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AN ASSESSMENT OF RISK FACTORS IMPACTING BUDGET VARIABILITY IN NEW ZEALAND COMMERCIAL CONSTRUCTION PROJECTS

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A review of several authors shows that various risk factors abound which potentially impact on the outturn tender sums (OTS) of construction projects from the design-stage elemental cost plans (ECPs)/budget estimates. Proper risk analysis could at least partially solve this problem, by lowering the variation between the design-stage ECPs and their OTS. The concern of the current study is the variability between design-stage ECP and OTS, whereas the conjecture is that risk could be responsible for the observed variability. Empirical data was obtained from 208 practising New Zealand (NZ) construction consultants through an online survey. A quantitative analysis was performed to determine the most critical risk factors that impact ECPs. Findings revealed variation between ECPs and OTS (inflated risks) within the region of +1% and 23.86%. These verify discrepancies in the budgeted costs of commercial projects at preconstruction phase, and the risk factors responsible should be the initial focus of construction project consultants. The research provides invaluable insights from practice that could propose and strengthen the development of an effective mitigation strategy by using risk management approach which promotes risk/cost management integration in project delivery for the construction industry. This study therefore attempts to influence government policy to develop support mechanisms to encourage effective risk management practice in the construction industry in NZ.

Keywords: budget overrun, elemental cost plan, New Zealand, out-turn tender sum

INTRODUCTION

The construction industry in New Zealand (NZ) is of paramount importance for employment and economic growth. While MBIE (2014) claimed that it contributes about 6.3% to the gross domestic product (GDP) and represents over 40% of the national budget revenue; PWC (2011) affirmed that construction accounts for more than 8% of employment creation and an average of 50% of the gross fixed capital formation (GCFC). This makes the industry a significant driver of economic growth. Therefore, efforts directed towards revamping construction efficiency by means of cost-effectiveness, timeliness and quality standard would be beneficial as this obviously contributes to cost savings for the country. Cost as one of the measures of overall success (Ameyaw *et al.,* 2015) seems most significant, owing to its direct financial

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impact on all stakeholders. It is thus noteworthy that pre-tender budgeting activities continue to pose challenges to project stakeholders.

Despite much care and effort in the preparation of design-stage ECPs, differences observed between them and OTS are usually significant (Odeyinka 2010). Deviations in the region of +1% and +12% are mentioned in Morrison (1984), Skitmore and Picken (2000) and Oladokun *et al.,* (2011). Research undertaken by Adafin *et al.,* (2015) indicated discrepancies in budgeted costs between the ECPs and OTS in the region of -14% and +16%. These are reasons behind a follow-up study that investigated the accuracy and reliability of design-stage ECP in building projects. Adafin (2017) stated that the observed variance between ECPs and OTS differ significantly, drawing inferences from a study that evaluated cost data from completed building projects in NZ. Adafin (2017) found these deviations to be significantly higher for commercial projects (-14.22% and +16.33%; Reliability [Rel.] Rank = 3), than in residential projects with small, reliable and acceptable percentage deviations (-3.67% and +3.95%; Rel. Rank = 1). Significant discrepancies are further noted in both educational (-3.98% and +12.15%; Rel. Rank = 2) and refurbishment (-10.07% and +30.14%; Rel. Rank = 4) projects (see Adafin 2017). These findings suggested that deviations occur even in developed countries with mature construction industries and established construction practices. Xia *et al.,* (2017) observed that such deviations could be due to risk factors that are inherent in both design and construction activities. Odeyinka (2010) explained that these risks are covered by allocating contingency costs to include both expected and unexpected circumstances in design-stage ECPs and tender sums. Observed variance between ECPs and OTS could be reduced, if risk items were identified and reasonably priced during design development. As evidenced in Adafin *et al.,* (2016), this study posits that budget overrun could vary with procurement and project types. Projects awarded under the traditional lump sum fixed price contracts were considered for this investigation, because of accessibility of data.

Substantive research has indicated that most studies on risk management acquired data on projects executed in the East Asia, Europe, Middle East and United States (El-Sayegh and Mansour 2015). Predominantly, the key objective is how these risk factors that are inherent in construction projects, interact to cause the variations observed between ECPs and OTS. Limited attention is known to have been given to this area in NZ, which could foster/promote industry practice. While clients are becoming uncomfortable at seeing their projects completed over-budget, this study therefore attempts to influence government policy to develop support mechanisms to foster/encourage effective risk management practice in the construction industry in NZ.

LITERATURE REVIEW

Cost Planning and Inherent Risks Impacting Budget Overrun

Jaggar *et al.,* (2002) described cost planning as the totality of processes involved in the financial management of a construction scheme during design development, so that the contractor's tender price matches the initial financial plan. Within the context of the current study, cost planning describes any means of utilising early-stage strategic cost advice in the design process to give project owners good value for money. ECP therefore portrays a basic budget and represents a final ECP amendment before tenders are invited, while OTS is the accepted tender sum or in other words, initial contract sum. The difference between ECP and OTS is the increase of cost in addition to tenderer's mark-up. In Carter et al.'s (1994) opinion, risk frequently refers to the ways in which actual results may be worse than planned. This definition reflects the views of some early studies cited in Akintoye and MacLeod (1997). According to Akintoye and MacLeod (1997), project risk denotes "an exposure of project activities to adverse consequences of future events that affect project objectives". Risks are uncertain events or conditions that, when they occur, have positive or negative effect on a project's objectives (Akintoye and MacLeod 1997; Carter *et al.,* 1994; PMI 2008). This research embraces the view that the benefits or positive impacts of risk on project objectives could be achieved by minimising some risk occurrences and detrimental impacts. By this, this study connects with the realities of practice by viewing risk as the extent and impact of adverse occurrences that cause a project to exceed its predicted ECPs.

Several studies have identified numerous risks that influence budgetary performance of construction projects (see Akintoye 2000; Doyle and Hughes 2000; Ling and Boo 2001; Odusami and Onukwube 2008; Enshassi *et al.,* 2013; Adafin *et al.,* 2018: 2, 3 and 5). Evidence and arguments in construction management researches (Odeyinka *et al.,* 2010; Adafin *et al.,* 2018: 3; Agyekum-Mensah 2018; Love and Ahiaga-Dagbui 2018; Yap *et al.,* 2018) indicated that it is rare to find a project in which the OTS equals the budget estimate for a variety of reasons. Therefore, an effective mitigation strategy using risk management approach (a deterministic system to risk) should reduce budget/cost and schedule/time overruns on construction projects (Hwang *et al.,* 2014). Thus, as a partial solution, this research proposes to reduce the variances between ECPs and OTS during preconstruction phase, through an analysis of risks.

There is a dearth of literature and research specific to NZ's construction project risk. Furthermore, identifying and assessing risk factors for NZ construction projects, and how these interact to account for the wide variation between design-stage ECPs and OTS, will be significant. The examination of perceptions held by NZ construction consultants on risk occurrence in traditionally procured commercial construction projects has remained unexplored. The current study therefore investigates variations between ECPs and OTS in commercial projects from construction consultants' (i.e., architects, quantity surveyors [QS], and project managers [PMs]) perspectives. Questions addressed by this study include: what are the risk factors impacting variability between design-stage ECPs and OTS; and how these identified risk factors can be evaluated using Kendall's concordance, to determine the most significant?

METHODOLOGY

To address the research questions posed by the current study, a questionnaire with closed-ended questions was administered to gain more understanding of cost and risk issues, following Fellows and Liu (2008). An initial pilot study including 32 participants (i.e. NZ-based architects, QS and PMs) was conducted in line with Nworgu (2006), to ensure clarity of the questionnaire and the relevance of the risks explored to NZ commercial construction.

36 risk factors were classified into 7 main groups (see Adafin *et al.,* 2018: 3), based on literature review and expert judgment by five construction consultants (i.e. architects, QS and PMs). Using expert judgments has been extensively noted for risk identification (Kassem *et al.,* 2019). A criticality cut-off point of 3.00 (Fellows and Liu 2008) on a five-point Likert scale was employed to prioritise the top 16 critical risks from the 36 risk factors. Adafin *et al.,* (2016) suggested that risk factors, with overall mean scores of 3.00 and above, had significant impacts on variability and viewed to have potential impacts on budgetary performance of construction projects. These 16 significant factors formed the basis of a refined questionnaire administered to participants (private consultancies). Key sections in the questionnaire included: questionnaire introduction;

project-specific questions including risk factors on the observed variation (i.e. extent and impact); demographic information and, conclusion and feedback. Respondents were requested to indicate the level of importance of the categorised 16 critical risk factors using the five-point Likert scale of 1 (very low risk occurrence) to 5 (very high level of risk occurrence); and 1 (very low risk impact) to 5 (very high-risk impact). The theoretical justification for the application of the five-point scale was found in Arif *et al.,* (2015), and the two-dimensional scaling questionnaire used in this study followed Odeyinka *et al.,* (2012). Thus, the measuring scale had the property of an interval scale, which makes the collected data suitable for various statistical analyses.

A stratified random sampling approach, following Naoum (2007) was employed with the sampling frame drawn from the databases of the New Zealand Institute of Building (NZIOB), New Zealand Institute of Architects (NZIA), and New Zealand Institute of Quantity Surveyors (NZIQS) (see Table 1). 420 registered members (financially valid members), selected from the directories maintained by the Institutes, received an email from the representatives of the professional bodies in January/February 2017. The participants are reasonably well experienced and with good understanding of project-risk issues. Of these, 245 complete responses were received (see Table 1), but only 208 (sample size) of these involved traditionally procured commercial projects. The study is based on those 208 responses, which is an adequate relevant-data response rate of 65% higher than 40% suggested by Moser and Kalton (1981). The survey's demographic information included designation, work experience, and academic and professional qualifications (see Table 1). It is significant to highlight that 85% of the respondents based their views on personal experiences with traditionally procured commercial projects.

Responses to the questionnaire survey were analysed using descriptive statistics (Naoum 2007), the mean score analysis and degree of risk (Odeyinka *et al.,* 2012) and Kendall's coefficient of concordance w (Offei-Nyako *et al.,* 2016). The responses were ranked to determine the relative importance of the risk factors considered. Mean scores MS were used to determine the degree-of-risk values; whereas the "Degree of Risk" measure was used for subsequent ranking of identified risk variables. This is expressed as R = P x I, where R = the degree-of-risk, P = extent of risk occurrence, and I = the perceived impact on a project. Further, Kendall's coefficient of concordance (w) was used to measure the degree of agreement among sets of rankings in the estimation of risk factors, by the study participants.

DATA ANALYSIS AND RESULTS

Table 2 (Risk factors' means and rankings) provides a summary of the data analysis of the extent of risk occurrence and its perceived impacts, and the 'degree-of-risk' scores in commercial projects. The 'degree-of-risk' values for the combined sample range from 3.73 to 15.08. A few risk factors fall between 7.58 and 15.08, revealing the complex interaction of the most critical risk items. The resultant ranking of the 16 risk factors highlights the following top-five risk factors that could influence predictive modelling: scope change (owner's requirements), project complexity, information quality and flow requirements, availability of design information, and consultants' skills. Further to the mean ranking analysis, the study performed the Risk impacts' Kendall's concordance analysis to measure concordance of the three groups of consultants (architects, QS and PMs), from which opinions were sought. The Statistical Package for Social Sciences (SPSS) software was used for the analysis and the results presented in Table 3.

Table 1: Participants' Demographic Information

Characteristics	Number of Respondents	Percent	Cumulative Percent
Designation of Respondents			
Architect	102	41.63	41.63
Client's QS	71	28.98	70.61
Project Manager	72	29.39	100.00
Total	245	100.00	
Academic Qualification of Respondents			
PhD	4	1.63	1.63
Master's Degree	81	33.06	34.69
Bachelor's Degree	110	44.90	79.59
PGD / Graduate Diploma	21	8.57	88.16
Diploma/ND/HNC/HND	26	10.61	98.77
None	3	1.23	100.00
Total	245	100.00	
Professional Qualification of Respondents			
Fellow membership, e.g. FNZIA, FNZIQS, FNZIOB	108	44.08	44.08
Full membership, e.g. MNZIA, MNZIQS, MNZIOB	127	51.84	95.92
None	10	4.08	100.00
Total	245	100.00	
Professional Experience of Respondents			
1-10 years	16	6.53	6.53
11-20 years	46	18.78	25.31
21-30 years	93	37.96	63.27
31-40 years	67	27.35	90.62
Over 40 years	23	9.38	100.00
Total	245	100.00	
Mean = 26.93 years			

Note: QS = quantity surveyor; PhD = doctor of philosophy; PGD = postgraduate diploma; ND = national diploma; HNC = higher national certificate; HND = higher national diploma; FNZIA = fellow, New Zealand Institute of Architects; MNZIA = member (full), New Zealand Institute of Architects; FNZIQS = fellow, New Zealand Institute of Quantity Surveyors; MNZIQS = member (full), New Zealand Institute of Quantity Surveyors; FNZIOB = fellow, New Zealand Institute of Building; MNZIOB = member (full), New Zealand Institute of Building.

A Kendall's w value of 0.84 was obtained; this means that the 208 respondents significantly agreed in their assessments. The value of w = 0.84 (w is greater than 0 and close to 1) indicates a positive and strong agreement amongst the consultants in their estimation of each of the risk factors. Also, this shows that a positive/perfect concordance exists in the ranking of risk factors that affect variability between ECPs and OTS. Hence if any predictive modelling was to be undertaken, the top-five risk factors could provide reliable inputs into the model development.

From the sample population of 208 participants, a stratified sample of 12 QS provided ECPs and OTS data for this study. Table 4 shows variation between ECPs and OTS within the region of +1% and 23.86% for commercial projects. The cost data was analysed to achieve an estimated relationship between the factors and their variances. This gives a further insight into the top-five risk factors that cause variation in the budgeted costs and could be relied upon for future predictive modelling. Table 2 displays the risk factors in line with their relative importance.

The results are presented in this section, aligning with the outcome of previous studies with a focus on risks during estimating and tendering practices. Scope change was ranked 1st as observed in Table 2. This finding is consistent with some previous studies (Odeyinka *et al.,* 2010; Ameyaw *et al.,* 2015) that ranked this risk factor 2nd and 4th in the UK and Ghana respectively. This suggests that the accuracy of cost plan estimates is highly dependent on the level of details available within the project scope definition. Early (and frequent changes) in design and scope will impact budgetary performance of a commercial project at the pre-contract phase, as there seems to be some level of inevitability in design changes.

The risk factor ranked 2nd is Design and Construction complexity. Doyle and Hughes (2000) stated that the rapid development in technology affects design and construction activities. Project complexity implies innovations, and a degree of difficulty in performing tasks. Thus, complexity in commercial design and construction is known to be significant in budget overruns. It can safely be concluded from this finding that the more complex a project is (in size, shape, height and aesthetics), the more detailed will be the design/plan of work and site production.

Table 2: Construction consultants' opinion of risk occurrence for commercial projects

		Architects (N=82)			Quantity Surveyors (N=62)			Project Managers (N=64)			Total Sample (N=208)		
Overall Rank	Risk Factors	Risk extent mean	Risk impact mean	Degree of risk	Risk extent mean	Risk impact mean	Degree of risk	Risk extent mean	Risk impact mean	Degree of risk	Overall risk extent mean	Overall risk impact mean	Overall degree of risk
1	Scope change (owner's requirements)	3.53	3.78	13.34	3.86	4.21	16.25	3.82	3.88	14.82	3.76	4.01	15.08
2	Project complexity	3.18	3.60	11.45	3.51	2.92	10.25	3.44	3.78	13.00	3.42	3.65	12.48
3	Information quality and flow requirements	3.01	3.22	9.69	3.73	3.82	14.25	3.50	3.83	13.41	3.35	3.72	12.46
4	Availability of design information	2.99	3.33	9.96	3.75	3.68	13.80	3.49	3.79	13.19	3.36	3.63	12.20
5	Consultants' skills	2.94	3.24	9.53	3.52	2.90	10.21	3.53	3.86	13.63	3.28	3.60	11.81
6	Property market condition	3.22	3.34	10.75	3.45	3.80	13.11	3.18	3.40	10.81	3.25	3.58	11.64
7	Experience of project team	2.83	2.94	8.32	2.62	2.45	6.42	3.74	3.85	14.40	3.15	3.47	10.93
8	Site condition information	2.62	3.11	8.15	2.72	2.87	7.81	3.72	3.82	14.21	3.12	3.48	10.86
9	Tender documentation	1.92	2.40	4.61	2.78	2.80	7.78	3.56	3.76	13.39	2.79	3.21	8.96
10	Extent of completion of pre-contract design	2.42	2.58	6.24	2.60	2.46	6.40	2.69	2.90	7.80	2.58	2.94	7.58
11	Provision of labour and materials	2.11	2.41	5.09	1.72	1.92	3.30	3.17	3.56	11.29	2.53	2.87	7.26
12	Project type	2.38	2.65	6.31	1.87	1.86	3.48	2.57	3.14	8.07	2.46	2.76	6.79
13	Construction method	2.05	2.46	5.04	1.82	1.78	3.24	2.56	2.88	7.37	2.25	2.69	6.05
14	Project location	2.15	2.38	5.12	1.68	1.26	2.12	2.39	2.44	5.83	2.18	2.42	5.28
15	Defective design and specification	1.65	1.88	3.10	1.62	1.60	2.59	1.68	2.56	4.30	1.92	2.31	4.44
16	Client type	1.93	2.16	4.17	1.46	1.38	2.01	2.18	1.81	3.95	1.82	2.05	3.73

The risk variable ranked 3rd by the respondents is Information quality and flow requirements. Table 2 reveals that this factor has a significant impact in NZ on the budgetary performance of commercial projects at the pre-contract phase of development process. However, it ranked 15th in Akintoye (2000) suggesting that it is less critical in the UK as cost planning practice requires the consultants to supply most of the information required for the estimating function; they influence the quality of information provided and the efficiency of flow of such information.

This variable (Availability of design information) was ranked 4th, based on the sample score. The results presented in Table 2 show that availability of design information is considered a key risk affecting cost planning accuracy in NZ and has some significant impact on the budgetary performance of commercial projects at the preconstruction phase of project development. This finding is however consistent with Ling and Boo's (2001) submission, that drawings are important for effectively communicating designer intentions for the project owner's conceptions. Therefore, project implementation strategies for collecting information on project performance are considered vital for project planning and control. This necessitates why incomplete or inadequate design information, especially as it affects quality and availability, could influence the budgetary performance of commercial projects in the pre-construction phase.

Table 3: Measuring construction consultants' agreement/disagreement using Kendall's concordance analysis

Risk Factors	Architects (N=82) rank (R_1)	Quantity Surveyors (N=62) rank (R_2)	Project Managers (N=64) rank (R_3)	**R** Sum of Ranks $R_1+R_2+R_3$	**D** (R –A)	Kendall's concordance coefficient *(w)*
Scope change (owner's requirements)	1	1	1	3	-22.5	506.25
Project complexity	2	5	8	15	-10.5	110.25
Information quality and flow requirements	5	2	5	12	-13.5	182.25
Availability of design information	4	3	7	14	-11.5	132.25
Consultants' skills	6	6	4	16	-9.5	90.25
Property market condition	3	4	10	17	-8.5	72.25
Experience of project team	7	9	2	18	-7.5	56.25
Site condition information	8	7	3	18	-7.5	56.25
Tender documentation	14	8	6	28	2.5	6.25
Extent of completion of pre-contract design	10	10	12	32	6.5	42.25
Provision of labour and materials	12	12	9	33	7.5	56.25
Project type (residential, commercial, educational, etc.)	9	11	11	31	5.5	30.25
Construction method	13	13	13	39	13.5	182.25
Project location	11	15	14	40	14.5	210.25
Defective design and specification	16	14	15	45	19.5	380.25
Client type (private, public, government, agencies, NGOs, etc.)	15	16	16	47	21.5	462.25
Total	-	-	-	408	-	2576
Mean (A)	-	-	-	25.5	-	-
W	-	-	-	-	-	0.84

Consultants' competency was also ranked 5th by the respondents. This ranking agrees with Odusami and Onukwube's (2008) and Enshassi et al.'s (2013) findings, where their respondents ranked this factor 1st and 4th, respectively. However, in Akintoye (2000), expertise of consultants was ranked 23rd out of 24 of the risk factors they evaluated. This is because project participants are usually responsible not only for providing a reasonable amount of information during design development and tender stages, but also its quality and flow.

Table 4: Estimated variation between ECPs and OTS

Case Study Project No.	ECPs (NZ$)	OTS (NZ$)	Variation	% Variation
1	31,790,000.00	35,790,100.00	4,000,100.00	12.58
2	28,245,000.00	30,285,225.00	2,040,225.00	7.22
3	3,780,100.00	3,790,200.00	10,100.00	0.27
4	1,578,317.00	1,954,865.00	376,548.20	23.8576
5	26,795,275	31,250,000	4,454,725	16.625
6	1,730,000.00	1,960,000.00	230,000.00	13.2948
7	13,000,000	15,500,000	2,500,000	19.2308
8	26,795,275	31,250,000	4,454,725	16.625
9	4,536,000.00	5,201,189.00	665,189.20	14.6647
10	1,090,000.00	1,120,000.00	30,000.00	2.7523
11	12,650,000	13,720,000	1,070,000	8.4585
12	23,500,000	27,000,000	3,500,000	14.8936

Note: ECP = elemental cost plan; OTS = out-turn tender sum; NZ$ = New Zealand dollars

It is thus apparent from this study that uncertainties and hence risks, will be greatly reduced where an estimator is more professional in cost plan development. An experienced estimator is therefore critically important to producing high-quality and reliable cost plans. It is not surprising that these top-five risk factors are ranked high in terms of extent of occurrence and impacts. The risk factors are design-related and at the preconstruction phase, and such could be difficult to predict in advance in most large-scale projects, Odeyinka *et al.,* (2010) suggested. However, during the construction phase, as more information is available, designers/clients may suggest changes to the scope of work to ensure their objectives are met. Since the reliability of ECP and OTS depends on available pre-construction information, it is predictable that any change may cause variability between the ECP and OTS.

CONCLUSION AND FURTHER RESEARCH

The current assessment explored the risk factors producing variability between design-stage ECPs and OTS and evaluated the degree of agreement amongst three groups of consultants (Architects, QS and PMs). Findings revealed variation between ECPs and OTS (inflated risks) within the region of +1% and 23.86%. This research establishes and prioritises risk factors contributing to this increase, and this may affect commercial project development budgeting in NZ. Within the confines of the data collected, mean scoring analysis revealed the top five risk variables in traditionally procured commercial projects that influence variability between design-stage ECPs and OTS: scope change (owner's requirements), project complexity, information quality and flow requirements, availability of design information, and consultants' skills. Furthermore, Kendall's concordance analysis found a high level of participants' agreement in their rank-ordering of the relative importance of the factors identified. Results showed that these are preconstruction risk factors which have a high bearing on clients' expenditure. Therefore, studying and ranking of risk factors by extent and impact in projects helps the consultants to plan for appropriate responses to these risks according to the priority of occurrence and the importance of impact.

As a main contribution, this study broadens awareness of researchers in the global construction community regarding the relationship between construction costs and various risk variables, particularly for those countries where this problem is under-researched. Although, the research was conducted to identify the significant risk factors in NZ commercial construction projects, the results can be applied to construction projects implemented in any of developed and developing countries. The sample size used in this study is more favourable than those in earlier studies in the same field. The knowledge also provides proper risk analysis (guidelines) that could assist construction consultants in measuring cost risks and managing practical risk control. Thus, consultants are more able to accurately conduct risk analysis to identify potential threats at an early stage of the project and to maximize the project-budget benefits by creating a cost risk mitigation plan using risk management approach. These could assist NZ stakeholders play a key role in improving the accuracy of cost forecast in the construction market; thus, enabling pro-active management of project owner's expenditure.

Since this study focused on traditionally procured building projects, future research could explore the development of models for assessing risk impacts on the variability between design-stage ECPs and OTS in other procurement methods, such as 'design and build' procured projects, with the aim of comparing the outcome with the present study.

REFERENCES

Adafin, J, Rotimi, J O B and Wilkinson, S (2015) Why do the design-stage elemental cost plan and final tender sum differ in New Zealand? *Journal of Financial Management of Property and Construction*, 20(**2**), 116-131.

Adafin, J, Rotimi, J O B and Wilkinson, S (2016) Risk impact assessments in project budget development: Architects' perspectives, *Architecural Engineering and Design Management*, 12(**3**), 189-204.

Adafin, J K (2017) *Prediction of Final Tender Sums of Construction Projects from the Design-Stage Elemental Cost Plans: A Decision Support Tool for New Zealand*. PhD Thesis, The University of Auckland, Auckland, New Zealand.

Adafin, J, Rotimi, J O B and Wilkinson, S (2018) Risk impact assessments in project budget development: Quantity surveyors' perspectives, *International Journal of Construction Management*, 12(**3**), 1-16.

Agyekum-Mensah, G (2018) The degree of accuracy and factors that influence the uncertainty of SME cost estimates, *International Journal of Construction Management*, 19(**5**), 413-426.

Akintoye, A (2000) Analysis of factors influencing project cost estimating practice, *Construction Management and Economics*, 18(**1**), 77-89.

Akintoye, A S and MacLeod, M J (1997) Risk analysis and management in construction, *International Journal of Project Management*, 15(**1**), 31-38.

Ameyaw, E E, Chan, A P C, Owusu-Manu, D G and Coleman, E (2015) A fuzzy model for evaluating risk impacts on variability between contract sum and final account in government-funded construction projects, *Journal of Facilities Management*, 13(**1**), 45-69.

Arif, F, Lodi, S H and Azhar, N (2015) Factors influencing accuracy of construction project cost estimates in Pakistan: perception and reality, *International Journal Construction Management*, 15(**1**), 59-70.

Carter, B, Hancock, T, Morin, J and Robins, N (1994) *Introducing Riskman Methodology: the European Project Risk Management Methodology*. Oxford: Blackwell Publishing.

Doyle, A and Hughes, W (2000) The influence of project complexity on estimating accuracy. *In: A*kintoye, A (Ed.), *Proceedings 16th Annual ARCOM Conference*, 6-8 September 2000, Glasgow, UK. Association of Researchers in Construction Management, Vol. 2, 623-34.

El-Sayegh, S M and Mansour, M H (2015) Risk assessment and allocation in highway construction projects in the UAE, *ASCE Journal of Management in Engineering*, 31(**6**), 1-11.

Enshassi, A Mohamed, S and Abdel-Hadi, M (2013) Factors affecting the accuracy of pre-tender cost estimates in the Gaza strip, *Construction in Developing Countres*, 18(**1**), 73-94.

Fellows, R and Liu, A (2008) *Research Methods for Construction*. Oxford: Blackwell Publishing Ltd.

Hwang, B G, Zhao, X and Toh, L P (2014) Risk management in small construction projects in Singapore: status, barriers and impact, *International Journal of Project Management*, 32, 116-124.

Jaggar, D, Ross, A, Smith, J and Love, P E D (2002) *Building Design Cost Management*. Oxford: Blackwell Science.

Kassem, M A, Khoiry, M A and Hamzah, N (2019) Risk factors in oil and gas construction projects in developing countries: A case study, *International Journal of Energy Sector Management*, https://doi.org/10.1108/IJESM-11-2018-0002.

Ling, Y Y and Boo, J H S (2001) Improving the accuracy estimates of building of approximate projects, *Building Research and Information*, 29(**4**), 312-318.

Love, P E D and Ahiaga-Dagbui, D D (2018) Debunking fake news in a post-truth era: the plausible untruths of cost underestimation in transport infrastructure projects, *Transport Research Part a*, 113(**2018**), 357-368.

Ministry of Business Innovation and Employment (2014) *Annual Report*. New Zealand: New Zealand Government.

Morrison, N (1984) The accuracy of quantity surveyors' cost estimating, *Construction Management and Economics*, 2(**1**), 57-75.

Moser, C A and Kalton, G (1981) *Survey Methods in Social Investigation*. UK: Heinemann Educational.

Naoum, S G (2007) *Dissertation Research and Writing for Construction Students*. UK: Elsevier Ltd.

Nworgu, B G (2006) *Educational Research: Basic Issues and Methodology*. Nigeria: Wisdom Publishers Ltd.

Odeyinka, H, Larkin, K, Weatherup, R, Cunningham, G, McKane, M and Bogle, G (2012) *Modelling Risk Impacts on the Variability Between Contract Sum and Final Account*. UK: Royal Institution of Chartered Surveyors, 1- 19.

Odeyinka, H A (2010) Assessing risk impacts on the budgetary reliability of design stage elemental cost plan. Available from http://www.docstoc.com/docs/99896893/built_environment [Accessed 11/06/2014).

Odeyinka, H, Weatherup, R, Cunningham, G, McKane, M and Larkin, K (2010) Assessing risk impacts on the variability between tender sum and final account, *In*: *Proceedings of RICS COBRA*. London: RICS.

Odusami, K T and Onukwube, H N (2008) Factors affecting the accuracy of pre-tender cost estimate in Nigeria, *In*: *Proceedings of RICS COBRA*. London: RICS.

Offei-Nyako, K, Tham, L C O, Bediako, M, Adobor, C D and Asamoah, R O (2016) Deviations between contract sums and final accounts: the case of capital projects in Ghana, *Journal of Construction Engineering*, Vol 2016, Article ID 2814126, 1-8.

Oladokun, M G, Oladokun, A A and Odesola, I A (2011) Accuracy of pre-tender cost estimates of consultant quantity surveyors in Nigeria, *Journal of International Real Estate and Construction Studies*, 1(**1**), 39 - 52.

Pricewaterhousecoopers (2011) *Valuing the Role of Construction in the New Zealand* economy. New Zealand: The Construction Strategy Group, 81.

Project Management Institute (2008) *A Guide to the Project Management Body of Knowledge 4th Edition*. Pennsylvania: Project Management Institute.

Skitmore, R M Picken, D (2000) The accuracy of pre-tender building price forecasts: An analysis of USA data, *Australian Institute of Quantity Surveyors Refereed Journal*, 4(**1**), 33-39.

Xia, N, Zhong, R and Wu, C (2017) Assessment of stakeholder-related risks in construction projects: Integrated analysis of risk attributes and stakeholder influences, *ASCE Journal of Construction Engineering and Management,* 143(**8**) 04017030.

Yap, J B H, Abdul-Rahman, H, Wang, C and Skitmore, M (2018) Exploring the underlying factors inducing design changes during building production, *Production Planning and Control*, 29(**7**), 586-601.