EVALUATION OF CONSTRUCTION COST AND TIME ATTRIBUTES

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Understanding the influences of cost and duration attributes assists developing reliable cost forecasting models and building successful construction projects. This paper presents the findings of a questionnaire survey, which is commissioned to evaluate and rank factors affecting cost and duration of construction projects. A total of 67 effective variables were identified through literature review and interviews, these factors were classified into six different categories. The study is focused on quantity surveyors based in the UK. Statistical analysis is carried out to establish a priority rating of the influencing factors. A detailed discussion of the outcomes indicates a strong agreement between quantity surveyors in ranking the significant variables. The results reveal that the category that contains consultant and design parameters is ranked top followed by client characteristics. Whereas, the third and forth ranks are occupied by project characteristics and external market conditions respectively. On the other hand, the fifth group of factors includes contract procedures and procurement methods, and finally contractor attributes occupy the bottom of the list.

Keywords: concordance analysis, cost, severity index, time.

INTRODUCTION

Cost and time influencing factors have been extensively researched but form different perspectives and views. Wide rages of effective variables were identified in the literature. This study classified these factors into six main categories. The objective of this paper is to assess and rank these categories according to their degree of influence on time and cost of construction projects.

A questionnaire methodology was adopted to extract the views of an arbitrarily selected sample of quantity surveyors in the UK. The questionnaire was sent to 118 UK quantity surveyors and 31% response rate was achieved. The paper describes statistical analyses of the survey, which include severity index computations and Kendall's concordance test. The results indicate that there is a strong agreement between quantity surveyors in ranking the main cost and time categories.

BACKGROUND LITERATURE

A great deal of research approached factors affecting cost and duration of construction projects from different angles. Moselhi, *et al.* (1993) undertook a questionnaire survey and identified thirty attributes which significantly affect project profitability in Canada and USA.

Naoum (1994) conducted a comparison analysis of time and cost for management and traditional contracting in the UK. A model was developed linking various project performances with different characteristics of construction projects. Relationships

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between procurement methods on one hand and type of client and project type, size, complexity and cost on the other hand were concluded, in order to deliver better project performance and success.

Nkado (1995) examined time-influencing factors in the UK. Through a questionnaire survey and statistical analysis the research managed to prioritize 28 factors, which affect duration of construction projects. A significant degree of consistency in ranking the factors was found.

Causes of high costs of construction in Nigeria had been investigated by Okpala and Aniekwu (1988). The study shows that 27 factors contribute to time and cost overruns. A questionnaire survey was conducted which included engineers, architects and quantity surveyors. The rankings of the influencing variables by the three professions are found to be fairly similar, despite some differences in views held by each profession.

Factors influencing construction time and cost overruns on high-rise projects in Indonesia had been examined by Kaming, *et al.* (1997). Project managers were consulted to assess the different variables. Using factor analysis techniques, the variables affecting delay and cost overrun were successfully grouped into main categories.

Assaf, *et al.* (1995) studied causes of delay in large building projects in Saudi Arabia. A sample of 24 contractors, 15 architectural / engineering firms (A/Es) and 9 owners was involved in the survey. Degrees of importance of 56 causes of delay were evaluated. It was shown that contractors and A/Es substantially agree on ranking of the delay factors, whereas owners and contractors, and owners and A/Es do not match. It was also depicted that finance factors were ranked the highest by all three parties, whereas environmental factors were ranked the lowest.

Kumaraswamy and Chan (1995) and Chan and Kumaraswamy (1995) probed a range of construction duration determinants in Hong Kong. The research studied the relationships between construction time on hand and floor area, number of stories, productivity and standardization on the other hand.

Shash (1993) identified and evaluated 55 factors considered in tendering decisions by top UK contractors. The results indicated that several factors are considered equally significant for both bid / no bid and mark-up size decisions. Other factors were seen to have considerable importance for one decision but not for the other.

METHODOLOGY

This study compiled the above mentioned literature survey and identified 67 factors which affect cost and duration of construction projects. Furthermore, industrial interviews were conducted to assist clustering these factors into main groups, 6 different categories emerged:

Category 1: Client characteristics

- Type of client (public / private / developer)
- Financial ability / payment record
- Project finance method /appropriate funding in place on time
- Partnering arrangements
- Priority on construction time / deadline requirements
- Experience of procuring construction

- Client requirements on quality
- Certainty of project brief

Category 2: Consultant and design parameters

- Completeness and timeliness of project information (design, drawings, specifications)
- Buildability of design
- Working relationships with client / contractors / other design team consultants (previous / present)
- Variation orders and additional works (magnitude, timing, interference level)
- Quality of design and specifications
- Inspection, testing and approval of completed works (toughness / requirements)
- Submission of early proposals for costing / cost planning
- Absence of alterations and late changes to design (no 'design-as-we-go' on site philosophy)

Category 3:Contractor attributes

- Management team (suitability, experience, performance)
- Management / labour relationships and confidence in work force
- Financial capability
- Experience on similar projects
- Current work load
- Level of communications within the contractor organization
- Estimation method and cost control technique (accuracy and reliability)
- Planning capability and level of resource deployment / utilization / optimization
- Productivity effects: (managerial, organizational, labour, technology)
- % of main contractor direct work and % of sub-contracted work
- Number of sub-contractors
- Mark up policies and % (general and project wise) (special or normal conditions applied)
- Record of payments to sub-contractors
- Previous claims record i.e. assessment of 'low tender' – 'high claims' performance
- Present claims (size and quantity)
- Accidents on sites record
- Bond / warranty arrangements
- CDM regulations awareness

Category 4: Project characteristics

- Type / function (residential, commercial, industrial, offices)
- Size / gross floor area
- Height / no. of stories
- No. of basement levels
- Level of uncertainty of soil conditions
- Complexity
- Type of structures (steel, concrete, brick, timber, masonry)
- Location (regions / rural ; urban) (inner city / outskirts)
- Site conditions / site topography
- Construction method / technology

- Type of foundations (pile / raft / pad / etc.)
- Off-site prefabrication
- Type of cladding and external walls (brick, double glazing, etc.)
- Access to site
- Intensity / complexity of building services
- Phasing requirements (areas to be handed over first or initial non-availability)
- Quality of finishing

Category 5: Contract procedures and procurement methods

- Type of contract / Use of standard form of contract
- Tender selection method (open, selected, negotiation, single or two stage, etc.)
- Payment modalities (fixed price, cost plus, BOT, PFI-DBFO, etc.)
- Method of procurement (traditional, design and build, project management, etc.)
- Spread of risk between construction parties (client / consultant / contractors)
- Claims and disputes resolution methods (litigation / arbitration / others)
- Interviewing of selected prospective contractors

Category 6: External factors and market conditions

- Material prices / availability / supply / quality / imports
- Labour costs / availability / supply / performance / productivity
- Plant costs / availability / supply / condition / performance
- Weather condition
- Government regulations/policies (health and safety, fire, CDM,... etc.)
- Level of competition and level of construction activity
- Number of bidders on competitive projects
- Interest rate / inflation rate
- Stability of market conditions

A questionnaire methodology was adopted to evaluate and rank these main clusters according to their significance. The questionnaire survey was mailed to 118 quantity surveyors in the UK, 31% response rate was achieved.

RANKING OF INFLUENCING FACTORS

A scale for rating each variable is used, where 1 = not significant, 2 = moderately significant and 3 = highly significant. The Severity Index (S.I.) is obtained for each factor as a measurement of its significance according to cost and duration of

$$S.I. = (\sum_{i=1}^{3} w_i * f_i) * \frac{100\%}{n} \qquad \text{.....(1)}$$

construction projects. It is illustrated by Equation 1 and Figure 1.

Where:

i = represent the ratings 1, 2, 3
f_i = frequency of responses
n = total number of responses
w_i = weight for each rating

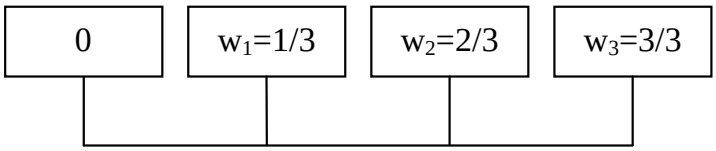

Figure 1: Rating weights

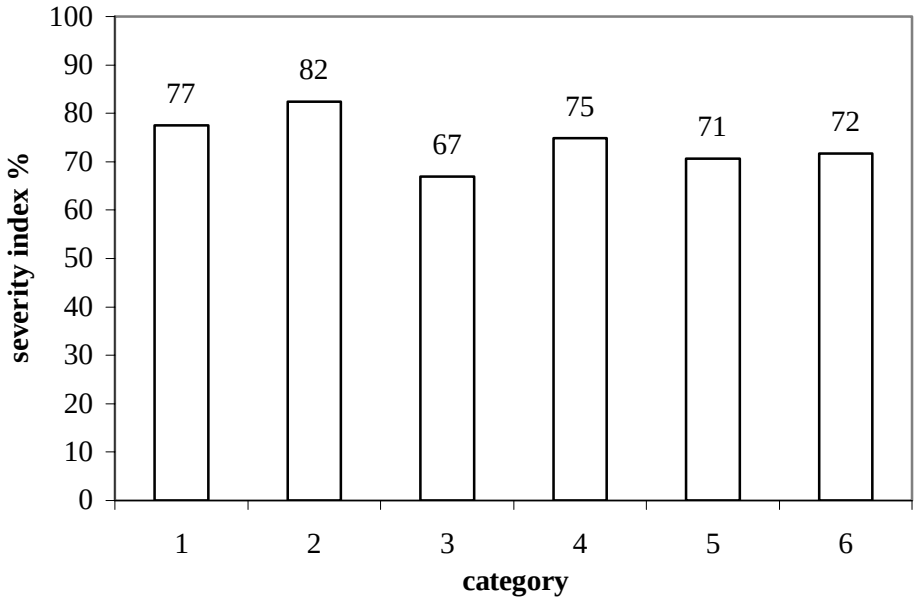

Figure 2: Average severity indices

A comparison of average severity indices obtained by each category is portrayed in Figure 2. The top ranked category is found to be consultant and design parameters with an average severity index of 82%, followed by client characteristics with an S.I. of 77%. Whereas the third and forth categories were found to be project characteristics and market conditions, which scored 75% and 72% respectively. Contract procedure and procurement method were ranked fifth with an average S.I. of 71%. On the other hand, the contractor attributes group scored the least average severity index of 67%. Detailed analysis of each group revealed the following findings:

Client characteristics
The top three highly ranked factors within this category are found to be: deadline requirements; certainty of project brief; and client requirements on quality.

Consultant and design parameters
The respondents placed the absence of alterations and late changes to design as the top-influencing factor in this group. The second rank is shared by two factors namely: the variation orders and additional works variable and the completeness and timeliness of project information.

Contractor attributes
The performance of the management team is seen as the most important factor in this category. The contractor previous experience on similar projects occupied the second rank; followed by the planning capability and level of resource deployment.

Project characteristics
The intensity and complexity of building services is the highly ranked variable in this group; followed by the number of basement levels in the project. Whereas, the level of uncertainty of soil conditions comes as the third ranking factor.

Contract procedure and procurement method
The first ranked factor within this category is perceived as the method of procurement, which include the options of traditional contracting, design and build, project management, etc. The tender selection method is the second ranked variable; followed by risk allocation among construction parties (client, consultant and contractor).

External factors and market conditions
The level of competition and level of construction activity is believed to be the highly important factor in this group. Material prices and availability captured the second position; and on the third rank is labour costs and productivity.

Overall Ranking
An alternative statistical analysis is carried out to evaluate the degree of influence of the whole 67 cost and time variables without considering the categorization process, which is described earlier. The outcomes of this analysis unveil that the top ten highly effective factors are selected, according to their influence, as follows:

1. Absence of alterations and late changes to design
2. Experience and performance of management team
3. Deadline requirements
4. Variation orders and additional work
5. Completeness and timeliness of project information
6. Intensity and complexity of building services
7. Quality of design and specifications
8. Overall building complexity
9. Level of competition and level of construction activity
10. Certainty of project brief

MEASURING QUANTITY SURVEYORS CONCORDANCE

Kendall's concordance test provides a measure of the agreement between the quantity surveyors for their judgements on each category of factors. Kendall's coefficient of concordance (w) ranges between '0' and '1', with '0' indicating no agreement and '1' designating perfect concordance. It is illustrated by Equation 2 as follows (Siegel 1988):

$$w = \frac{12 * s}{k^2 * n * (n^2 - 1)} \qquad \text{..... ....(2)}$$

Where:

s = sum of squares of deviations of factors
k = number of quantity surveyor groups
n = number of factors in each category

In order to undertake Kendall's concordance test the quantity surveyor responses were divided arbitrarily into three different groups. Accordingly, the six different categories of cost and time determinants were then ranked separately for each group of quantity

Table 1: Kendall's Concordance Analysis Using SPSS

Category ID	Degree of freedom	Chi-square	Kendall's Coefficient	Significance
Category 1	7	19.8889	0.9471	0.0058
Category 2	7	19.6734	0.9368	0.0063
Category 3	17	48.3423	0.9479	0.0001
Category 4	16	42.5310	0.8861	0.0003
Category 5	6	15.7952	0.8775	0.0149
Category 6	8	23.4667	0.9778	0.0028

surveyors. SPSS software was used to carry out Kendall's concordance test. Table 1 depicts the statistical findings of these analyses.

It is shown that those values of Kendall's coefficient (w) ranges between 0.88 and 0.98 for the six categories. These high values of Kendall's coefficient indicate strong agreement between quantity surveyors on ranking these categories of factors affecting cost and duration of construction projects.

The values of significance level are computed between 0.0149 and 0.0001. These values indicate that, the null hypothesis: there is no agreement between quantity surveyors, has to be rejected ($p < 0.05$). The alternative hypothesis that, there is a significant agreement between quantity surveyors, is acceptable with confidence limit $p > 95\%$.

CONCLUSIONS

This study consulted 118 UK-based quantity surveyors via a questionnaire survey. The main objective was to evaluate and rank cost-influencing factors of construction projects. Sixty-seven variables affecting construction cost were identified through literature and interviews. These factors were grouped into six different categories.

Statistical analysis revealed that a strong agreement between quantity surveyors existed. This was proven by high Kendall's coefficients of concordance achieved within each category.

The average severity index computed for each category ranged between 82% and 67%. This result prevailed that there is no significant variation in the ranking of each group. However, the category contains consultant and design parameters was ranked top followed by client characteristics. Whereas, the third and forth ranks were occupied by project characteristics and external market conditions respectively. On the other hand, the fifth group of factors included contract procedures and procurement methods. The contractor attributes group scoring the least index occupied the bottom of the list.

This study represents a foundation stage for a future research aiming to develop tender price estimation models, which utilize the cost and time attributes evaluated in this paper.

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