

Achieving Design-Stage Elemental Cost Planning Accuracy: Case Study of New Zealand

Johnson Adafin, James O. B. Rotimi, Suzanne Wilkinson, Abimbola O. Windapo

Abstract—An aspect of client expenditure management that requires attention is the level of accuracy achievable in design-stage elemental cost planning. This has been a major concern for construction clients and practitioners in New Zealand (NZ). Pre-tender estimating inaccuracies are significantly influenced by the level of risk information available to estimators. Proper cost planning activities should ensure the production of a project's likely construction costs (initial and final), and subsequent cost control activities should prevent unpleasant consequences of cost overruns, disputes and project abandonment. If risks were properly identified and priced at the design stage, observed variance between design-stage elemental cost plans (ECPs) and final tender sums (FTS) (initial contract sums) could be reduced. This study investigates the variations between design-stage ECPs and FTS of construction projects, with a view to identifying risk factors that are responsible for the observed variance. Data were sourced through interviews, and risk factors were identified by using thematic analysis. Access was obtained to project files from the records of study participants (consultant quantity surveyors), and document analysis was employed in complementing the responses from the interviews. Study findings revealed the discrepancies between ECPs and FTS in the region of -14% and +16%. It is opined in this study that the identified risk factors were responsible for the variability observed. The values obtained from the analysis would enable greater accuracy in the forecast of FTS by Quantity Surveyors. Further, whilst inherent risks in construction project developments are observed globally, these findings have important ramifications for construction projects by expanding existing knowledge on what is needed for reasonable budgetary performance and successful delivery of construction projects. The findings contribute significantly to the study by providing quantitative confirmation to justify the theoretical conclusions generated in the literature from around the world. This therefore adds to and consolidates existing knowledge.

Keywords—Accuracy, design-stage, elemental cost plan, final tender sum, New Zealand.

I. INTRODUCTION

RISKS plague the construction industry, perhaps more than most other industries. These risks in construction project environments are often dealt with inadequately, and are a contributory factor to the instances of poor performance of construction projects [10], [17], [9]. These risks must be

Johnson Adafin, PhD Researcher, and Suzanne Wilkinson, Professor, are with the Department of Civil & Environmental Engineering, University of Auckland, 20 Symonds Street, Auckland 1142, New Zealand (e-mail: jada393@aucklanduni.ac.nz, s.wilkinson@auckland.ac.nz).

James O. B. Rotimi is an Associate Professor in the Department of Built Environment Engineering at Auckland University of Technology, AUT City Campus, Auckland 1142, New Zealand (e-mail: james.rotimi@aut.ac.nz).

Abimbola O. Windapo is an Associate Professor in the Department of Construction Economics and Management at the University of Cape Town, Cape Town, South Africa (e-mail: abimbola.windapo@uct.ac.za).

assessed and accounted for in cost plans and tenders, otherwise tenderers may suffer tremendous losses and eventual failures [19], [26].

The reliable prediction of FTS (contract sums) of building projects from the cost plans have posed challenges for clients and practitioners in NZ. No matter how much care and effort is put into the preparation of design-stage ECPs, FTS very often significantly differ from cost plans [1]. Deviations in the region of +1% to +12% are recorded in a number of studies such as: [32], [25], [2], [29], [13].

Odeyinka [23] suggested that the major attributable factors for these deviations are risk elements that are inherent in construction project developments. Other studies on the factors that affect the accuracy of pre-tender cost estimates include those of [3], [14], [35], [37], [28]. Whilst it is recognized that risks exist during the design phase of project development, the traditional way of dealing with them is to make a percentage or lump sum contingency allowance in cost plans and tender sums [24]. Bello and Odusami [8] suggested that this conventional approach may account for projects being completed over budget. Accordingly, more analytical and scientific methods have evolved in construction risk assessment that could improve the quality of construction estimates [7], [8].

This study investigates the variations between ECPs and FTS of construction projects, with a view to identifying risk factors that are responsible for the observed disparity. The respective measures of influence of the identified risk factors are also determined. From the review of previous studies, the dearth of literature on cost and risk issues in the variability between the design-stage ECPs and FTS (contract sum) is observed. In other words, the deviation of ECPs from FTS in NZ is yet to be studied for NZ. This study therefore intends to close this knowledge gap.

II. LITERATURE REVIEW

A. Overview of Cost Planning and Observed Variations

RICS NRM 1 [31] defined cost planning as a budget distribution process that is performed during the design stages of a building project. Smith and Jaggar [33] argued that this process continues up to the tender documentation stage of project development. In practice, Project Managers refer to cost planning as the process of applying economic principles to building projects; this is a function of cost prediction that reflects the process of client's cost forecasting. In Rawlinsons' [30] opinion, cost planning frequently refers to the process of designing to, or within, a pre-calculated cost, determined by the finances available to obtain an optimum value for money.

This suggests that the earlier cost planning is introduced into the design process, the greater the measure of control that can be exercised. These definitions reflect the views of some contemporary authors: Ashworth [4], Ashworth and Hogg [6],

Kirkham [18], and Ashworth [5]. According to them, cost planning is not only a pre-tender estimating method but also seeks to offer a control mechanism during design development.

TABLE I
 PROJECT INFORMATION ON COMMERCIAL AND EDUCATIONAL BUILDING PROJECTS IN AUCKLAND, CHRISTCHURCH AND WELLINGTON, NZ. DATA ANALYSIS WITHOUT GST OR VALUE ADDED TAX (VAT) EXCHANGE RATE: NZ\$1.00 = US\$0.85 = AU\$0.91 = £0.51 STERLING (2014)

Risks Identified	Procurement System Adopted	Project Location	Year	Percentage Difference	Cost Difference (NZ\$)	FTS (NZ\$)	ECP Sum (NZ\$)	Project Type	Project Code (PN)
Market conditions, inadequate tender documentation, incomplete design information, and site investigation information	Traditional	Auckland	2012-13	5%	+100,369.83	2,085,369.83	1,985,000.00	Commercial building	PN01
Improvement in design cost planning functions and improvement in market conditions	Traditional	Auckland	2013	-14%	-4,406,815.00	26,593,185.00	31,000,000.00	Commercial building	PN02
Market movement, inadequate tender documentation, documentation errors/omissions, client change and site investigation information	Traditional	Auckland	2013	6%	+59,322.00	1,054,000.00	994,678.00	Educational building	PN03
Late client changes, incomplete documentation for cost plan and co-ordination errors at tender documentation stage	Traditional	Auckland	2013	1%	+13,381.00	2,417,000.00	2,403,619.00	Educational building	PN04
Improvement in design cost planning functions and improvement in market conditions	Traditional	Auckland	2013	-8%	-77,591.00	906,409.00	984,000.00	Educational building	PN05
Market conditions, client change, design enhancements and site investigation information	Traditional	Christchurch	2012	10%	+3,705,150.00	38,628,000.00	34,922,850.00	Educational building	PN06
Client change, design variations, market conditions and site investigation information	Traditional	Christchurch	2011-12	16%	+5,425,125.00	38,650,125.00	33,225,000.00	Commercial building	PN07
Client change, inadequate tender documentation, incomplete design information and site investigation information	Traditional	Auckland	2012-13	7%	+208,252.85	3,058,252.85	2,850,000.00	Commercial building	PN08
Improvement in market conditions and improvement in design cost planning functions (opportunities)	Traditional	Wellington	2013	-14%	-2,069,900.00	18,193,180.00	20,263,080.00	Commercial building	PN09
Market movement, documentation errors/omissions, client change, site investigation information and inadequate tender documentation	Traditional	Auckland	2013	10%	+95,350.00	1,094,000.00	998,650.00	Commercial building	PN10
Late client changes, incomplete documentation for cost plan and co-ordination errors at tender stage, incomplete design information	Traditional	Auckland	2013	7%	+249,180.00	3,989,698.00	3,740,518.00	Educational building	PN11
Improvement in market conditions and improvement in design cost planning functions (opportunities)	Traditional	Wellington	2013	-2%	-81,700.00	3,904,300.00	3,986,000.00	Educational building	PN12
Incomplete design information, market conditions, client change and site investigation information	Traditional	Christchurch	2012	7%	+3,634,500.65	52,468,250.65	48,833,750.00	Educational building	PN13
Market conditions, design variations, client change and site investigation information	Traditional	Christchurch	2010-11	13%	+4,000,100.00	35,790,100.00	31,790,000.00	Commercial building	PN14
Late client changes, design enhancements, market conditions and site investigation information	Traditional	Wellington	2010	7%	+2,040,225.00	30,285,225.00	28,245,000.00	Commercial building	PN15

In view of these expressions on cost planning and within the context of the current study, cost planning is simply a term that describes any system of bringing cost advice to bear upon a design process. In the same vein, design-stage ECP is a pre-contract or specifically, a design-stage cost control strategy based on elemental cost analysis which is prepared during the design development to give construction clients value for

money. Therefore, ECP portrays a budget in an elemental form and represents the final ECP amendment before tenders are invited, while FTS describes the accepted tender sum or initial contract sum. However, Odeyinka [24] asserted that no matter how much care and effort is put into the preparation of a design-stage ECP; deviations observed between it and the FTS are usually significant. Related studies in the UK, Middle

East, Asia, and Africa suggested that, in procurement methods where cost plans are used, deviations between the cost plans and FTS are common. According to Odeyinka [23] the major attributable factor for these deviations is the risk inherent in construction project developments. Deviations in the region of +1% to +12% are mentioned in [21], [11], [32], [25], [29], [13]. For example, Morrison [21] investigated the disparity between cost plan estimates and accepted tenders in the United Kingdom by collecting and analysing data from seven separate quantity surveying firms. Morrison found that a mean deviation of 12% was obtained by these quantity surveyors. Factors that are responsible for the deviation were identified as the variability of lowest tenders, the source of cost data used in estimating, the inherent error attached to the estimating technique and the suitability of cost data, in the order of importance. It was suggested that, using previous cost data from projects where quantity surveyors have had experiences, and using single source of cost data is likely to improve the accuracy of cost plan estimates.

In the United States, a coefficient of variation of 7.82% was obtained by Skitmore and Picken [32] when they carried out an analysis of pre-tender estimating performance of a USA consulting firm on 217 building projects. This coefficient was used to describe an estimate of variability in the consultants' responses. From the survey, they concluded the major causes of variation in cost estimating as "systematic errors attached to year by year changes, and the USA annual inflation rate", and a regression model was used to examine the possible effects of adjusting for these in the estimation process.

Oladokun et al. [29] analysed the pre-tender cost estimating performance of a Nigerian consulting quantity surveying firm and found that, on 81 building projects, there was an estimate bias reflecting underestimates of approximately 34%. They found that estimation in the construction industry in Nigeria is largely affected by the estimating technique used and quantity surveyor's experience. They suggested regression modelling for improved FTS predictions. Whilst inherent risks are observed in the discrepancies between ECPs and FTS; effective management requires proper determination and integration of risks into the estimation of construction costs in some way other than using intuition and loose rules [36]. Deterministic approaches to risks could help curb budget/cost and schedule/time overruns [15].

Knowledge of how risk factors combine to influence the variations between ECPs and FTS, and their respective measure of influences is yet to be investigated. This then is the concern of this study with the overall aim of developing a model to improve the accuracy of FTS predictions from cost plans in NZ.

B. Case Study Background

The case study collated data on ECPs and FTS from completed projects in NZ. Data were sourced from five NZ-based consultant quantity surveyors of three randomly selected firms through interviews. Table I presents the project information for eight commercial and seven educational building projects located in Auckland, Wellington, and

Christchurch, NZ. For the purposes of anonymity, the fifteen projects were coded: PN01 – PN15. Hence, general knowledge about cost and risk issues with a focus on the risk factors responsible for the disparity between design-stage ECPs and FTS in the selected commercial and educational building projects were obtained. There was also an aspect of the interview questions that sought possible solutions to this disparity. The table shows that disparity between design-stage ECP and FTS is in the region of -14% and +16%. The risk factors generally responsible for the disparity observed in this study include: market conditions, client's change, design enhancements/variations, site investigation information, co-ordination errors, documentation errors/omissions, incomplete design information, incomplete documentation for cost plan and inadequate tender documentation. Meanwhile, improvement in design cost planning functions and improvement in market conditions are considered as opportunities rather than risk factors. These represent savings made on two different projects (see PN02, PN05, PN09, and PN12).

III. RESEARCH METHODOLOGY

The research approach collated data on ECPs and FTS from completed projects in NZ. Access was obtained to project records held by three quantity surveying firms based in Auckland. A thorough examination of their project files within the limitations of the Privacy Act was undertaken. Data were sourced from five NZ-based consultant Quantity Surveyors of three randomly selected firms through interview sessions held over a period of two months April-May 2013. Initially ten out of seventeen registered quantity surveying firms were contacted by telephone after a random internet search limited to the website of New Zealand Institute of Quantity Surveyors (NZIQS). Ten firms were preferred because project cost planning/pre-tender estimating falls within their areas of concentration in practice. From these, three firms replied that they were willing to participate in the research. Meanwhile, five senior partners within the three firms were subsequently communicated with via telephone and e-mail requests for thirty minutes' one-on-one interviews. As viewed by Gibson and Brown [16] document analysis refers to the process of using documents as a means of social investigation and involves exploring records that individuals, professionals and organizations produce. In this study, the use of document analysis helped to justify the theoretical conclusions generated from the review, regarding risk identification.

More supporting information on the projects was obtained from key personnel within the host organizations through interviews. Apart from empirical collection, some underlying contextual information was also gained from the interviews. Thus, the interviews helped to gain insights into people's experiences in particular project scenarios [34]. Zuo [38] also suggested that interviews provide detailed understanding emanating from direct observation of people and listening to what they have to say at a particular scene.

Thematic analysis was used to analyze interview data by pinpointing, examining and recording patterns within them

[16]. Themes and theme co-occurrence were identified, as well as comparison of theme frequencies. Simple descriptive analysis was used to express the influence of risks on the observed disparity [22].

IV. PRESENTATION AND DISCUSSION OF FINDINGS

Demographic information obtained from participants include: designation, academic and professional qualifications and work experience. Generality of the respondents hold tertiary education at HNC/HND/Bachelor's degree levels in quantity surveying, while one of them holds an MBA. They are senior partners in their individual firms and are professionally qualified (three full members and two fellows) with the NZIQS. The participants have an average of 28 years of work experience in their consultancies. This demographic information indicates that the participants are competent, experienced and capable of exercising sound judgment in responding to the interview questions. Therefore, responses provided by them could be relied upon for this study.

Specifically, PN01 recorded a budget overrun of +5% as a result of such risks as market conditions, inadequate tender documentation, incomplete design information and site investigation information. PN03 registered a budget overrun of +6% and the risk factors responsible were market conditions, inadequate tender documentation, documentation errors/omissions, client's change and site investigation information. Budget overrun of +1% was noted on PN04 while the risk factors found in the archive data were late client's changes, incomplete documentation for cost plan and co-ordination errors at tender documentation stage. Similarly, PN06 overran +10% consequent upon market conditions, client's change, design enhancement and site investigation information. Also, PN07 recorded an overrun of +16% because of client's change, design variations, market conditions, and site investigation information as the evident risk factors. Further, PN08 recorded a budget overrun of +7% because of such risks as client's change, inadequate tender documentation, incomplete design information and site investigation information. PN10 registered a budget overrun of +10% and the risk factors responsible were market conditions, inadequate tender documentation, documentation errors/omissions, client's change and site investigation information.

Another budget overrun of +7% was noted on PN11 while the risk factors found in the archives were late client's changes, incomplete documentation for cost plan, co-ordination errors at tender documentation stage and incomplete design information. Similarly, PN13 attracted a budget overrun of +7% consequent upon incomplete design information, market conditions, client's change, and site investigation information. Also, PN14 recorded an overrun of +13% as a result of client's change, design variations, market conditions and site investigation information as the evident risk factors. Moreover, PN15 overran +7% while the risk factors responsible were late client's changes, design enhancement, market condition and site investigation

information. The generality of interviewees opined that the FTS is usually higher than the ECP on building projects.

For the four building projects (PN02, PN05, PN09, and PN12) on which the FTS is lower than the cost plan sum (-14% and -2%, respectively), the consultants interviewed explained that this was consequent upon an improvement in design cost planning functions by the professional team and an improvement in market conditions (opportunities). This suggests that the risk factors and opportunities identified by the cost consultants constitute the reasons for the disparity. Market conditions, client's change, and site investigation information appeared as the risks with the highest frequency of occurrence in the study. In total, this analysis gives an insight into nine risk factors causing a negative impact on the budgetary performance of the selected building projects.

The conditions in the property market including situations with project resources within the cost planning/tender period resulted in the significant cost difference observed on PN01, PN03, PN06, PN07, PN09, PN10, PN13, PN14, and PN15. This upward trend may not be unusual because of the extended period of cost planning and tendering for most construction projects. Traditional contracting systems in NZ require contractors to prepare their own quantities in a lump sum competitive contract. The time for the receipt or return of tenders by contractors may be extended if errors are discovered or queries are raised by the Architect, Quantity Surveyor or Contractor concerning the project specification or other tender documents. This must be dealt with accordingly to ensure parity of tendering. This finding justifies the submission of Akintoye and Macleod [3] submission as tender period and market conditions are some of the more significant pre-tender estimating risks. ECPs prepared for a project is an attempt to forecast the successful contractor's FTS; hence consultant quantity surveyors must consider the trends in market condition between the two specified periods and the implications on the costs of project resources. This factor must be considered by the consultant quantity surveyors while preparing design stage ECP.

Similarly, changes at the early stages of design or design variations/enhancements and client's change impact on the budgetary performance of some of the projects (PN03, PN04, PN06, PN07, PN08, PN10, PN11, PN13, PN14, and PN15). Because these risk factors occurred during the pre-construction phase and are design-related, the quality of such a design needs to be as reasonable as the design information available. However, within the cost planning and tender action stages of development process (pre-contract phase) as more information are available, Architects may see the need for changes to the original design. Also, clients who are equally grasping design and construction realities may wish to suggest changes or enhancements that will ensure that their objectives are met. In some cases, clients or Architects may also suggest changes to the scope of works. Since the design stage ECP and FTS are based on pre-construction information available, it is therefore not a surprise that significant variability exists between the cost plan and FTS.

Site investigation information reveals the site conditions, nature of the soil, sub-ground or geological conditions that may affect design and construction. The level of information available (or not) at the time of ECP preparation is shown to be significant to the variance between the cost plans and FTS in this study. From Table I, PN01, PN03, PN06, PN07, PN08, PN10, PN13, PN14 and PN15 projects had experienced significant impacts by risks associated with site conditions. This is consistent with [37] where site investigation information is identified as a key risk in construction projects in China. Zou et al. [37] stressed that inadequate site information (soil tests and survey report) leads to uninformative designs and further can negatively affect the progress of excavation and foundation construction. This view was shared by Odeyinka et al. [27] through a study conducted in the UK. Lack of site investigation information could lead to defective design and consequently to foundation problems. Hence, deficiency in the site investigation impacts on a project's budgetary performance and consequently the client's cash flow position.

The results further showed that co-ordination and documentation errors also caused deviation of cost estimates from FTS. Lack of effective communication and co-ordination among members of the project team is a typical source of risk which brings about co-ordination errors. The emergence of co-ordination errors bred documentation errors or omissions which partially affected the budgetary performance of PN03, PN04, PN10 and PN11 and consequently an upward review of cost plan estimates. The importance of effective communication and co-ordination among project team members cannot be underestimated as it improves cost planning accuracy if there are proper documentation, smooth flow of information and a synergy of solutions/ideas from project participants. Once failure or deficiency is experienced in setting up a communication and co-ordination model at project inception, this generates documentation errors and project participants are unable to have a complete idea of their expected roles, responsibilities and expected performance in relation to project design and cost planning functions.

The project information in this study comprised availability of design information, quality of design information and the extent of completion of pre-contract design in the face of cost planning accuracy and reliability. It is noteworthy that drawings are important for communicating the designers' intentions regarding the structure conceived by the project owner. Therefore, project implementation strategies must include procedures for collecting information on project performance that is vital for project planning and control. This explains why incomplete or inadequate design information has partially caused the variance recorded on the budgetary performance of P01 at the pre-contract phase of the project. As opined in [3], since consultants supply most of the information required for the cost planning/estimating functions, the expertise available within the consultant organisations may have a bearing on the amount of detailed design available during design development and tender stages, the quality of information provided and the efficiency of flow of such

information. Generally, project participants are responsible not only for the provision of a reasonable amount of information required during design development and tender stages but also the quality of such information and its flow requirements. The information here means the amount of design details and cost data available for the project. For example, an estimate or ECP based on detailed drawings should be more accurate than the one based on sketch drawings. Consultant Quantity Surveyors normally use superficial methods (based on floor area) for sketch drawings and approximate quantities method for detailed drawings. Odusami and Onukwube [28] suggested that estimates or cost plans based on approximate quantities method (priced at current rates) are more accurate than those based on superficial floor area method.

It is important to have adequate and proper cost plan and tender documentation as well as information management in order to improve cost planning/estimating accuracy [20]. Incomplete documentation for cost plan and inadequate tender documentation have partly explained the reason for the disparity between the design stage ECP and FTS in this study (see Table I for information on PN01, PN03, PN04, PN08, PN10, and PN11). Besides making estimates more accurate, adequate documentation could go a long way to reduce problems such as variations and claims at the construction stage [12].

V. CONCLUSION AND FURTHER RESEARCH

The aim of this study was to investigate the reasons for the observed disparity between design stage ECP and FTS in building project procurement. Extant literature, interviews and project data have indicated that risks have an impact, first on the preparation of design stage ECP, and secondly on the deviations or disparity between ECPs and FTS. The assessment of these risk elements could assist in determining the FTS from cost plans. The study suggests that the essence of having an ECP as a reliable budgetary tool for building projects is secured if the risk elements are properly evaluated while preparing the design stage ECP. With this information, Quantity Surveyors are more able to accurately forecast FTS of building projects from the cost plans through proper risk identification and analysis, thus increasing accuracy. This study provides further insight into the relationship between construction costs and various risk variables in terms of the benefits to researchers and experts in the broader global construction community.

It is important to acknowledge the limitations of this research. The 15 projects examined did not exactly mirror the percentage difference occasioned by each of the risk factors identified by the cost consultants. Access was negotiated into the offices of top three quantity surveying firms to enable the researcher carry out a thorough examination of files related to past projects. Some limitations were experienced due mainly to the Privacy Acts in operation within the industry.

Further development of the work reported here, when further data are collected and analysed, will provide information for the development of a predictive model for application in NZ. Future study could also explore a factor

approach to the analysis of risks impacting variability between design stage ECP and FTS.

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