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AN ANALYSIS OF THE IMPACTS OF RISKS AND UNCERTAINTIES ON CONSTRUCTION CASH FLOW FORECAST

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ABSTRACT

Various attempts have been made to model construction cash flow. However, in spite of these efforts, significant variations between the modelled cash flow profiles and the actual were observable. In previous research by the authors (Odeyinka and Lowe, 2000), it was found that the variations were due to uncertainties and risk factors inherent in construction cash flow forecast. This complementary study attempts to analyse the impacts of the identified risk factors on construction cash flow forecast. The study was conducted through a questionnaire survey of small, medium and large-scale construction contractors. Responses were analysed using 'mean response' analysis and univariate analysis of variance (ANOVA). The results showed that most of the risk factors with critical impacts on cash flow forecast relate to contractors' cash inflow, change in the design or specification and construction programming. Results also indicated that some risk factors such as 'problems with the foundations' and 'inclement weather' were found to assume more critical impacts than others in certain project situations. The implication of this is that the knowledge of such situations as well as the awareness of the possible impacts of the risk factors occurring therein will provide suitable information for construction practitioners to proactively manage the identified risks.

Keywords: Construction cash flow, contractor, mean response analysis, risk, uncertainty

1 INTRODUCTION

Proper cash flow management is crucial to the survival of a construction company because cash is the most important corporate resource for its day to day activities. A proper cash flow management is also important as a means to obtain loans, as banks and other money lending institutions are normally much more inclined to lend money to companies that can present periodic cash flow forecasts (Navon, 1995). However, construction industry suffers the largest numbers of bankruptcy of any sector of the

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economy with companies failing because of poor financial management, especially inadequate attention to cash flow forecasting (Boussabaine and Kaka, 1998; Calvert, 1986; Harris and McCaffer 2001). The major problem that construction managers encounter in making financial decisions involves both the uncertainty and ambiguity surrounding expected cash flows (Eldin, 1989). In the case of complex projects, the problem of uncertainty and ambiguity assumed even greater proportion because of the difficulty in predicting the impact of unexpected changes on construction progress and consequently, on cash flows (Boussabaine and Elhag, 1999). The uncertainty and ambiguity are caused not only by project-related problems but also by the economical and technological factors (Laufer and Coheca, 1990).

Lowe (1987) grouped the factors responsible for variation in project cash flow forecast under five main headings of contractual, programming, pricing, valuation and economic factors. These factors include: receiving interim valuation, agreeing interim valuations on site, delay in agreeing variation/daywork, delay in settling claims, inclement weather, problems with the foundations, delay in payments from client, level of inflation, archaeological remains, changes in interest rates, tree preservation orders and changes in currency exchange rates. Harris and McCaffer (2001), Calvert (1986), Kaka and Price (1993) and Kaka (1996) identified other factors to include: variation, tender unbalancing or tendering strategy and estimating error or variances between the actual and estimated resources requirements. The identified risk factors have been reported to affect cash flow profiles as well as its modelling significantly. However the perception of contractors to the impacts of the risk factors occurring in different project types and of varying scope and duration is yet to be investigated. This then is the focus of the study reported in this paper and it is a complementary study in an on-going programme of research that intends to investigate the risk sources and their impacts on cash flow forecasting.

2 AN OVERVIEW OF CASH FLOW MODELLING METHODS

The traditional approach to cash flow prediction usually involves the break down of the bill of quantities in line with the contract programme to produce an estimated expenditure profile. This could be expected to be reasonably precise provided that the bill of quantities is accurate and the contract program is complied with (Lowe, 1987). This however is likely to be slow and costly to produce; as such, several attempts have been made to devise a ‘short cut’ method of estimation, which will be both quicker and cheaper to utilise. Attempts have been made at the mathematical formulae and statistical based modelling of construction cash flow in both the contractor and client’s organisations. This was demonstrated by the development of a series of typical value S-curves by many researchers (Hudson, 1978; Berny and Howes, 1983; Evans and Kaka, 1998, etc.). The models obtained by these researchers rest on the assumption that reasonably accurate prediction is possible by means of a single formula utilising two or more parameters which may vary according to the type, nature, location, value and duration of the contract. Attempts have also been made at the development of cost flow or cost commitment S-curves (Peer, 1982 and Kaka and Price, 1993).

Berny and Howes (1983) and Kenly and Wilson (1986) took the idiographic approach to cash flow forecasting by maintaining that value curves are generally unique and should be modelled separately.
They insisted that a curve should be fitted for each project as opposed to the nomothetic models, which aggregate groups of projects in order to develop a single standard curve to produce typical value curves. Kaka and Boussabaine (1999) however maintained that idiographic models are only useful for analytical purposes. As such, they argued that forecasting requires the use of standard curves developed out of a group of projects similar to the one to be executed (nomothetic models). They therefore have developed cash flow models based on standard cost commitment/ cost flow curves using logit transformation to fit the data.

Several attempts have also been made at computer modelling of cash flow forecast. Some of the models were based on computer simulations (Lowe and Lowe, 1986) while others were based on the use of artificial intelligence techniques. Boussabaine and Kaka (1998) have attempted to model cash flow forecast using artificial neural networks, which simulates neuronal systems of the brain. Boussabaine and Elhag (1999) also applied fuzzy set theory to model movement of cash flow at valuation periods. Attempts have also been made in modelling cash flow forecast using expert systems. Efforts in this regard include that of Lowe *et. al.*, 1993 and Lowe and Lowe, 1997.

3 DATA AND METHODOLOGY

In order to asses the perception of contractors to the risk factors involved in modelling cash flow forecast, a structured questionnaire was designed. This was based on an in-depth literature review of risk factors responsible for variation in cash flow profile and the authors' general knowledge of the factors. The questionnaire was administered through a postal survey to 101 Chartered building companies with annual turnover of £ 5 million and over. All the construction companies in this category listed in the directory and handbook of Chartered Building companies, Published by the Chartered Institute of Building were included in the survey. The sample selection was based on the assumption that construction firms in this category place a very high premium on cash flow forecasting and also do employ qualified personnel to perform the duty. A total of 34 construction firms returned their questionnaires duly completed. This represents a 33.7% response rate which is typical of the norm of 20-30% response rate in most postal questionnaire survey of the construction industry (Akintoye, 2000).

The questionnaire elicited information regarding the firms' annual turnover, which enabled their groupings into small, medium and large firms as shown in Table1. About 68% of the respondents are in senior management position, 61% have higher education and about 94% are professionally qualified. The mean experience of the respondents is 26.94 years with a standard deviation of 8.19 years. This background information regarding the respondents indicated that responses provided by them could be relied upon for this study.

Table 1: Surveyed firms' turnover in the last financial year

Size	Turnover (£ million)	Number	Percent	Cumulative percent
Small	5 - 25	15	44.1	44.1
Medium	25 – 100	12	35.3	79.4
Large	Over 100	7	20.6	100.0
Total		34	100.0	

Table 2: Project procurement options employed

Option	Number	Percentage	Cumulative percent
Traditional	17	50.0	50.0
Design & build	14	41.2	91.2
Management	3	8.8	100.0
Total	34	100.0	

The questionnaire listed 15 risk factors derived from literature as potentially impacting on cash flow forecast. Contractors were then asked to provide opinion regarding the likelihood of the impact of each factor should it occur. The scoring was done on a 0 to 5 Likert scale (Holt, 1997) so as to accommodate the instances where the risk factors identified are not applicable by assigning a score of zero. The greatest impact of a risk factor occurring was assigned a score of 5 while a score of 3 was defined as critical. In order to obtain a more focussed and targeted scoring, contractors were requested to base their scoring on one recently completed or an on-going project. With reference to the chosen project, respondents were requested to supply further project details. This included project type, construction duration, project value, procurement option and nature of project client. Some of these project details which have been used for the analysis are shown in Tables 2 to 4.

Table 3: Project construction duration grouping

Construction duration range (months)	Number	Percent	Cumulative percent
0 - 6	6	17.6	17.6
7 – 12	16	47.1	64.7
13 – 24	11	32.4	97.1
25 – 36	1	2.9	100.0
Total	34	100.0	

Table 4: Type of construction projects

Type	Number	Percent	Cumulative percent
Commercial / industrial building	17	50.0	50.0
Public & community building	11	32.4	82.4
Hospital / laboratory building	2	5.9	88.3
Contract housebuilding	3	8.8	97.1
Civil engineering	1	2.9	100.0
Total	34	100.0	

4 DATA ANALYSIS AND RESULTS

Data were analysed using the Statistical Package for Social Sciences (SPSS). The analysis involved the ranking of the risk variables identified as impacting on cash flow forecast. The mean response of the variables was utilised for the ranking. This was followed by the Analysis of Variance (ANOVA) to test the null hypothesis that the mean values of the dependent variables are equal for all the groups considered (Akintoye, 2000).

4.1 Analysis of the impacts of risks and uncertainties on cash flow forecast

Project characteristics were utilised in carrying out the analysis of the impacts of risks and uncertainties on cash flow forecast. These include size of construction firms, procurement

Table 5: Ranking of the effects of risk factors in cash flow forecasting utilising construction firms size grouping

Factors	Overall mean score	Rank	Small firms' mean	Rank	Medium firms' mean	Rank	Large firms' mean	Rank	*F* Stat.	Level of significance (*p* values)
Delays in payments from client	3.75	1	3.40	4	4.30	1	3.71	4	0.871	0.429
Delay in settling claims	3.75	1	3.60	1	3.70	5	4.14	1	0.297	0.746
Architect's instructions	3.66	3	3.53	2	4.00	2	3.43	6	0.591	0.560
Receiving interim certificates	3.63	4	3.53	2	3.90	3	3.43	6	0.436	0.651
Delay in agreeing variation/ daywork	3.44	5	3.27	5	3.80	4	3.29	8	0.604	0.554
Problems with the foundations	3.25	6	2.73	7	3.40	9	4.14	1	1.867	0.173
Agreeing interim valuations on site	3.13	7	2.67	8	3.70	5	3.29	8	2.146	0.135
Estimating error	3.13	7	2.60	9	3.60	7	3.57	5	2.026	0.150
Inclement weather, strikes, etc.	3.09	9	2.87	6	2.90	10	3.86	3	1.366	0.271
Archaeological remains	2.47	10	1.73	12	3.60	7	2.43	12	3.063	0.062
Tender unbalancing	2.41	11	2.27	10	2.20	12	3.00	11	0.847	0.439
Level of inflation	2.41	11	1.87	11	2.70	11	3.14	10	2.485	0.101
Changes in interest rates	1.59	13	0.93	13	2.10	13	2.29	13	3.269	0.052
Tree preservation orders	1.22	14	0.67	14	1.80	14	1.57	14	3.157	0.058
Changes in currency exchange rates	0.72	15	0.27	15	1.10	15	1.14	15	3.139	0.058

method, construction duration, project type, project value and type of project client. The risk factors impacting on construction cash flow are listed in Table 5. Using a criticality scale of 3 as previously defined, the first 9 risk factors with overall mean scores of 3.00 and over are shown to have critical impact on cash flow forecast. These factors with critical impacts are: delays in payments from client, delay in settling claims, architect's instructions, receiving interim certificates, delay in agreeing valuation/ daywork, problems with the foundations, agreeing interim valuations on site, estimating error and inclement weather, strikes, etc. Three of these factors, namely: delays in payments from the client, receiving interim certificates and agreeing interim valuations on site can be grouped under 'interim valuation and certificates'. It is not surprising that the effects of 'interim valuation and certificates' rank high and are critical because that is the means whereby contractors derive the needed cash to inject into construction. Should that source of cash inflow be tampered with, the effect is expected to be critical. Moreover, three of the factors with critical impacts, namely: delay in settling claims, architect's instructions and delay in agreeing variation/ daywork can be grouped under 'changes in design or specification'. Since changes in design and specification occasioned by architect's instructions usually involve a change in work schedule and resources requirements, it is not surprising that its effect is critical on cash flow forecast. 'Problem with the foundation' which is another factor with critical impact relates to site conditions, 'estimating error' relates to variances between the estimated and actual resources utilised and 'inclement weather' relates to construction programming. It is therefore not surprising that their impacts on the cash flow profile are critical. It is however noteworthy that many of the

factors with non-critical impacts are economic factors, suggesting that in a non-inflationary and stable economic regime, these factors are not if adverse consequences.

Aside from the risk factors with critical impacts identified by overall ranking, analyses were also carried out based on project characteristics and other identifiable criteria. These are presented in the following sections.

4.2 construction firms' size and impacts of risk factors on cash flow forecast

An analysis of the impacts of risk factors on cash flow forecast based on the size of construction firms is shown in Table 5. The analysis indicates that there is no statistically significant difference (p = 0.05) in the opinion of the firms' grouping regarding the variables identified as impacting on the cash flow profile. This suggests that construction contractors, irrespective of firm size, generally have similar opinions regarding the impacts of the risk factors influencing cash flow forecast. However, while the impact of problems with the foundations was ranked 6th overall, 7th and 9th by the small and medium firms respectively, it ranked 1st by large firms. This is not unexpected because large firms usually undertake complex projects with huge capital involvement of which foundation is a significant fraction and most times of a complex nature. As such, problems with the foundation are expected to impact significantly on the cash flow profile. This is not necessarily so in the case of small and medium firms where the nature of building projects undertaken is less complex. Moreover, while the impact of inclement weather, strikes, etc. ranked 9th overall, it ranked 6th and 10th respectively under the small and medium firms while it ranked 3rd under the large firms grouping. This is not surprising because the projects undertaken by large firms are usually long gestation ones where the impact of inclement weather is highly significant. Khosrowshahi (2000) submitted that cash flow forecasting is not an exact science and that in developing a forecast, contractors are almost always faced with numerous variables of unpredictable nature; hence, the development of an accurate forecast relies on current knowledge and past experience. In the light of this, the information provided by this analysis is of value to construction project team to proactively manage the impacts of risk in cash flow forecast.

4.3 Procurement methods and impacts of risk factors on cash flow forecast

An analysis using the same data set but based on procurement method grouping is presented in Table 6. The questionnaire survey targeted various procurement options, however, responses were received on three procurement routes only (Table 2). Due to scanty data available on management procurement option, this analysis was based on traditional and design and build procurement methods only.

With the exception of the impact of 'problems with the foundations' variable that is significant at 5% level, there is no statistically significant difference of opinion in the procurement methods grouping of the impact of the other risk factors. This suggests that contractors, irrespective of procurement methods employed, generally have similar opinions regarding the impacts of the risk factors influencing cash flow forecast. However, the significant difference of the impact of the 'problems with the foundations' is noteworthy. While the impact of this variable ranked 7th overall, it ranked 9th under the

traditional procurement method while it ranked 1st under the design and build procurement method. This is not unexpected because design and build procurement method is usually employed for complex projects where it is expected that the construction expertise of the contractor would be utilised in the design. Due to the complex nature of the projects and uncertainties of site conditions, problems with the foundations are not uncommon. As such, it is not surprising that the impact of this variable ranked highest under the design and build procurement method. Moreover, the impact of 'agreeing interim valuations on site' variable ranked 6th overall, it ranked 7th under the traditional procurement method while it ranked 3rd under design and build procurement method. It is not surprising that the impact of this risk factor ranked higher under the design and build procurement method. This is because there being no bills of

Table 6: Ranking of the impacts of risk factors in cash flow forecasting utilising procurement options grouping

Factors	Overall mean score	Rank	Traditional mean	Rank	Design & Build mean	Rank	*F* Stat.	Level of significance (p values)
Delays in payments from client	3.79	1	4.07	1	3.50	5	0.781	0.385
Delay in settling claims	3.69	2	3.93	2	3.43	6	0.729	0.401
Receiving interim certificates	3.69	2	3.60	5	3.79	2	0.188	0.688
Architect's instructions	3.62	4	3.67	3	3.57	4	0.040	0.844
Delay in agreeing variation/ daywork	3.45	5	3.67	3	3.21	8	0.876	0.358
Agreeing interim valuations on site	3.17	6	2.73	7	3.64	3	3.664	0.066
Problems with the foundations	3.14	7	2.33	9	4.00	1	9.153	0.005 *
Inclement weather, strikes, etc.	3.07	8	2.93	6	3.21	8	0.260	0.614
Estimating error	2.97	9	2.53	8	3.43	6	3.187	0.085

* Significant at 5% level

quantities to base interim valuation as in traditional procurement method, it is not unlikely that the impact of 'agreeing interim valuations on site' variable would be more significant under the design and build procurement method than the traditional method.

4.4 Construction duration and impacts of risk factors on cash flow forecast

Using the same data set, an analysis was carried out based on construction duration grouping (Table 7). The construction duration range of 25-36 months (Table 3) was not included in the analysis because only one project fell into that category. The analysis indicates that there is no statistically significant difference (p = 0.05) of opinion in the construction duration grouping regarding the variables identified as impacting on the cash flow profile. This suggests that contractors, irrespective of construction duration, generally have similar opinions regarding the impacts of the risk factors influencing cash flow forecast. However, while the impact of 'estimating error' risk factor ranked 7th overall, it also ranked 7th under projects of 0-6 months duration, it ranked 8th under projects of 7-12 months duration while it ranked 2nd under projects of 13-24 months duration. The impact of 'estimating error' ranked higher under projects of longer duration possibly due to the fact that underestimated resources requirement would affect cash in flow for a longer period than it does under projects with shorter duration. Moreover, while the effect of 'inclement weather, strikes, etc.' risk factor ranked 9th overall, it

however ranked 10th under projects of 0-6 months duration, it ranked 7th under projects of 7-12 months duration while it ranked 4th under projects of 13-24 months duration. This is not surprising because the longer the duration of a construction project, the more susceptible it is to the vagaries of weather conditions. It is therefore expected that the effect of inclement weather is more pronounced under projects of longer duration.

4.5 Construction project types and impacts of risk factors on cash flow forecast

An analysis using the same data set but based on construction project type grouping is presented in Table 8. The questionnaire survey targeted 5 types of construction projects normally carried out by chartered builders (Table 4). However, due to scanty data available on other types, this analysis was based on commercial/industrial and public/community buildings only. The analysis indicates that there is no statistically

Table 7: Ranking of the impacts of risk factors in cash flow forecasting utilising construction duration grouping

Factors	Overall mean score	Rank	0-6 months duration mean	Rank	7-12 months duration mean	Rank	13-24 months mean	Rank	*F* Stat.	Level of significance (p values)
Delays in payments from client	3.71	1	4.50	1	3.40	5	3.70	2	0.917	0.411
Delay in settling claims	3.71	1	4.17	2	3.67	2	3.50	4	0.351	0.707
Architect's instructions	3.61	3	3.83	4	3.73	1	3.30	7	0.498	0.613
Receiving interim certificates	3.58	4	4.00	3	3.27	6	3.80	1	1.222	0.310
Delay in agreeing variation/ daywork	3.59	5	3.67	5	3.60	3	2.90	10	1.179	0.323
Problems with the foundations	3.32	6	2.50	9	3.60	3	3.40	6	0.978	0.389
Estimating error	3.19	7	2.67	7	3.07	8	3.70	2	1.152	0.331
Agreeing interim valuations on site	3.10	8	3.50	6	3.00	9	3.00	9	0.342	0.713
Inclement weather, strikes, etc.	3.06	9	2.00	10	3.20	7	3.50	4	2.467	0.103

Table 8: Ranking of the impacts of risk factors in cash flow forecasting utilising construction project type grouping

Factors	Overall mean score	Rank	Comm/ Indust. building mean	Rank	Public & Commun building mean	Rank	*F* Stat.	Level of significance (p values)
Delays in payments from client	3.70	1	3.69	1	3.73	4	0.003	0.955
Delay in settling claims	3.70	1	3.50	4	4.00	1	0.599	0.446
Architect's instructions	3.63	3	3.56	3	3.73	4	0.105	0.749
Receiving interim certificates	3.63	3	3.50	4	3.82	2	0.438	0.514
Problems with the foundations	3.44	5	3.69	1	3.09	9	0.994	0.328
Delay in agreeing variation/ daywork	3.41	6	3.25	6	3.64	6	0.559	0.462
Inclement weather, strikes, etc.	3.33	7	3.19	8	3.55	7	0.484	0.493
Agreeing interim valuations on site	3.26	8	3.25	6	3.27	8	0.002	0.963
Estimating error	3.22	9	2.81	9	3.82	2	3.577	0.070

significant difference (p = 0.05) of opinion in the construction project type grouping regarding the variables identified as impacting critically on the cash flow profile. This

suggests that contractors, irrespective of construction project types, generally have similar opinions regarding the impacts of the risk factors influencing cash flow forecast.

However, it is observable from Table 8 that while the impact of 'estimating error' risk factor ranked 9th overall and also 9th under commercial and industrial building type, it however ranked 2nd under public and community building type. This is not surprising because in most cases, public and community building projects are executed under the traditional firm price contract system where there is no allowance for estimating error. As such, in the case of this risk factor occurring, it is not surprising that its impact will be considerable under this building type. Moreover, while the impact of 'problems with the foundation' ranked 5th overall, it ranked 9th under public and community building type but ranked 1st under commercial/industrial building type. This is not unexpected because while public and community buildings are usually simple designs and in some cases repetitive, commercial/industrial buildings are usually complex designs with complex foundation systems and in many cases one off building projects. As such, it is not unexpected that in the case of problems with the foundation occurring in commercial/industrial building construction, its impact will be considerable.

4.6 Impacts of risk factors on cash flow forecast and other groupings

Analyses using the same data set but based on construction project value and project client groupings were also carried out but the results of the analyses are similar to those for construction firm size and project type respectively. As such, due to space restriction, they are not presented separately in this paper.

5 CONCLUSION

This paper has attempted to investigate the impacts of some identified risk factors on construction cash flow forecast. The impacts have been analysed by ranking the mean scores and analysis of variance to examine significant differences of the mean scores between various project characteristics and groupings identified.

Within the limitations of the data, results showed that the risk factors with critical impacts on cash flow forecast include the following: delays in payments from client, delay in settling claims, architect's instructions, receiving interim certificates, delay in agreeing valuation/ daywork, problems with the foundations, agreeing interim valuations on site, estimating error and inclement weather, strikes, etc. Economic factors were found to have non-critical impacts. Most of the factors with critical impacts relate to contractors' cash inflow, change in design or specification and construction programming factors.

While generally contractors' opinions were not significantly different on the scoring of the impacts of risk factors, it was found that some risk factors assume more critical impacts than do others in certain situations. For instance, 'problems with foundations' risk factor assume the greatest impact under the large firms' scoring as well as under the design and build procurement method (Figs. 5&6). However, the impact of this risk factor

is lower in overall ranking. Moreover, 'inclement weather' risk variable assume a greater impact under projects undertaken by large firms as well as under projects of 13-24 months duration (Figs. 5&7), however, the impact of this risk factor is the least in overall ranking. These findings therefore underscore the need for a detailed assessment of the impacts of risk variables based on project characteristics, rather than a global assessment. This is of great benefit to construction practitioners as the knowledge of the possible impacts of a risk factor occurring, provides a good basis for proactively managing the risk.

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