important factors relate to the parties' competence, such as competent multidisciplinary project team (X31); client's project manager's competence and experience (X32); design consultant's thorough understanding of the construction process to develop a cost-effective design on time (X29) and contractor's project team leader's competence, experience and delegated authority (X25). The implication of this finding is that DB projects should be implemented by competent parties so as to achieve a high system quality.

It is interesting that the contractor's competence (X25, X26, X22, X24) is less correlated to system quality than both the client's (X31, X32) and design consultant's competence (X29). A possible explanation is that in Vietnam, contractors usually execute the construction works according to approved designs and clients' instructions and requirements. Nevertheless, the contractor's role is still very important in DB projects, because many contractor-related factors are found significantly correlated to system quality (see Table II). The implication of this finding is that contractors who are competent and experienced should be selected to deliver DB projects. In fact, it is hard to select contractors who possess enough competence and experience to deliver DB projects with an acceptable quality in Vietnam. This is because bureaucracy, fraudulent practices and kickbacks, which have been highlighted by Long *et al.* (2004), can result in a poor selection of contractors.

Further analysis shows that if a DB project is implemented by a competent multidisciplinary project team (X31) with high team spirits (X11), then it will achieve a high system quality (see Table IV). The project teams play an important role in determining the project works' quality, because they directly deliver the projects (Nguyen *et al.*, 2004). Thus, when managing DB projects, they should take a more active role instead of trying to transfer most responsibilities to contractors.

CSFs versus owner's satisfaction

In this study, 10 CSFs which are significantly correlated to owner's satisfaction (Y9) are identified. The results show that if the 10 identified CSFs are performed well, then the owner's satisfaction should be high (see Table II). Interestingly, many owner-related factors were found significantly correlated to owner's satisfaction, of which competent multidisciplinary project team (X31) has the highest degree of correlation with owner's satisfaction. This implies that the client's role may be also important for owner's satisfaction.

The results show that to achieve a high owner's satisfaction, competent project teams (X31) and project managers (X32) should be employed to implement DB projects. In addition, project participants should pay attention to some other CSFs which have a significant correlation with owner's satisfaction, such as resolving conflicts quickly (X13); comprehensive contract documentation (X4); contractor's project team leader's commitment to time, cost and quality (X26); consultant's/owner's quick response to contractor's requests and instructions (X30); adequate funding throughout the project (X27) and thorough understanding of project complexity (X5) (see Table II). Good performance of these CSFs would tend to improve project performance and, therefore,

achieve the owner's satisfaction. Thus, these CSFs should be controlled well so as to ensure a high owner's satisfaction.

Further analysis shows that if a DB project is funded adequately (X27) and conflicts are quickly resolved (X13), then it should achieve a higher owner's satisfaction (see Table IV). Good funding is important for owner's satisfaction, because it could increase the chance of a project to be delivered as scheduled (Dang *et al.*, 2012; Nguyen *et al.*, 2004) and, therefore, achieve the client's expectations. In addition, when project participants would tend to resolve their conflicts quickly, they should maintain their mutual relationships well and establish a harmonious working environment. As a result, they could improve project performance and, therefore, achieve a higher owner's satisfaction. When managing DB projects, project participants should focus more on these CSFs to achieve a high owner's satisfaction.

Limitation

With the aim of identifying the correlation and causality between CSFs and DB project performance, this study used the data sets of only 25 DB projects in Vietnam in the research. In terms of project size, approximately 50 per cent of the projects are over US$ 10 million. Moreover, 24 per cent of them are even over US$ 50 million [1 US$ = 20,000 VND (2010)]. Thus, the data sets are assumed to be quite acceptable when compared with the overall size of the Vietnamese construction industry.

Conclusions

Project success is very important not only for all project participants but also in the age of national development in industrialization and modernization. However, project success is hard to achieve, especially for a construction project delivered by an innovative procurement method as DB (Lam *et al.*, 2004). Thus, the identification of CSFs which affect DB project performance significantly could enhance the chance of project success.

In this study, the CSFs which are significantly correlated to different aspects of DB project performance were identified through correlation studies. Some CSFs were found to be significantly correlated to many aspects of project performance, such as adequate funding throughout the project; consultant's/owner's quick response to contractor's requests and instructions; resolving conflicts quickly; effective monitoring and approval mechanisms for design changes and effective overall managerial actions in planning, organizing, leading and controlling. It can be seen that most CSFs relate to parties' capabilities. This implies that parties' capabilities play an important role in determining the success or failure of a DB project. Thus, related parties in DB projects should frequently improve their own capabilities, which could directly enhance DB project performance, to increase the chance of project success.

The findings of this study also provide some useful information for project participants to better control DB projects in Vietnam. The causality between CSFs and KPIs were explored by using regression analysis technique. From the results, the key factors which significantly affect different aspects of project performance were identified. The results could be generalized that if a DB project with a good financial return is implemented by a competent project team with high team spirits, effective overall managerial actions, adequate funding and quick resolution of conflicts, it would tend to have a better chance of project success. Despite a little subjective point of view,

this inference is also useful to project participants in Vietnam, as well as other similar developing countries, especially to those who still have little experience with DB projects.

The findings of this study could provide project participants in Vietnam, as well as similar developing countries, with a better understanding of the impact of CSFs on different aspects of DB project performance. Hence, they could make effective CSFs-based improvements on their management-oriented approaches to enhance different aspects of DB project performance. Further researches should be conducted on investigating the criteria for project success which are appropriate to the natures and conditions of the Vietnamese construction industry. Such criteria may be useful to establish an assessment framework for project success for DB projects so as to control them better. CSFs for partnering in DB projects should also be investigated. When DB projects are larger and more complex, such CSFs could be useful to formulate effective strategies for minimizing conflicts and, hence, improve DB project performance.

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Further reading

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