Assessing risk impacts on the variability between tender sum and final account.

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Assessing Risk Impacts on the Variability between Tender Sum and Final Account

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Abstract

In a previous study, the budgetary reliability of the Bills of Quantities (BOQ) in procuring building projects was investigated using secondary data from completed building projects in the UK. The study concluded that in procurement methods where bills of quantities were used, deviations between the tender sum in the BOQ and final account figures were observable. In the case of housing projects, the percentage deviation was found to be within an acceptable margin. However in the case of educational buildings, commercial projects and refurbishment projects, the percentage deviation was found to be significantly high in each case. This suggests that the more complex the nature of a construction project, the more likely is the tendency of deviation between the tender sum and final account. This present study therefore uses the risk theory to uncover the explanatory risk variables thought to impact the construction phase with attendant impact on the out turn cost of construction projects. In addition, the study seeks to assess the impacts of the identified risk factors on the observed variability between tender sum and final account. The study concludes that different sets of significant risk factors seem to impact the variability between the tender sum and final account of

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different project types. It is a first step in an ongoing programme of research which seeks to model risk impacts on the variability between tender sum and final account.

Keywords: *construction project, financial management, risk variables, risk impacts, risk management, tender sum, final account, project type,*

Introduction

It is widely acknowledged that the construction industry is both more risky and uncertain than most other industries. This makes the subject of risk a very important factor to be considered in construction projects. Change is inevitable in construction and if it is not dealt with properly it can have detrimental effects on time, cost and quality targets. Smith (1999) points out that change cannot be eliminated but, by applying the principles of risk management, practitioners are able to improve the effective management of this change. According to Smith (1999) risk exists when a decision is expressed in terms of a range of possible outcomes and when known probabilities can be attached to the outcomes.

Flanagan and Norman (1993) are of the opinion that all risk encountered on construction projects are related to one or more of the following: failure to keep within the cost budget/forecast/estimate/tender; failure to keep within the time stipulated for the approvals, design, construction and occupancy or failure to meet the required technical standards for quality, function, fitness for purpose, safety and environmental preservation. According to Flanagan and Norman (1993) in most situations, the effect that adverse events will have will be financial loss.

Odeyinka *et. al.* (2009) investigated the budgetary reliability of bills of quantities (BOQ) in building project procurement and concluded that the difference between the budgeted cost and the final cost incurred differed greatly depending on project type. The variation between the budgeted cost of a project in the BOQ and the actual cost incurred was evaluated using secondary data obtained from recently completed traditionally procured building projects in Northern Ireland. The study concluded that with housing projects the percentage deviation from the BOQ was between -3.42% and +3.85%. With educational projects the percentage deviation was found to be between -3.69% and +17.05%. The range in regards to commercial projects is between -19.94% and +19.92%. When refurbishment projects were looked at, the percentage deviation was found to be between -10.72% and +36.90%. This information shows that there can be a huge difference between the budgeted cost and the actual cost with commercial projects; this is in comparison to housing projects which have a small and acceptable deviation from the budgeted cost. It is therefore important to focus on commercial projects, with a view to identifying the risks which occur within commercial construction and establishing why the final cost is so often different from the original budgeted cost.

According to Flanagan and Tate (1997) clients want certainty of price, projects constructed within budget and no surprises. According to them, the budgeted cost decided at the pre-contract stage of any construction project forms the basis of the contract sum. As this is the budget established for the project it is not expected to be exceeded. According to Flanagan and Tate (1997) a contingency sum should be included in the cost budget to cover unforeseen items and all eventualities which can occur during the construction of a project. This should ensure the completion of all projects within the cost budget. However according to Winch (2002) and Walker (2002) there is much evidence in construction management literature that would indicate that it is very difficult to find a project in which the initial contract sum is not exceeded at completion.

According to Winch (2002), risk is inherent in construction from the inception to the completion stages of a project’s life. According to him, the less information is available at the inception of a construction project, the higher the level of risks and uncertainties. Whilst it is a known fact that the risk factors inherent in a construction project are responsible for the observable deviation between the tender sum and final account, how these risk factors combine to impact the project cost is the concern of this study. The overall aim of the research is to model risk impacts on the variability between tender sum and final account. However, the work reported is a first step in the overall research program and the objective is to assess risk impacts on the variability between tender sum and final account.

Risk and Construction Cost

According to Baloi and Price (2001) risk can mean different things to different people and therefore the concept of risk can vary according to individual’s viewpoint, attitudes and experience. For example; engineers, designers and contractors may be more likely to view risk from the technological perspective whereas lenders and developers tend to view it from an economic and/or financial point of view, etc. Baloi and Price (2001) therefore concluded that risk is in general seen as an abstract concept which is very difficult to measure. Smith (1999) defines risk as a decision which has a range of possible outcomes and that a known probability can be attached to each of these potential outcomes. Akintoye and MacLeod (1997) state that risk in construction has come to attention as a very important aspect to be considered because of the occurrence of cost and time overruns in construction projects.

Baloi and Price (2001) maintained that risk within construction projects could be defined as the likelihood of a detrimental event occurring to the project. Similarly, Wideman (1986) defines project risk as the chance of certain occurrences adversely affecting project objectives. However, Chapman (1999) argued that this definition does not take into consideration, the possibility of a positive outcome and so he defined risk as an event, which should it occur, would have a positive or negative effect on the achievement of a project's objectives.

Chapman’s (1999) definition was supported by Porter (1981), Heale (1982) and Perry and Hayes (1985) who also argued that risk is an exposure to either economic loss or gain due to involvement in the construction process. Similarly, Winch (2002) argued that in statistical terms risk refers to unexpected events where the outcome is either to the benefit or detriment of the decision maker. However, he also goes on to say that in common practice risk is only used to refer to the probability of a detrimental effect, with the word reward being used to signify the probability of a beneficial event occurring.

According to Flanagan and Tate (1997) the budgeted cost established at the pre-contract stage forms the basis of the contract sum, this is the amount established for the entire project and it is not expected to be exceeded. In addition, Flanagan and Tate (1997) maintained that the budgeted cost should include for both foreseen and unforeseen costs that are needed for the completion of the project’s objectives. According to Ashworth and Hogg (2002) all the planning and decision making by both the contractor and the client depends upon the budgeted cost and so the budgeted cost is expected to be accurate in order to avoid cost overruns.

According to Potts (2008), most clients work within tight pre-defined budgets, which are usually part of a larger scheme. If a budget is exceeded, the whole scheme may fail. Pre-contract estimating produces the original budget and this forecasts the likely expenditure for the client. He goes on to say that this budget should be used positively in order to make sure that the design stays within the scope of the original scheme. According to Magnussen and Olsson (2005) the observed difference between the budgeted cost and actual cost of construction projects is due to factors which are not only hard to predict but difficult to manage. Morris and Hough (1991) state that cost overruns are caused by circumstances which are outside of the project’s area of control. According to them, many projects overrun on cost because of price escalation, government action, strikes etc. Therefore an important issue is the ability to predict such factors and the impact they will have on the project.

According to Winch (2002) and Walker (2002) it is very difficult to find a project in which the initial contract sum is not exceeded at completion. Perry and Hayes (1985) and Odeyinka (2000) state that this could be due to the risk factors inherent in construction.

In their study into the risk impacts on the budgeted cost of traditionally procured projects, Odeyinka (2007) identified the 8 most significant risk factors to focus on, these were; under-estimation;

inadequacy of cash flow; completion delay; poor site investigation; change in the scope of work; default of contractors; defective construction work and delay in payment. They then went on to see what impact these 8 risk factors had on the budgeted cost. Their research showed that 74.6% of the risk impact on the budgeted cost, resulting in a cost overrun was caused by the 8 identified risk factors. This means the remaining 25.4% of variance from the budgeted cost would be due to some other risk factors.

Fong (1987) and Odeyinka *et. al.* (2006) asserted that it is generally recognised that those within the construction industry are continually faced with a variety of situations involving many unknowns, unexpected, frequently undesirable and often unpredictable factors. These factors according to Fong (1987) include timing schedule slippage of the project tasks, technological issues, people-oriented issues, finance, managerial and political issues. Chapman and Ward (1997) submitted that generally, risk is viewed within the context of the probability of different outcomes and that the general attitude towards risk is its identification, evaluation, control and management.

Data and Methodology

Data were sourced from UK based Private Quantity Surveyors (PQS), Project Managers and Commercial Managers. A stratified random sampling approach was adopted whereby the sampling frame was drawn from available databases such as the RICS Find a Surveyor Service. A total of 348 potential respondents were emailed enquiring whether they were willing to complete a questionnaire for the purpose of this research, of these 62 replied that they were willing to complete a questionnaire. In all, 30 completed responses were received, which translates to a response rate of 48.4%. The designation of the respondents is shown in Table 1. A total of 28 risk factors thought to potentially influence the variability between tender sum and final account were identified from literature and also from discussion with construction professionals. Using a two-dimensional scaling, respondents were requested to score on a Likert –type scale of 0-5, the extent of the identified risk factors occurring and their perceived impacts in case of occurrence. The Likert-type scale used for the two-dimensional scaling questionnaire was defined as follows: 0 – no likelihood of occurrence

Table 1: Designation of Respondents

Respondent	Frequency	Percentage	Cumulative Percentage
Project Manager	5	16.67	16.67
Commercial Manager	4	13.33	30.00
Client’s Quantity Surveyor	21	70.00	100.00
Total	30	100.00	

and no impact, 1 – very low occurrence and very low impact, 2 – low occurrence and fairly critical impact, 3 – medium level of occurrence and critical impact, 4 – high level of occurrence and very critical impact, 5 – very high level of occurrence and extremely critical impact. This then gives the measuring scale the property of an interval scale, which makes the collected data suitable for various statistical analyses.

Many risk management researchers as stated earlier viewed risk as the probability that cost, schedule or technical performance of a system goes wrong combined with the consequences of these aspects going wrong. With this view, they argued that risk could be measured using the following formula:

$$R = P * I \qquad \text{(Equation 1)}$$

where: R = the degree of risk, P = probability/extent of occurrence of a risk factor; I = the consequence or perceived impact on a project

Akintoye *et. al.* (2001) and Carter *et. al.* (1994) referred to this as the risk exposure or expected value (EV) while Tweeds (1996) referred to it as average risk estimate. This method of risk measurement has a well-established place in decision theory domain and has been employed in this study.

Responses to the questionnaire survey were analysed using the mean analysis, which were subsequently ranked in order to determine relative importance of the risk factors considered. The mean score is determined as follows:

$$MeanScore = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1 + 0n_0}{(n_5 + n_4 + n_3 + n_2 + n_1 + n_0)} \qquad \text{(Equation 2)}$$

Where: n_0, n_1, n_2, n_3, n_4 *and* n_5 are the number of respondents who scored the responses as 0, 1, 2, 3, 4 and 5 respectively.

Data Analysis and Results

The summary of the analysis result regarding the surveyed construction professionals' perception of the extent of occurrence of the identified risk factors and their perceived impacts is shown in Table 2. From the table, the mean score analysis of the extent of risk occurrence ranges from 0.20 to 2.53; a result which shows that on average, none of the identified risk factors has occurred up to the medium level of occurrence. The mean score analysis of the perceived impacts of risk occurrence ranges from 0.23 to 2.60 which also indicates that on average, none of the risk factors has critical impacts but some fall between fairly critical and critical impacts; i.e. between 2.0 and 3.0. These risk factors are ‘changes in design’, ‘variations by the client’, ‘changes in scope of works’ and ‘unexpected site conditions’. Using Equation 1, the degree of risk of these risk factors was calculated in column 6 of Table 2 and it ranges from 4.73 to 6.59. This analysis gives an insight into the top 4 risk factors to focus attention on for modelling purposes.

It is actually not a surprise that ‘changes in design’, ‘variations by the client’, ‘changes in scope of works’ and ‘unexpected site conditions’ all ranked high in terms of extent of occurrence and impacts. This is because these are risk factors which are difficult to predict in advance in most large scale and one off projects. The first three risk factors are design-related and at the pre construction phase, the quality of the design will be as good as the design information available. However, during the construction phase, as more information are available, Architects may see the need for changes to the original design, clients who are also getting the grasp of construction realities may also wish to suggest variations so as to ensure that their objectives are met. In some cases, they may also suggest changes to the scope of works. Since tender sum is based on pre construction information available, it is therefore not a surprise that significant variability exists between the tender sum and the final account.

In addition to the overall analysis of the perception of the respondents on all the projects surveyed, further analyses were carried out based on project types. Table 3 shows the analysis regarding commercial projects. From the table, the mean score analysis of the extent of risk occurrence ranges from 0.23 to 2.85; a result which shows that on average, none of the identified risk factors has occurred up to the medium level of occurrence. The mean score analysis of the perceived impacts of risk occurrence ranges from 0.23 to 2.92 which also indicates that on average, none of the risk factors has critical impacts but some fall between fairly critical and critical impacts; i.e. between 2.0 and 3.0. These risk factors are ‘variations by the client’, ‘changes in design’, ‘changes in scope of works’ and ‘unexpected site conditions’. Using Equation 1, the degree of risk of these risk factors was calculated in column 6 of Table 3 and it ranges from 3.90 to 8.32. This analysis again gives an insight into the top 4 risk factors to focus attention on for modelling purposes.

Although there is a slight change in the mean rank order of risk factors between the overall projects and commercial projects. Table 3 however shows that the same top 4 risk factors obtained in the mean ranking analysis of the overall projects are also the same for commercial projects. Again, it is not a surprise that ‘changes in design’, ‘variations by the client’, ‘changes in scope of works’ and ‘unexpected site conditions’ all ranked high in terms of extent of occurrence and impacts. This is because these are risk factors which are difficult to predict in advance especially in commercial

Table 2: Perception of extent of risk occurrence and their impacts – all projects

Risk Factors	Risk Occurrence Mean Score (P)	Rank	Risk Impact Mean Score (I)	Rank	Degree of Risk (P*I)	Rank
Changes in design	2.53	1	2.60	1	6.59	1
Variations by the client	2.23	3	2.43	2	5.43	2
Change in scope of works	2.30	2	2.17	4	4.98	3
Unexpected site conditions	2.00	4	2.37	3	4.73	4
Extremely bad weather	1.90	5	1.70	7	3.23	5
Inadequate programme scheduling	1.53	7	1.77	6	2.71	6
Contractors' poor management ability	1.40	8	1.93	5	2.71	7
Defects in design	1.57	6	1.70	8	2.66	8
Third party delays	1.17	9	1.47	9	1.71	9
Under-estimation	1.20	10	1.27	14	1.52	10
Inadequate specification	1.00	11	1.37	10	1.37	11
Delay in resolving disputes	1.03	13	1.33	12	1.37	12
Project funding problems	0.87	15	1.33	11	1.16	13
Delay in material supply	0.80	16	1.23	15	0.99	14
Default of sub-contractor	0.90	14	1.27	13	1.14	15
Defective construction works	1.07	12	1.30	16	1.39	16
Under-valuation	0.67	17	0.90	18	0.60	17
Feasibility of construction methods	0.60	18	0.73	19	0.44	18
Default of contractor	0.47	19	0.90	17	0.42	19
Price Fluctuations	0.47	20	0.67	20	0.31	20
Loss or damage by fire	0.17	24	0.57	21	0.09	21
Loss or damage by flood	0.23	25	0.57	22	0.13	22
Fluctuation in market demand	0.37	21	0.47	23	0.17	23
Use of inappropriate plant	0.17	23	0.27	27	0.04	24
Labour strikes	0.10	28	0.43	24	0.04	25
Loss or damage in material transportation	0.23	26	0.37	26	0.09	26
Corrupt/fraudulent practices	0.10	27	0.33	25	0.03	27
Increase in interest rates	0.20	22	0.23	28	0.05	28

projects. As previously discussed in the analysis of the overall projects, the first three risk factors are design-related whilst the last has to do with the geological or archaeological conditions of the site.

There are other risk factors which have been identified from literature and by construction professionals which were scored by respondents and presented in Table 3. Such risk factors include default by contractors, loss or damage by fire, loss or damage by flood, labour strikes, etc. However, all these risk factors scored very low on average in terms of the extent of their occurrence and impacts in cases of occurrence and as such would not be included in the modelling part of this research. In addition, the majority of those risk factors are usually dealt with by insurance provisions in the standard conditions of contracts.

A further analysis was carried out based on another project type. Table 4 shows the analysis for educational projects. From the table, the mean score analysis of the extent of risk occurrence ranges from 0.17 to 2.33; a result which shows again that on average, none of the identified risk factors has occurred up to the medium level of occurrence. The mean score analysis of the perceived impacts of risk occurrence ranges from 0.00 to 2.50 which also indicates that on average, none of the risk factors has critical impacts but some fall between fairly critical and critical impacts; i.e. between 2.0 and 3.0. These risk factors are 'variations by the client', 'extremely bad weather', 'changes in scope of works' and 'unexpected site conditions'. Using Equation 1, the degree of risk of these risk factors was calculated in column 6 of Table 4 and it ranges from 4.66 to 5.83. This analysis again gives an insight into the top 4 risk factors to focus attention on for modelling purposes.

It will be noticed from this analysis that unlike the previous analyses, 'extremely bad weather' is now included in the top 4 risk factors whilst changes in design is no longer included in the top 4 but now with a rank of 5 and the impact is not within the 2.0 and 3.0 criticality range as before. Again, it is not a surprise that 'variations by the client', 'changes in scope of works' and 'unexpected site conditions' all ranked high in terms of extent of occurrence and impacts. This is because these are risk factors which are difficult to predict in advance especially in educational projects. As previously discussed in the analysis of the overall projects, the first and the third risk factors are design-related whilst 'unexpected site conditions' has to do with the geological or archaeological conditions of the site. However, 'extremely bad weather' as a risk factor seemed to have assumed a significant importance under the educational projects. This may be because educational projects may be of shorter duration than commercial projects and since timely completion is of the essence, bad weather during the winter months may have significant impacts. Unlike in previous analyses however, 'changes in design' does not assume a significant importance under educational projects. The reason for this may be because

Table 3: Perception of extent of risk occurrence and their impacts –commercial projects

Risk Factors	Risk Occurrence Mean Score (P)	Rank	Risk Impact Mean Score (I)	Rank	Degree of Risk (P*I)	Rank
Variations by the client	2.85	1	2.92	1	8.32	1
Change in design	2.62	2	2.77	2	7.26	2
Change in scope of works	2.31	3	2.31	3	5.34	3
Unexpected site conditions	1.69	4	2.31	4	3.90	4
Project funding problems	1.69	5	1.92	5	3.24	5
Defects in design	1.69	6	1.69	6	2.86	6
Extremely bad weather	1.69	7	1.46	10	2.47	7
Inadequate specification	1.46	8	1.62	7	2.37	8
Under-estimation	1.23	9	1.54	8	1.89	9
Third party delays	1.15	10	1.38	11	1.59	10
Default of sub-contractor	1.00	11	1.38	12	1.38	11
Contractors' poor management ability	0.77	13	1.54	9	1.19	12
Inadequate programme scheduling	1.00	12	1.15	14	1.15	13
Defective construction works	0.69	14	1.31	13	0.90	14
Delay in material supply	0.54	16	1.15	15	0.62	15
Fluctuation in market demand	0.69	15	0.85	18	0.59	16
Under-valuation	0.46	18	1.15	16	0.53	17
Delay in resolving disputes	0.46	19	1.00	17	0.46	18
Feasibility of construction methods	0.54	17	0.85	19	0.46	19
Default of contractor	0.46	20	0.77	20	0.35	20
Loss or damage by fire	0.31	21	0.77	21	0.24	21
Loss or damage by flood	0.31	22	0.77	22	0.24	22
Price Fluctuations	0.31	23	0.54	24	0.17	23
Labour strikes	0.23	24	0.69	23	0.16	24
Loss or damage in material transportation	0.23	25	0.46	25	0.11	25
Use of inappropriate plant	0.23	26	0.38	27	0.09	26
Corrupt/fraudulent practices	0.15	28	0.46	26	0.07	27
Increase in interest rates	0.23	27	0.23	28	0.05	28

most educational projects like residential building projects may be repetitive, needing very few changes in design.

A further analysis was carried out based on another project type. Table 5 shows the analysis for refurbishment projects. From the table, it would be seen that the mean score of the extent of risk occurrence ranges from 0.00 to 4.00. Unlike the previous analyses, this result shows that on average, three risk factors, namely ‘changes in scope of works’, ‘changes in design’ and ‘third party delays’ have occurred beyond the medium level of occurrence. The mean score of the perceived impacts of risk occurrence ranges from 0.50 to 4.00. Again unlike in the previous analyses, this result showed that on average, six risk factors were found to be in the region of critical and very critical impacts; i.e. between 3.0 and 4.0. These risk factors are ‘changes in scope of works’, ‘changes in design’, ‘third part delays’, ‘variations by the client’, ‘inadequate specifications, and ‘unexpected site conditions’. Using Equation 1, the degree of risk of each of these risk factors was calculated in column 6 of Table 5 and it ranges from 4.50 to 16.00. This analysis gives an insight into the 6 significant risk factors to focus attention on for modelling purposes.

Unlike the case in the previous analyses, it is evident in the analysis of the data from refurbishment projects that a total of 6 risk factors were found to be significant as opposed to 4 risk factors in the previous analyses. It is not a surprise that many more risk factors assume significant importance under refurbishment project than other project types. This is because refurbishment projects by nature are very difficult to define in precise terms at the pre construction phase. The majority of issues not considered at that stage may crop up during the construction phase which needed to be attended to. This also explains why there are on average high risk occurrence/ impact mean score for refurbishment projects than any other projects.

Table 4: Perception of extent of risk occurrence and their impacts –educational projects

Risk Factors	Risk Occurrence Mean Score (P)	Rank	Risk Impact Mean Score (I)	Rank	Degree of Risk (P*I)	Rank
Variations by the client	2.33	1	2.50	1	5.83	1
Extremely bad weather	2.17	3	2.17	3	4.71	2
Change in scope of works	2.33	2	2.00	4	4.66	3
Unexpected site conditions	2.00	4	2.33	2	4.66	4
Change in design	1.83	5	1.50	5	2.75	5
Inadequate programme scheduling	1.33	6	1.50	6	2.00	6
Inadequate specification	1.00	7	1.50	7	1.50	7
Under-estimation	1.00	8	1.00	10	1.00	8
Delay in resolving disputes	1.00	9	1.00	11	1.00	9
Default of sub-contractor	0.83	11	1.17	8	0.97	10
Third party delays	0.83	12	1.17	9	0.97	11
Contractors' poor management ability	1.00	10	0.83	12	0.83	12
Delay in material supply	0.83	13	0.83	13	0.69	13
Defects in design	0.83	14	0.67	14	0.56	14
Defective construction works	0.83	15	0.67	15	0.56	15
Price Fluctuations	0.67	16	0.67	16	0.45	16
Under-valuation	0.67	17	0.50	17	0.34	17
Increase in interest rates	0.33	18	0.33	19	0.11	18
Project funding problems	0.33	19	0.33	20	0.11	19
Default of contractor	0.17	20	0.50	18	0.09	20
Corrupt/fraudulent practices	0.00	23	0.00	22	0.00	21
Loss or damage in material transportation	0.00	24	0.17	21	0.00	22
Fluctuation in market demand	0.17	21	0.00	23	0.00	23
Use of inappropriate plant	0.00	25	0.00	24	0.00	24
Labour strikes	0.00	26	0.00	25	0.00	25
Loss or damage by fire	0.00	27	0.00	26	0.00	26
Loss or damage by flood	0.00	28	0.00	27	0.00	27
Feasibility of construction methods	0.17	22	0.00	28	0.00	28

Table 5: Perception of extent of risk occurrence and their impacts –refurbishment projects

Risk Factors	Risk Occurrence Mean Score (P)	Rank	Risk Impact Mean Score (I)	Rank	Degree of Risk (P*I)	Rank
Change in scope of works	4.00	1	4.00	1	16.00	1
Change in design	3.50	2	4.00	2	14.00	2
Third party delays	3.00	3	4.00	3	12.00	3
Variations by the client	2.00	4	3.50	4	7.00	4
Inadequate specification	2.00	5	3.00	5	6.00	5
Unexpected site conditions	1.50	6	3.00	6	4.50	6
Inadequate programme scheduling	1.50	7	2.00	9	3.00	7
Defective construction works	1.00	8	1.50	13	1.50	8
Delay in resolving disputes	1.00	9	1.50	14	1.50	9
Feasibility of construction methods	1.00	10	1.50	15	1.50	10
Delay in material supply	0.50	11	2.50	7	1.25	11
Contractors' poor management ability	0.50	12	2.00	10	1.00	12
Under-estimation	0.50	13	1.00	16	0.50	13
Extremely bad weather	0.50	14	1.00	17	0.50	14
Defects in design	0.50	15	1.00	18	0.50	15
Under-valuation	0.50	16	0.00	21	0.00	16
Corrupt/fraudulent practices	0.00	17	0.00	22	0.00	17
Price Fluctuations	0.00	18	0.00	23	0.00	18
Loss or damage in material transportation	0.00	19	0.00	24	0.00	19
Default of contractor	0.00	20	2.00	11	0.00	20
Default of sub-contractor	0.00	21	2.00	12	0.00	21
Increase in interest rates	0.00	22	0.00	25	0.00	22
Project funding problems	0.00	23	2.50	8	0.00	23
Fluctuation in market demand	0.00	24	0.00	26	0.00	24
Use of inappropriate plant	0.00	25	0.00	27	0.00	25
Labour strikes	0.00	26	0.00	28	0.00	26
Loss or damage by fire	0.00	27	1.50	19	0.00	27
Loss or damage by flood	0.00	28	0.50	20	0.00	28

Conclusions and Further Research

This study has attempted to assess risk impacts on the variability between tender sum and final account. Using 28 risk factors derived from literature and from discussion with construction professionals data were collected on a Likert type scale using a two-dimensional scaled questionnaire. Data collection was on a project by project basis from different project types, including commercial, educational and refurbishment projects. Data analysis was carried out using a mean response analysis and ranking of the mean. Further analysis was done using the degree of risk calculation, a procedure which is well established in risk and decision theory.

Within the limitation of the data collected at the stage of the research reported, it can be concluded that the significant risk factors impacting the variability between tender sum and final account relate to the level of design information or lack of it at the pre construction stage. Those significant risk factors include ‘changes in design’, ‘variations by the client’, ‘changes in scope of works’ and ‘unexpected site conditions’. This finding corroborates Winch’s (2002) assertion that the more information is available at the pre construction stage, the less risk to contend with during construction.

From further analyses of different project groupings, it can also be concluded that different sets risk factors assume significant importance depending on project types. For instance, the data analysis for the commercial projects studied led to the conclusion that the following set of risk factors are of significant importance: ‘variations by the client’, ‘changes in design’, ‘changes in scope of works’ and ‘unexpected site conditions’. However, for educational projects, the following set of risk factors were found to be significant: ‘variations by the client’, ‘extremely bad weather’, ‘changes in scope of works’ and ‘unexpected site conditions’. Regarding refurbishment projects, the following set of risk factors were found to be significant: changes in scope of works’, ‘changes in design’, ‘third part delays’, ‘variations by the client’, ‘inadequate specifications, and ‘unexpected site conditions’. These conclusions provide some insights into the next phase of this research which deals with modelling risk impacts on the variability between tender sum and final account. The different sets of significant risk factors obtained from different project types indicate that any attempt at modelling risk impacts cannot be a ‘one hat fits all’ model but one that considers different project types.

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References

Akintoye, A. and MacLeod, M. (1997) Risk analysis and management in construction, *International Journal of Project Management,* Vol. 15, No. 1, pp. 31-38

Asworth, A. (1994) *Cost Studies of Buildings.* Essex. Longman Group Limited.

Baloi, B and Price, A. (2001) Modelling global risk factors affecting construction cost performance, *International Journal of Project Management*, Vol. 21, Issue 4, pp 261–269

Barnes, M (1990) *Financial Control, Engineering Management Series*. Thomas Telford.

Bennet, F.R. (2003) *The Management of Construction: A Project Life Cycle Approach*. Butterworth Heinemann.

Chapman, R (2001) The controlling influences on effective risk identification and assessment for construction design management, *International Journal of Project Management* Vol. 19, pp 147-160

Cooke, B and Williams, P. (2009). *Construction Planning, Programming and Control.* Third Edition. Wiley –Blackwell.

Flanagan, R. and Norman, G. (1993) *Risk Management and Construction*. Blackwell Science, London.

Flanagan, R. and Tate, B. (1997): *Cost Control in Building Design*. Oxford, Blackwell Science Ltd.

Harper, W.M. (1976) *Management Accounting. M and E Handboooks,* McDonald and Evans.

Heale, J R. (1982) 'Contingency funds evaluation' *Transaction of American Association of Cost Engineers* B3.1-B3.4

Mason, *G.* (1973) A Quantitative Risk Management Approach to the Selection of a Construction Contract Provisions. Ph.D. Thesis, Department of Civil Engineering, Stanford University.

Morris PWG, Hough GH. (1991). *The anatomy of major projects: a study of the reality of project management*. Chichester, UK: Wiley.

Moavenzadeh, F and Rossow, J. (1976) 'Risks and risk analysis in construction management' *Proceedings of the C1B W65, Symposium on Organisation and Management of Construction,* US National Academy of Science, Washington DC, USA, 19-20

Oberlender, G.D. (1993) *Project Management for Engineering and Construction*. McGraw-Hill.

Odeyinka, H.A. (2000) An evaluation of the use of insurance in managing construction risks. *Construction Management and Economics.* Vol. 18, pp 519-524.

Odeyinka, H.A. (2007) Modelling risk impacts on the budgeted cost of traditionally procured building projects. *Proceedings of The 23rd Annual ARCOM Conference, Belfast,* pp 755-763

Odeyinka, H.A., Kelly, S. and Perera S. (2009). An Evaluation of the Budgetary Reliability of Bills of Quantities in Building Procurement. *The construction and building research conference of the Royal Institution of Chartered Surveyors held at the University of Cape Town*, pp 435-446

Pilcher, R. (1992) *Project Cost Control in Construction Projects*, Second Edition. Oxford. Blackwell Scientific Publications.

Porter, C E. (1981) *Risk Allowance in Construction Contracts* M.Sc. Thesis, University of Manchester, UMIST

Potts, K. (2008) *Construction Cost Management, learning from case studies.* Taylor & Francis

Smith, N.J. (1999) *Managing Risk in Construction Projects*. Blackwell Science

Wideman R.M. (1986) Risk Management. *Project Management Journal*, Vol. 17, no. 4, pp 20-6.

Winch G.M. (2002) *Managing Construction Projects*, Oxford, Blackwell Publishing.