COST CERTAINTY AND TIME CERTAINTY: AN INTERNATIONAL INVESTIGATION

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Cost certainty and time certainty are major concerns to both clients and contractors, as they have a direct impact on resources. An international study of contractors' cost certainty and time certainty is presented. Based on the performance and practice of contractors in Japan, the UK and the US, the multiple regression analysis reveals cost certainty to be influenced by time certainty and its perceived importance, annual leave, and past performance. Time certainty is found to be influenced by cost certainty and the perceived importance of cost, number of defects and past performance. Findings indicate that cost certainty and time certainty are closely related and interact with each other. An improvement in one aspect can lead to the enhancement of the other, and vice-versa. Contractors are advised to adapt an integrated approach, to emphasize cost and time certainty and to reduce defects in order to improve their performance in cost certainty and time certainty and strengthen their competitiveness in the market.

Keywords: contractor performance, cost certainty, international, multiple regression, time certainty.

INTRODUCTION

Cost certainty represents the probability of completing a project within the budget agreed between clients and contractors before the commencement of construction. Time certainty represents the certainty and reliability of completing projects on time compared with that planned. High certainty in cost and time is known to be one of the top priorities for construction clients (Davenport, 1997; Chinyio *et al.*, 1998; Flanagan *et al.*, 1998). This is because cost overruns and delays may result in increased costs for clients, leading to dissatisfaction. Cost certainty and time certainty are thus two of the most important performance criteria for construction clients (Soetanto *et al.*, 2001). It is the task of project management to minimize or eliminate surprises to clients (Winch *et al.* 1998). Poor performance in cost certainty and time certainty may affect contractors' profit levels and consequently their competitiveness in the market. However, construction projects are becoming more and more complex technologically, bringing accelerating changes and increasing uncertainties (Rwelamila and Hall, 1995). The high-risk nature of construction projects leads to cost overruns and delays (Akinci and Fischer, 1998). Normally, most construction projects meet the required quality specifications but are seldom completed within budget and time (Wright, 1997). In their investigation, Graves and Rowe (1999) reported that two thirds of the public projects investigated exceeded cost estimates and three quarters experienced delayed completion. Although influenced by many internal and external factors, cost certainty and time certainty are more likely to be within the control of

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contractors (Construction Industry Board, 1996). Cost overruns and delays are a symptom of poor management. Higher certainty is associated with contractors who are better able to predict and control construction cost and time. Therefore, contractors should put great emphasis on cost certainty and time certainty, which is believed to be attainable by the majority of contractors (Barnes, 1988).

Cost certainty and time certainty have caused increasing concern worldwide due to their importance to both clients and contractors. Jahren and Ashe (1990) investigated a large number of US naval facilities construction projects and found that the quality of the contract documents, the nature of interpersonal relations on the project and the policies of the contractors had the most significant impact on the cost overrun rate. Kaming *et al.* (1997) identified that inflationary increases in material costs, inaccurate material estimating and project complexity were the main causes of cost overruns in Indonesia. Further, design changes, poor labour productivity and inadequate planning were responsible for delays in high-rise building projects. Assaf *et al.* (1995) studied the causes of delays in large building projects in Saudi Arabia and attributed materials-related delays as the main cause of project delays. Through a survey among clients, consultants and contractors, Chan and Kumaraswamy (1996) identified poor site management and supervision, unforeseen ground conditions and low speed of decision making involving all project teams as the three most significant factors causing delays in Hong Kong building projects.

With the aim of this research being to identify best practice among contractors internationally, this paper presents two multiple regression models developed to identify factors within the contractors' control found to be paramount to cost certainty and time certainty respectively for high rise concrete framed buildings. This research differs from that discussed above in that it is based on the practices of contractors from the world's leading construction industries, namely Japan, the UK and the US, with a view to providing a robust benchmark for contractors across the globe. Data used for modelling was based on a hypothetical construction project to minimize the influence of project characteristics. Factors considered include both technical (such as construction methods and communication tools) and managerial (such as quality management and procurement methods) aspects. Findings demonstrate how contractors from these three countries (and others) may improve their performance in cost certainty and time certainty on building projects of this type.

METHODOLOGY

A hypothetical construction project (a six-storey concrete framed office building considered common to the three countries) formed the basis of a semi-structured questionnaire used to accrue the necessary performance data from contractors in the three countries. Respondents were encouraged to drawn upon their experience routine practices (Xiao *et al.* 2000 and 2001). A survey was conducted simultaneously in Japan, the UK and the US. In Japan, translated versions of the questionnaires were distributed to contractors of the Building Contractors Society (BCS). General contractors in the US were contacted by means of a large contracting body, The Associated General Contractors of America (AGC). In the UK, companies listed in the *Kompass* Directory (Reed Business Information, 1999) and members of the CIOB (Chartered Institute of Building, 2000) were targeted in the survey.

In the questionnaire, a small part of the data required was estimated from the hypothetical project. For example, respondents were asked to estimate the probabilities of completing the hypothetical project within budget and on time, assuming that they were the general contractor. Other information relevant to contractors' management and production practices, such as the average number of design variations encountered during construction, the frequency of meetings with subcontractors and project teams, and preferred construction methods in their previous similar projects, was also sought in order to identify their respective routine practices on site and reveal possible causes of any performance disparities found.

Altogether, 659 questionnaires were distributed to contractors and ninety-eight completed responses were obtained, representing an average response rate of 15%. Twenty-two responses from Japan and thirty-two responses from both the UK and the US respectively were used for the analysis. The remaining twelve responses were reserved for validation purposes. The relatively low response rate was not unexpected, considering the complexity and volume of the questionnaire. This, however, should not invalidate the outcome of the survey. Rather, it does imply that the questionnaire had been taken seriously and the responses received were both valid and reliable.

The performance of contractors, as measured by their levels of cost certainty and time certainty, was evaluated and compared amongst the three countries with a view to identifying their respective strengths and weaknesses and possible ways of improvement (Xiao, and Proverbs, 2002a and 2002b). Two performance-enhancing models were subsequently developed to identify the relationships between cost certainty and time certainty (i.e. dependent variables) and contractors' preferred practices and methods (i.e. independent variables) in the building process. The aim of the models was to identify the factors found to be significant towards achieving outstanding performance in cost certainty and time certainty. The development of the models is now described.

Model development

In this research, multiple regression analysis was utilized to (i) identify the factors influencing contractor performance in regard to cost certainty and time certainty, (ii) to establish the relationships between dependent and independent variables, and (iii) to determine the relative importance of each independent variable. With such, contractors can benchmark their own performance and identify areas in need of improvement. Here, the dependent variables are indicators of contractor certainty performance (probabilities of completing the hypothetical project within budget and on time), and the independent variables are the characters of contractors' operating practice identified to be influential to contractor performance through literature review and collected by the questionnaire survey. All relevant independent variables were considered in the multiple regression analysis in order to fully explore the possible relationships between dependent and independent variables.

The analysis was conducted with the aid of the Statistical Package for Social Sciences (SPSS 10). The Pearson correlation (r) was selected to measure the strength of a linear association. Only those independent variables which were significantly related to the respective dependent variables were incorporated into the modelling process. The significance level was 0.05 (2-tailed). Multicollinearity among the independent variables was assessed by means of the tolerance value with those less than 0.1 being omitted from the multiple regression analysis.

Table 1: Regression analysis results of cost certainty

Multiple regression R		0.725		Standard error	12.864		
R^2		0.525		Adjusted R^2	0.502		
Durbin-Watson		1.895					
Analysis of variance		DF		Sum of squares	Mean square		
Regression		4		14843.093	3710.773		
Residual		81		13403.749	165.478		
F = 22.425, Sig. F = 0.000							
Variables in the equation	B	SE*B*	Beta	*t*	Sig.	Tolerance	VIF
(Constant)	19.381	11.306		1.714	0.090		
TIMECERT	0.622	0.096	0.545	6.478	0.000	0.828	1.207
HOLIDAYS	-0.460	0.146	-0.242	-3.150	0.002	0.994	1.006
BOVERRUN	-0.878	0.348	-0.197	-2.542	0.014	0.964	1.038
CERTTIME	2.431	1.211	0.167	2.008	0.048	0.852	1.174

RESULTS

Multiple regression analysis was respectively applied to the dependent variables of cost certainty and time certainty. The Pearson correlation tests identified ten independent variables significantly related to cost certainty and twenty-six independent variables significantly related to time certainty.

A stepwise multiple regression procedure was applied. Under the selection criteria (to enter, F<=0.050; to move, F>=0.100), four independent variables were selected for cost certainty. The final regression model for cost certainty can be presented as:

Y (Cost certainty) = 19.381 + 0.622 (TIMECERT) + (-0.460) (HOLIDAYS) + (-0.878) (BOVERRUN) + 2.431 (CERTTIME)

Here, TIMECERT represents the level of time certainty for the hypothetical project, HOLIDAYS represents the amount of annual leave on site, BOVERRUN represents the typical cost overrun, and CERTTIME represents the importance contractors allocate to time certainty. The resulting R^2 for cost certainty was 0.525, signifying that 53% of the total variation in cost certainty could be explained by these four independent variables selected. The regression analysis results for cost certainty are summarized in Table 1.

A stepwise multiple regression procedure was subsequently applied to time certainty and four independent variables were selected. The final regression model for time certainty can be presented as:

Y (Time certainty) = 22.351 + 0.526 (COSTCERT) + 3.074 (COST) + -5.585E-02 (DEFECTS) + -0.652 (DELAYEDT)

Here, COSTCERT represents the level of cost certainty, COST represents the importance contractors allocate to cost, DEFECTS represents the number of defects at practical completion, and DELAYEDT represents the typical delays. The resulting R^2 for cost certainty was 0.595, signifying that 60% of the total variation in time certainty could be explained by these four independent variables selected. The regression analysis results for cost certainty are summarized in Table 2.

Table 2: Regression analysis results of time certainty

Multiple *R*	0.771		Standard error	10.415			
R^2	0.595		Adjusted R^2	0.575			
Durbin-Watson	2.026						
Analysis of variance	DF		Sum of squares	Mean square			
Regression	4		12904.147	3226.037			
Residual	81		8786.123	108.471			
F = 29.741, Sig. F = 0.000							
Variables in the equation	B	SE*B*	Beta	*t*	Sig.	Tolerance	VIF
(Constant)	22.351	10.315		2.167	0.033		
COSTCERT	0.526	0.065	0.601	8.148	0.000	0.920	1.087
COST	3.074	0.842	0.267	3.649	0.000	0.935	1.069
DEFECTS	-5.585E-02	0.017	-0.240	-3.316	0.001	0.957	1.045
DELAYEDT	-0.652	0.261	-0.191	-2.502	0.014	0.857	1.166

DISCUSSION

The multiple regression models have identified factors found to influence cost certainty and time certainty respectively, and the implications of these results for contractors are now discussed.

Cost certainty model

Multiple regression analysis revealed that cost certainty was positively influenced by time certainty (β = 0.545) and the importance contractors allocate to time certainty (β = 0.167). Conversely, the amount of annual leave on site (β = -0.242) and typical cost overrun (β = -0.197) were found to have a negative effect on cost certainty.

Among the four influencing factors, time certainty played a predominant role and the importance contractors allocate to time certainty was also significant. In construction projects, there are many uncertainties which may have cost and time implications. For example, clients may change their minds about the functions or specifications of their projects and introduce variations which will inevitably increase construction costs and prolong construction time. Other factors such as unforeseen ground conditions, bad weather, late drawings, inflation, and fluctuating market demands, etc., may worsen the situation (Hillebrandt, 1984; Akinci and Fischer, 1998). Even though contractors may claim an extension and/or compensation from clients, fundamentally, contractors are exposed to more risks than clients whatever contracts are used and they should not rely on the sharing of cost overruns and delays with clients through contracts (Akinci and Fischer, 1998). Once delays occur, contractors will suffer additional costs from items such as labour, plant hire, material storage, overheads, liquidated damages and delayed payments from clients (Scott, 1997; Kumaraswamy and Chan, 1999; Akpan and Igwe, 2001). Lost time might be made up, but usually at a considerable cost, by means of working longer hours, more shifts, increasing numbers of operatives and additional plant (Barnes, 1988; Farrow, 1991). This kind of schedule acceleration may also cause labour inefficiencies (Noyce and Hanna, 1998; Thomas, 2000). Moreover, the injection of additional resources may lead to overcrowded working conditions, causing severe quality and safety problems (Li *et al.*, 2000). Prolonged construction duration makes the risk of cost overrun even more significant. An emphasis on time certainty on behalf of clients may encourage contractors to strive to complete projects on time. If contractors regard time certainty as a priority in project management, cost certainty will also be improved, as indicated in this research. Typical cost overrun on similar projects impacted negatively on cost certainty. In fact, past performance has been identified as a significant variable for the assessment of contractor performance (Tam and Harris, 1996). The past performance of contractors, together with their financial capability and past experience, was ranked as the top selection criteria by clients (Fong and Choi, 2000). The model confirmed that clients could be confident in selecting contractors with good levels of past performance in cost certainty, as that corresponds positively with their actual performance. Consequently, contractors can strengthen their competitiveness in the market by improving their ability to deliver projects on budget. Longer periods of annual leave on site were found to reduce levels of cost certainty on construction projects. Annual leave of key staff and workers may cause disruption and delays to progress on site. Absences cause more interruption to the normal workflow and task accomplishment and underutilization of s tools and equipments (Business Roundtable, 1982). This may make contractors vulnerable to the risk of cost overruns.

Time certainty model

Multiple regression analysis revealed a positive relationship between time certainty and cost certainty ($\beta = 0.601$) and the importance contractors allocate to cost ($\beta = 0.267$). Conversely, a negative relationship was found between time certainty and the number of defects at practical completion ($\beta = -0.240$) and the typical delays ($\beta = -0.191$). Time certainty was found largely dependent on cost certainty and the importance contractors allocate to cost. This is logical because time and cost are interchangeable in project management (Barnes, 1988). They are like the two sides of one coin. The neglect of one aspect will have a corresponding detrimental effect upon the other. The uncertainties in construction projects mentioned above will simultaneously impact on construction cost and time. Factors causing cost overruns such as design variations, unforeseen underground conditions, and non-conformance of specifications, may also cause delays. It is the attitude of the parties in a contract which primarily determines whether targets are met (NEDO, 1983). It is contended that projects completed within budget are usually those of which it is known in advance that no extra sums are available (Barnes, 1988). This is also true for construction time. In such cases, contractors realize that they have no other options but to finish the project within budget and on time, and therefore do as much as possible to ensure this take place. That is, a focus on construction cost may make contractors aware of the cost implications of delays, and urge them to complete projects on time, resulting in reduced construction costs and durations and improved certainties. Greater planning effort on behalf of the contractor is also known to have a positive effect on improving project performance (Faniran *et al.*, 2001). This is why faster projects are usually found to be cheaper at the tender stage, punctual to deadlines and completed to customers' satisfaction (NEDO, 1988). The typical delays experienced on similar previous projects were also identified as a predictor of time certainty performance. That is, contractors with longer delays in their previous projects are less likely to complete their future projects on time. Here, it seems that the performance of contractors is largely consistent from one project to another. The nature and characteristics of their project management is unlikely to change dramatically in a short period of time and similar results may therefore be expected. Indeed, past performance is used commonly during contractor selection (Fong and Choi, 2000). Realizing the vital importance of a good reputation in time certainty, contractors should strive to improve their time certainty performance to benefit both clients and themselves. The multiple regression model found that time certainty was detrimentally influenced by the number of defects at practical completion. In construction projects, quality, time and cost performance are inseparable and they affect one another (Duttenhoeffer, 1992; McKim *et al.*, 2000). It is undesirable to meet cost and/or time objectives by sacrificing or compromizing the quality of products. Poor quality was identified as one of the primary factors for the delays contractors had to be responsible for (Majid and MaCaffer, 1998). Once defects occur, rework is needed to rectify them, which increases the likelihood of cost increases and delays and ultimately leads to client dissatisfaction (Love *et al.*, 1999). As high quality is not achieved by checking but by producing, the focus to eliminate systemic or chronic defects on finished construction products should be on facilitating coordination at site level and enabling a properly trained work-force to do the work 'right first time' (Shammas-Toma *et al.*, 1996). With the reduction or even elimination of defects, it would be more likely for contractors to meet their time target. To improve time certainty, contractors should not just focus on activities directly related to construction time alone. Rather, an integrated approach should be taken to tackle the problems encountered.

CONCLUSION

Clients expect their projects to be completed within budget and on time. Any cost overruns or delays may introduce a burden to their investment. Contractors may also suffer from the extra costs and delays and their competitiveness in the market will consequently be damaged. With the aim being to identify best practice amongst contractors internationally, a questionnaire survey of contractors in Japan, the US and the UK was conducted. Data in connection with contractors' cost certainty and time certainty was collected based on a hypothetical high-rise concrete framed building. Subsequently, multiple regression analysis was used to investigate the factors influencing cost certainty and time certainty for such buildings. The multiple regression analysis indicated that cost certainty is positively influenced by time certainty and the importance contractors allocate to time certainty, but negatively influenced by the amount of annual leave on site and the typical cost overruns on previous projects. Cost overruns and delays are endemic to construction projects because of the uncertainties inherent in the construction process. Delays usually bring about extra cost to contractors because of the extended period on site, and additional resources needed to make up the lost time. A focus on construction time certainty will encourage contractors to deliver projects on time, reducing the risks of cost overruns. Contractors' past performance provides a reliable indicator of their ability to control construction cost. More annual leave on site prolongs construction time and can cause interruption to projects, thus affecting cost certainty. Time certainty was found to be positively influenced by cost certainty and the importance contractors allocate to cost, but negatively influenced by the number of defects at practical completion and the typical delays on previous projects. Time certainty shares a close relationship with cost certainty. Factors causing cost overruns may also induce delays. A focus on cost will encourage contractors to put more effort into time planning and controlling, resulting in enhanced performance in time certainty. Defects at practical completion need extra time and resources to rectify. Past performance is a reliable indicator of a contractor's future performance and should be considered by clients during contractor selection. To conclude, it is evident that cost certainty and time certainty are closely related and interact with each other. An improvement in one aspect can lead to the enhancement of the other, and vice-versa. Contractors are advised to take an integrated approach, to emphasize cost and time certainty and to reduce defects in order to improve their performance in cost certainty and time certainty and strengthen their competitiveness in the market.

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