

## **EVALUATING THE BUDGETARY RELIABILITY OF DESIGN STAGE ELEMENTAL COST PLAN IN BUILDING PROCUREMENT: A NEW ZEALAND STUDY**

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### **Abstract**

Accurate prediction of final tender sums (contract sums) of building projects depends on reliable projections of baseline cost plans developed at the design development stage. However, no matter how much care and effort is put into the preparation of design stage elemental cost plans, deviations are usually observed between these cost plans and the final tender sum. This makes accurate predictions challenging for construction practitioners in New Zealand. The major attributable factors for the observed variability are inherent risks in the design stage elemental cost plan development. Whilst this is recognised, this study evaluates the reliability of elemental cost plans in traditional building procurement. The study seeks to answer the question: is elemental cost plan a reliable budgetary tool for construction projects? The study was undertaken based on 20 completed building projects from which secondary data were collected within the New Zealand construction industry. Data analysis was carried out using document analysis and percentage deviation of final tender sums from the cost plans. Further analyses were carried out using root mean square and relative mean absolute deviation methods of analyses. The results showed that the budgetary reliability of elemental cost plans varied depending on project types. Whilst a deviation of -3.67% and +3.95% was obtained on the residential projects analysed, the deviation on educational projects was between -3.98% and +12.15%. Commercial projects attracted -14.22% and +16.33% while in the case of refurbishment projects, a deviation of -10.07% and +30.14% was obtained. These findings suggest that the larger or more complex a project is, the less reliable it is to use elemental cost plans to guarantee cost certainty.

**Keywords:** Elemental cost plan, Final tender sum, New Zealand, Reliability, Traditional building procurement

## **1 Introduction**

The main concerns of construction clients in New Zealand are projects delivered within budget, on time, to the expected quality and with no surprises (Alan et al., 2008). Potts (2008) suggested that most clients work within tight pre-defined budgets or cost plans prepared by the consultant Quantity Surveyor at the design development stage. This is normally not expected to be exceeded; otherwise the whole scheme may fail. According to Odeyinka (2010) risks in traditional procurement are covered through the allocation of contingencies to cover both foreseen and unforeseen circumstances in design stage elemental cost plans. This is expected to ensure the completion of a project within the budget or cost plan. However, there are evidences in construction management literature indicating that it is difficult to find a project in which the final tender sum is the same as the design cost estimate/cost plan estimate (Akintoye, 2000; Aibinu and Pasco, 2008; Odusami and Onukwube, 2008; Enshassi et al., 2013).

Further, related studies conducted by researchers in the UK, Middle East, Asia and Africa concluded that in procurement methods where cost plans are used, deviations between the cost plan sums and final tender sums are common. Such deviations in the region of +1% to +12% are mentioned in (Morrison, 1984; Cheong, 1991; Oladokun et al., 2011; Enshassi et al., 2013). According to Zou et al. (2007) the major attributable factors for these deviations are risk elements that are inherent in construction project developments.

Whilst these risk factors are recognised, the study determines the reliability of design stage elemental cost plan in building project procurement. This study provides information on cost plan and final tender sums of selected case study projects in New Zealand. This represents a benchmark for measuring cost planning accuracy or reliability. Although the usefulness of design stage elemental cost plan and final tender sum as pre- and post-contract cost control tools in traditional procurement has been documented, to the best of the knowledge of the researchers, there is no recent documentary evidence of an investigation into the budgetary reliability of design stage elemental cost plan in traditional building procurement in New Zealand construction. As such, the study finds its significance.

## **2 Literature Review**

### ***2.1 An Overview of Elemental Cost Planning***

Early study by Dent (1978) defined cost planning as a system for monitoring cost at building design stage such that: (a) tenders do not exceed preliminary estimates; and (b) costs are developed in a way that gives project owners the best value for money. According to Seeley (1996) cost planning is a systematic application of cost criteria to a building design process to maintain in the first place, a sensible and economic relation between project parameters (cost, time, quality and functionality) and in the second place, provide overall control of proposed expenditure as circumstances might dictate. Several contemporary authors including (Ashworth, 2004; Ashworth and Hogg, 2007; Kirkham, 2007; Smith and Jaggar, 2007; Ashworth, 2008) have expressed that cost planning is not only a pre-tender estimating method but also seeks to offer a control mechanism during the design stage.

Building cost planning was originally developed within the framework of the traditional procurement arrangement using conventional documentation, tendering and administration processes. With the advent of alternative forms of procurement and with more fluid approaches to design stage processes and documentation, the need for sound cost planning has not diminished (Smith et al., 2004). Thus, as a process established on solid theoretical foundations, Smith et al. suggested that cost planning should be robust enough to adapt and flourish in a variety of procurement environments.

In view of the above expressions 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 elemental cost plan 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. This bears in mind the need to meet specific requirements and ensure that available funds for a project are rationally distributed among the elements of the building. In this context, measuring the reliability of an elemental cost plan (a budget) means assessing the quality of the cost plan in term of the expected accuracy range. Consequently, the reliability of a cost plan is determined by whether the expected accuracy range matches the required accuracy range. Meanwhile, the accuracy of a cost plan can be defined as the difference between final tender sum (contract sum) and elemental cost plan sum; this can be measured by the error rate calculated from Equation (1) (An et al., 2011):

$$[1] \text{ Error rate (\%)} = (| \text{Final Tender Sum} - \text{Elemental Cost Plan Sum} | / \text{Final Tender Sum}) \times 100.$$

Similar view was illustrated in (Ashworth, 2004) whereby a range of -4% to +15% was recommended as an acceptable parameter for measuring estimating accuracy.

## 2.2 Previous Studies

Substantive research has been carried out in the field of pre-tender estimating for construction projects, a significant outcome of which is the identification of numerous risks that influence budgetary performance. Also some studies have investigated the accuracy of design stage elemental cost plans and their respective measure of influences, which is similar to the focus of the current study. Several researches (Akintoye, 2000; Enshassi et al., 2005; Aibinu and Pasco, 2008; Odusami and Onukwube, 2008; Onukwube et al., 2009; Oladokun et al., 2011; Jafarzadeh, 2012) have indicated that pre-tender estimating accuracies are significantly affected by the level of risk information available to estimators. These are recognised by this study as fundamental evidence of risk factors causing variability between elemental cost plans and final tender sums (Choy and Sidwell, 1991; Ling and Boo, 2001; Baloi and Price, 2003; Hlaing et al., 2008; Tsai and Yang, 2010).

The disparity between design stage elemental cost plan and final tender sums received in competition for a project would provide further evidence to the issues relating to the accuracy of pre-tender cost estimates in this study. Morrison (1984) had investigated this disparity 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 the quantity surveyors. Also Ogunlana (1991) reported significant deviations of design cost estimates from accepted tenders using information held by seven design offices in the United Kingdom.

Cheong (1991) found that the disparity between cost plan estimates and contract sums is generally between 5% and 10%. Cheong's study had collected opinions across a wide range of Quantity Surveyors in Singapore. Significantly, Cheong's analysis of 88 projects from one quantity surveying consultancy in Singapore found that variability values between cost plan estimates and contract sums ranged from 33.79% (over-estimates) to 31.30% (under-estimates).

Similarly in Nigeria, Odeyinka and Yusif (2003) using cost data on preliminary cost estimates and lowest tenders that were supplied by 24 quantity surveying firms, found the following: 17 of 40 building projects (42.5%) had their lowest tender sums lower than the Quantity Surveyors' estimates and this ranged between 1% and 47%. 23 of the projects (57.5%) had their lowest tender sums higher than the Quantity Surveyors' estimates and this ranged between 1% and 174%. An analysis of pre-tender cost estimating performance of a Nigerian consulting

quantity surveying firm by Oladokun et al. (2011) found that on 81 building projects there was an estimate bias reflecting underestimates of about 34%.

In a related study, Odeyinka (2010) asserted that no matter how much care and effort is put into the preparation of design stage elemental cost plans, deviations observed between them and the final tender sums are usually significant. According to Zou et al. (2007) the major reason for this is inherent risks in both design and construction. The traditional way of dealing with these risks is merely to allow a percentage as contingency allowance. Thus, the essence of having an elemental cost plan as a budgetary tool for building projects is defeated if these risk elements are not captured or properly evaluated. Overall project objectives regarding cost, time and quality targets become threatened.

### **2.3 Risk and Cost Predictability**

Risk could have different meanings to different people (Baloi and Price, 2003). The concept of risk can vary according to individual's perceptions, attitudes and experiences. For instance; architects, engineers and contractors are more likely to view risk from a technological perspective while lenders and developers tend to view it from an economic and / or financial point of view. Baloi and Price therefore concluded that risk is generally seen as an abstract concept that is difficult to measure. Rezakhani (2012) defined risk as a potential for complications around project completion, achievement of project objectives and an uncertain future event or condition whereby the occurrence rate is greater than 0% but lesser than 100%. Risk generates an effect on at least one of the main project objectives in terms of cost, time and quality targets. Early study by Akintoye and MacLeod (1997) explained that risk has been significant owing to the occurrence of budget/cost and schedule/time overruns associated with construction project developments. Joshua and Jagboro (2007) submitted that risk is inevitable and exposes project activities to adverse consequences of future events. The effect of risk on a project can be positive or negative. To align with the common usage of the word risk, this research embraces the view that benefits or positive impacts of risks on project objectives could be achieved by minimising risk occurrence and its detrimental impacts.

Potts (2008) explained that the budgeted cost established by the consultant Quantity Surveyor at the pre-contract stage forms the basis for the assessment of the tender sums submitted by bidding contractors. The successful tender therefore becomes the final tender sum (contract sum) for the project. Potts suggested that most clients work within tight pre-defined budgets/cost plans which are usually part of a larger overall scheme. If a budget or cost plan is exceeded, the whole scheme may fail. Pre-contract estimating produces the original budget or cost plan and this forecasts the likely expenditure for the client. The budget or cost plan should be used positively to make sure that the design stays within the scope of the original scheme. Thus, many budget overruns are due to circumstances observed as risk factors and an important issue is the ability to predict such factors and the impact they have on the project. The smaller the level of information available at the early stages of a construction project, the higher is the level of uncertainties and hence risks. This view was shared by Zou et al. (2007) and Taroun et al. (2011). Therefore, as project information increases, risk is expected to decrease.

There has been lesser attention paid to the disparity between design stage elemental cost plan and final tender sums in New Zealand. Recently, Adafin et al. (2014) undertook a preliminary exploration of the theoretical concepts and methods for assessing risk impacts on the variability between design stage elemental cost plan and tender sums in New Zealand. It is apparent that there is a dearth of literature on this subject, which is being addressed by this study.

## **3 Research Methodology**

This study was carried out primarily through the use of secondary data. The research approach collated data on elemental cost plan and final tender sums from twenty completed building

projects located in Auckland (AKL), Christchurch (ChC) and Wellington (WLT), New Zealand. Access was obtained to project records held by three quantity surveying firms based in Auckland. Project records and documents produced by professionals and organizations were explored as the main data analysis for the study (Gibson and Brown, 2009). A thorough examination of their project files within the limitations of the Privacy Act was undertaken. Apart from this project information, five senior partners within the three firms who had worked closely with the projects were interviewed. Project data were collected from four different types of building projects.

Tables 1-5 present the project information obtained for residential, educational, commercial, and maintenance projects. These project details were analysed to achieve the research objective, which was to evaluate the budgetary reliability of design stage elemental cost plans in each of the four project types. For the purpose of anonymity, the projects are coded P01 - P20. In this study, the use of document analysis helped to justify the theoretical conclusions generated from the review, regarding cost predictability. Simple descriptive analysis was used to express the percentage difference between cost plan and final tender sums (Nworgu, 2006). Two further analyses were carried out using root mean square (RMS) deviation, and relative mean absolute (Rel. MAD) deviation methods of analyses as adopted by (Odeyinka et al., 2009). The *RMS* is expressed mathematically as follows:

$$[2] \text{ RMS} = \sqrt{\frac{1}{n} \sum_{i=1}^n (c_i - o_i)^2}$$

Where *RMS* is the root mean square deviation measure; n is the number of projects investigated,  $c_i$  is the cost plan sum for individual project and  $o_i$  is the final tender sum for the individual project.

The *Rel. MAD* is expressed mathematically as follows:

$$[3] \text{ Rel. MAD} = \frac{\frac{1}{n} \sum_{i=1}^n |c_i - o_i|}{\frac{c_i}{n}}$$

=

Where *Rel. MAD* is the relative mean absolute deviation measure; n is the number of projects investigated,  $c_i$  is the cost plan sum for the individual project and  $o_i$  is the final tender sum for the individual project.

#### 4 Findings and Discussion

Demographic information obtained from participants included their designation, academic and professional qualifications and work experience. Generally, all 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 New Zealand Institute of Quantity Surveyors (NZIQS). The participants have an average of 28 years of work experience in their consultancies. This demographic information indicates that the participants have been involved with running of projects and therefore have some knowledge of issues relating to project cost planning. This also enhances validity of survey data. Therefore, the secondary data provided by them could be relied upon for this study.

Table 1 presents elemental cost plan sums and final tender sums for five residential building projects studied. An analysis of the percentage difference between the cost plan sum and final tender sum gives an indication of the budgetary reliability of the elemental cost plan. It is

evident from the Table that the percentage difference between the cost plan and final tender sums ranges between -3.67% and +3.95%. This falls within the  $\pm 5\%$  range adopted by

Morrison (1984) as the acceptable accuracy range between the Quantity Surveyor's estimate and the accepted or final tender sum. Similarly, a range of -4% to +15% was recommended by Ashworth (2004) as an acceptable standard for measuring estimating accuracy.

**Table 1. Budgetary reliability measures for residential building projects**

Project Code	Elemental	Final Tender Sum (NZ\$)	Cost Difference (NZ\$)	Percentage Difference (%)	Year	Project Location	Procurement System Adopted
	Cost Plan Sum (NZ\$)						
P01	7,210,250.80	6,859,266.32	-260,984.48	-3.67	2013	AKL	Traditional
P02	794,456.98	815,257.68	20,800.70	2.62	'12-13	ChC	Traditional
P03	905,500.00	924,680.00	19,180.00	2.12	'12-13	ChC	Traditional
P04	1,914,848.40	1,878,417.15	-36,431.25	-1.90	2013	AKL	Traditional
P05	1,034,360.00	1,075,210.00	40,850.00	3.95	'12-13	ChC	Traditional

Though, traditional contracting systems in New Zealand require contractors to prepare their own quantities in a lump sum competitive contract. The schedules of quantities prepared by contractors are usually in a trade format while cost plans are produced in an elemental format by the consultant Quantity Surveyors during design development stage. Hence, this does not allow a compatible platform for comparison. It is noteworthy that the budget or cost plan established by the consultant Quantity Surveyor during the design development stage forms the basis for the assessment of tender sums submitted by bidding contractors. The successful tender therefore becomes the final tender sum (contract sum) for the project. A thorough examination of the cost plan and final tender summary for each of the five projects studied showed a minimal difference between the cost plan sums and final tender sums. This then suggests that in traditional procurement where elemental cost plan based on New Zealand Institute of Quantity Surveyors (NZIQS) Elemental Analysis of Costs of Building Projects is used, the cost plan tends to be a reliable budgetary tool. This is not unsurprising because residential building projects are usually well defined in terms of design and specification at their pre-construction phases. This view was shared by Ling and Boo (2001) explaining that the risk of variation and change in scope is usually very low during the construction phase for this category of projects.

Table 2 presents the cost plan data and final tender sums for five educational building projects. An analysis of the percentage difference between the cost plan and final tender sums gives an indication of the budgetary reliability of the cost plan. Data on the Table show that the percentage difference between the cost plan and final tender sums range between -3.98% and +12.15%. This range is significant. The high disparity observed, may suggest that the cost plan is not a very reliable budgetary tool in educational building projects. As evident from the cost plan and final tender summary, high variability was observed in some cases which suggested the occurrences of risk factors such as client's change, incomplete design information and site investigation information among others. This finding justifies Potts' (2008) suggestion that failure to keep within the provisions of pre-defined budgets or cost plan is one risk that impacts on a project's budgetary performance and consequently the client's cash flow position.

**Table 2. Budgetary reliability measures for educational building projects**

Project Code	Elemental Cost Plan Sum (NZ\$)	Final Tender Sum (NZ\$)	Cost Difference (NZ\$)	Percentage Difference (%)	Year	Project Location	Procurement System Adopted
P06	994,678.00	1,084,000.00	89,322.00	8.98	2013	AKL	Traditional
P07	2,403,619.00	2,477,000.00	73,381.00	3.05	2013	AKL	Traditional
P08	944,000.00	906,409.00	-37,591.00	-3.98	2013	AKL	Traditional
P09	34,922,850.0	38,628,000.0	3,705,150.0	10.61	2012	ChC	Traditional
	0	0	0				
	48,833,750.0	54,768,250.6	5,934,500.6				
P10	0	5	5	12.15	2012	ChC	Traditional

Table 3 presents the cost plan data and final tender figures for five simple and complex commercial building projects. An analysis of the percentage difference between the cost plan and final tender sums shows a range between -14.22% and +16.33%. This is a very significant deviation. Further scrutiny of the percentage difference for each of the five projects indicates that the larger the scope of the commercial building, the higher the level of disparity between the cost plan sum and final tender sum. A thorough examination of the cost plan and final tender summary for each of the five projects showed a high disparity between the cost plan sums and final tender sums. The observed high variability therefore suggests that the elemental cost plan is not so much a reliable budgetary tool for commercial projects, especially where the project is large in scope and of a complex nature. This further suggests that there is uncertainty in a lot of project information available where large and complex projects are involved. Hence, it is noteworthy that the more uncertain the project information is at the pre-construction stage when elemental cost plan is prepared, the more risky it is for cost certainty to be guaranteed to the client at the end of the tendering process.

**Table 3. Budgetary reliability measures for commercial building projects**

Project Code	Elemental Cost Plan Sum (NZ\$)	Final Tender Sum (NZ\$)	Cost Difference (NZ\$)	Percentage Difference (%)	Year	Project Location	Procurement System Adopted
P11	1,985,000.00	2,085,369.83	100,369.83	5.06	'12-13	AKL	Traditional
P12	31,000,000.00	26,593,185.00	-4,406,815.00	-14.22	2012	ChC	Traditional
P13	33,225,000.00	38,650,125.00	5,425,125.00	16.33	'11-12	ChC	Traditional
P14	2,850,000.00	3,058,252.85	208,252.85	7.31	'12-13	AKL	Traditional
P15	28,245,000.00	31,285,225.00	3,040,225.00	10.76	2010	AKL	Traditional

Table 4 presents the cost plan data and final tender figures for five refurbishment projects. An analysis of the percentage difference between the cost plan and final tender sums shows a range between -10.07% and +30.14%. This presents a highly significant deviation. It is important to note that the highest positive variability emanated from a small maintenance project and the Table does not reflect a clear-cut pattern of percentage variability. A thorough examination of the cost plan and final tender summary for each of the five projects showed a high disparity between the cost plan sums and final tender sums. The observed significant variability suggests that the elemental cost plan is less reliable as a budgetary tool in refurbishment projects. This is not a surprise as refurbishment projects harbour loaded estimates and assumptions that cater for higher risks due to unknown items involved in terms of scope and complexity at project inception, hence unpredictability regarding cost certainty.



**Table 4. Budgetary reliability measures for refurbishment projects**

Project Code	Elemental Cost Plan Sum (NZ\$)	Final Tender Sum (NZ\$)	Cost Difference (NZ\$)	Percentage Difference (%)	Year	Project Location	Procurement System Adopted
P16	2,266,000.00	2,522,725.36	256,725.36	11.33	2011	WLT	Traditional
P17	380,341.12	342,045.24	-38,295.88	-10.07	2010	AKL	Traditional
P18	666,000.00	866,725.36	200,725.36	30.14	2011	WLT	Traditional
P19	805,134.60	736,687.56	-68,447.04	-8.50	2010	AKL	Traditional
P20	2,023,490.94	2,233,773.04	210,282.10	10.39	2011	WLT	Traditional

Further analyses were carried out to determine the budgetary reliability of the elemental cost plan for procuring the different types of buildings previously analysed. *RMS* deviation measure was expressed mathematically in Equation 2. This was converted to a percentage measure through normalization adjustment in order to make it comparable to other measures. In Table 5, this is regarded as the adjusted *RMS* measure. Odeyinka et al. (2009) justified the relevance of the normalization process as the *RMS* values obtained in their study are more of the function of tender and final account figures. This is applicable to the current study regarding the comparison between elemental cost plan and final tender sum. Moreover, the adjusted values are relative values that are more comparable.

The fourth analysis is the *Rel. MAD* measure that was expressed mathematically in Equation 3. The results of these analyses are presented in Table 5. As shown in the Table, the normalized / adjusted *RMS* measure and *Rel. MAD* measure are moderately close. This indicates that the two measures are reliable for measuring the budgetary performance of the design stage elemental cost plan under study. From the Table, the reliability ranking based on the normalized *RMS* and *Rel. MAD* measures shows that the elemental cost plan is most reliable as a budgetary tool for procuring residential building projects (Ranked 1). This is followed by educational, commercial and refurbishment projects respectively (Ranked 2, 3 and 4). The reliability ranking showed that the elemental cost plan is least reliable as a budgetary tool for procuring maintenance or refurbishment projects. Meanwhile, it is important to note that this result reveals the level of threats involved in relying considerably on elemental cost plan as a budgetary tool. Besides the residential building projects with a budgetary reliability of  $\pm 2.85\%$  that is quite reliable and acceptable, the deviation margins for other project types are quite significant. Hence, Quantity Surveyors need to attach some level of confidence limits to the estimate they give to project owners if interested in cost certainty. This is very important because the deviations observed are as a result of inherent risks in the design stage elemental cost plan development.

**Table 5. Elemental Cost Plan (ECP) budgetary reliability measures of different building types**

Building Type	RMS Measure (NZ \$)	Adjusted RMS Measure (%)	Rel. MAD Measure (%)	Reliability Ranking
Residential	119,924.48	3.00	2.85	1
Educational	3,129,255.85	9.15	7.75	2
Commercial	3,410,231.99	12.96	10.74	3
Refurbishment	176,956.90	17.16	14.09	4

Results and findings could be presented either in tables or figures for illustration purposes. These presentation modes could be adopted in the earlier and latter sections (2, 3, 4 and/or 5) when deemed necessary. The table caption should be numbered and positioned before the table as shown in Table 1.

## 5 Conclusion and Further Research

The aim of the study was to investigate the budgetary reliability of design stage elemental cost plan in procuring building projects using secondary data from completed building projects. This study therefore concludes within the limitations of the data set confined to New Zealand, that in traditional procurement where elemental cost plans are used, there are deviations between elemental cost plan sums and final tender sums. The percentage deviation ranges between -3.67% and +3.95% for residential building projects. It ranges between -3.98% and +12.15% in the case of educational buildings. Commercial buildings attract a range of -14.22% and +16.33%, while it ranges between -10.07% and +30.14% for refurbishment projects. This suggests that besides the residential projects with little and acceptable deviation, the deviations observed in other projects are very significant.

The study concludes further that the elemental cost plan was most reliable (*Rel. MAD* of 2.85%) as a budgetary tool in procuring residential projects. This was followed by educational projects (*Rel. MAD* of 7.75%) and commercial projects (*Rel. MAD* of 10.74%) respectively. The design stage elemental cost plan was found to be least reliable as a budgetary tool in procuring refurbishment projects (*Rel. MAD* of 14.09%). An awareness of the possibility of deviations in different project types in quantitative terms offered by this study makes the design stage elemental cost plan a relevant tool for risk management to avoid budget overrun. Further, given construction projects procured using the elemental cost plan in traditional procurement, inherent risks could be subjected to quantitative assessment and management. Hence, the observed deviation measures could offer a relevant background towards the application of risk management techniques in budgetary and cost control in order to avoid budget/cost overrun in construction projects.

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 New Zealand. Future study could also explore a factor approach to the analysis of risks impacting variability between design stage elemental cost plan and final tender sum.

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