ACCURACY IN DESIGN STAGE COST ESTIMATING THROUGH RISK-CONTINGENCY ANALYSIS: A THEORETICAL EXPLORATION

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ABSTRACT
Risk-contingencies can strongly influence cost certainty if properly evaluated and managed. Accuracy of early cost estimates is a major concern for construction industry practitioners in New Zealand, especially Quantity Surveyors. Several researchers have long expressed their concern about cost estimating inaccuracies by recognizing that the accuracy achieved in cost estimating has been less than desirable. The essence of having accurate design stage cost estimate as a reliable budgetary tool is defeated if risk estimates are not incorporated or not properly evaluated if incorporated. Hence, project objectives regarding cost, time and quality targets are threatened as contingency is proportional to the risk present in a construction project. Therefore, the aim of this study is to signify the design stage cost estimating as a function of risk-contingency reserve. This study is a literature-based theoretical exploration, and part of an on-going doctoral research on the budgetary reliability of design stage elemental cost plan. As a first step, a detailed review of related literature was made to establish the risk elements inherent in preparing the design stage cost estimate. Secondly, various factors affecting design stage cost estimating accuracy in construction practice were identified by demonstrating the theoretical context. The insights gained from the foregoing steps then helped in devising theoretical concepts for securing the design stage cost estimate as a reliable budgetary tool that guarantees cost certainty for building projects through risk-contingency analysis.

Keywords: Accuracy, contingency, design stage cost estimate, reliable budgetary tool, risk

INTRODUCTION
The reliability of tender sums depends on the accurate projections of baseline cost estimates developed at the design development stage. However no matter how much care and effort is put into the preparation of design stage cost estimates,
significant deviations are usually observed between these cost estimates and the final tender sum. This makes accurate predictions challenging for construction industry practitioners. The major attributable factors for the variability between design stage cost estimate and final tender sum are risk elements that are inherent in construction project developments. (Joshua and Jagboro 2007) suggested that risk is inevitable and exposes project activities to economic losses from foreseen and unforeseen events. If risk is not managed properly, it becomes a threat to project objectives and consequently detrimental to cost, time and quality targets. During the design development stage when cost estimates are being prepared, risks are associated with the level of project information available. (Odeyinka et al. 2010) explained that the smaller the level of information available at the early stages of a construction project, the higher is the level of risks and uncertainties. This view was shared by (Taroun et al. 2011) and (Zou et al. 2007). Thus, as project information increases, risk is expected to decrease.

Traditionally, risks in design cost estimates and tender sums are covered through the allocation of contingencies in construction projects. (Bello and Odusami 2008) have indicated that contingencies are often calculated as an across-the-board percentage addition or lump sum on the base estimate typically derived from intuition, past experience and historical data. For example, the (Christchurch City Council 2011) explained that a contingency sum of NZ$192 million was added as a lump sum to the base estimates submitted as the expected or most likely cost for the Christchurch (a New Zealand city) infrastructure rebuild. This conventional approach has been criticized and is a reason why so many projects are completed over budget (Bello and Odususami 2008). Effective risk management requires the integration of risk management techniques into the estimation of construction projects’ cost other than application of common sense and instinct in order to curb cost and time overrun (Farinloye et al. 2009). More analytical and scientific methods have evolved in construction risk assessment.

The overall aim of this study is to signify the design stage cost estimating as a function of risk-contingency reserve, with a view to providing a review of the risk elements inherent in preparing design stage cost estimate, and identifying various factors affecting design stage cost estimating accuracy in construction practice by demonstrating the theoretical context. This paper is intended as a preliminary literature review, prior to full research project aimed at developing a predictive model that will assist construction industry practitioners in New Zealand to have a better and reliable prediction of a final tender sum of building project from the cost plan.

LITERATURE REVIEW

Risk and contingency in construction

Risks are present in all construction projects but can be managed, minimized, shared, transferred, or accepted, they cannot be ignored (Larkin et al. 2012). The general consensus in literature is that when risks occur on construction projects, they impose detrimental effects on the main project objectives of cost, time and quality (Burtonshaw-Gunn 2009; Larkin et al. 2012). However, (Odeyinka et al. 2010) argued that this submission does not consider the possibility of a positive outcome
hence they viewed risk as an event which would have either a positive or negative effect on the achievement of project objectives upon its occurrence. According to the (Association for Project Management 2006) risk is an uncertain event or a set of circumstances which its occurrence will have an impact on the achievement of one or more project objectives. These views consider the fact that the effect of risk on project objectives could be either positive or negative. Therefore, in order to embrace the common practice usage of the word risk, this research embraces the view that the benefits of positive impacts of risk on project objectives will be achieved by minimizing risk occurrence and its detrimental impacts.

Contingencies are crucial to achieving project objectives; they are therefore defined as estimated funds included in development budgets to provide managers with the flexibility required to address risks and uncertainties that threaten achievement of project objectives (Bello and Odusami 2009). (Tseng et al. 2009) defined and explained this further, in the context of owner’s perspective, as the budget which is made available to cope with risks and uncertainties that would incur schedule and cost overrun. Thus, this can be interpreted as the amount of money that must be added to the base budget to account for the work that is difficult or impossible to identify at an early stage of the project life cycle.

A key component of a project cost estimate is the contingency fund; hence an accurate design cost estimate is an important ingredient for successful project delivery. According to (Musa et al. 2011) the accuracy of design stage cost estimate is measured by the magnitude of deviation between the design stage cost estimate of a project and its actual cost or final tender sum. He further noted that if an appropriate risk-contingency reserve is allowed, it addresses most of the risks associated with a project. Hence, the relative percentage variance between the design cost estimate and the final tender sum or actual project cost is expected to be less when a contingency is included in the base estimate than when it is not. Based on their findings, it was concluded that a project’s budgeted cost or final tender sum exceeds its initial estimate by an average value of 5.07% where contingency is applied and by an average value of 9.52% where no contingency is applied. This further indicates that there is a need for a risk-contingency allowance to ensure an accurate project cost estimate and is employed to cover the risks present in a construction project in order to avoid project objectives in terms of cost, time and quality targets being threatened.

**Design stage cost estimating and its inherent risk**

Design stage cost estimating has significant relevance to design stage cost planning as both sit between the conceptual planning phase and tender action phase of development process. Hence both are performed between the preliminary sketch plans / final sketch plans stage and detail design / tender action stage with full recognition of the plan of work or project development process.

At this point, it is extremely significant to consider design stage cost estimation as a function closely intertwined with the design process (Adafin 2000). The building design process is a complex interaction of skills, judgment, knowledge, information and time, which has as its objective the satisfaction of the client’s brief (Kirkham 2007), or demand for shelter within the overall needs of the society. The
quantity surveyor, as a member of the design team is charged with providing information on costs so that the designers could know the cost implications of their decisions. Hence, (Oyediran 1992) shared similar view that there is a need for the integration of cost information and design variables. This submission thus calls for a team approach in building design and the adoption of the Rawlinsons' New Zealand Construction Handbook on Cost Planning System Flow Chart in comparison with the Royal Institute of British Architects’ (RIBA) Plan of work for project development as shown in (Kirkham 2007; Rawlinsons Media Ltd 2011; Seeley 1996). However, (Ogunlana 1989) stressed that the design team is not constrained to conform rigidly to the plan of work in practice. Meanwhile, the Rawlinsons’ Cost Planning System Flow Chart is therefore devised to take cognizance of this team approach as the plan of work reflects a systematized procedure for taking design decisions with accompanying data to be incorporated at various stages of the design evolution. This clearly reflects the chronological development of project and the way in which the design stage cost estimates relate to the plan of work and cost planning process meant for design team operation. In view of the above expressions and within the context of the current study, design stage cost estimate is a forecast of the probable cost of a proposed building project and is produced only when some level of design information and project scope definition is available during the design stage, but tender documents are not available.

(RICS New Rules of Measurement 1 [RICS NRM 1] 2012) identified key elements that could be incorporated into a design stage cost estimate as contingency provision. These contingencies are to provide for risks associated with design development, construction, employer driven changes and other employer restrictive concerns:

- Design development risks (changes in estimating data, planning restrictions, legal requirements, covenants, environmental concerns, pressure groups, statutory requirements, procurement methodology and delays in tendering).
- Construction risks (site conditions, ground conditions, existing services and delays by statutory undertakers).
- Employer change risks (changes in brief, changes in scope of work, changes in quality of work and changes in time).
- Employer other risks (early handover, postponement, acceleration, funds availability, liquidated damages etcetera).

Furthermore, (RICS NRM 1 2012: 51) indicates the key constituents of a design stage cost estimate. This illustrates the base cost estimate as the total estimated cost of the building works, main contractor’s preliminaries and main contractor’s profit and overheads. Therefore, the base cost estimate contains no allowances for risk or inflation (that is, the risk-free estimate). Also, allowances for risk and inflation are to be calculated separately and added to the base cost estimate to determine the client’s cost limit for the building project concerned. At this point, it becomes apparent that the constituents of the risk estimates (11a-d) established in (RICS NRM 1 2012: 51) compare favorably with the risk elements covered with the contingency factors stated in (Smith and Jagger 2007: 231).
In comparison with the foregoing submission, (Smith and Jagger 2007) categorized contingency factors including the risks involved during cost planning stages especially from outline proposals / preliminary sketch plans onwards as:

- Planning contingency (planning restrictions, legal requirements, environmental concerns, statutory constraints etcetera).
- Design contingency (inadequate brief, aesthetics and space concerns, changes in estimating data, incomplete drawings, little or no information about M&E services etcetera).
- Contract contingency (variations encountered during construction).
- Project contingency (delays, disputes, inflation, fee negotiations etcetera).

From the foregoing analysis, it is concluded that design stage cost estimating provides cost data which assist the Architect in making design decisions with full recognition of the plan of work or project development process. The design stage cost estimate incorporates contingency provision to address the risks involved in construction projects as stipulated preferably in the RICS new rules of measurement. The lists of typical risks above for each of the categories are not meant to be definitive or exhaustive, but are simply a guide (RICS NRM 1 2012). In addition, the essence of having an elemental cost plan as a reliable budgetary tool is defeated if these risk estimates are not included and properly evaluated. Hence, project objectives regarding cost, time and quality targets become threatened.

**Accuracy in design stage cost estimating**

The view in construction management literature is that the accuracy of estimates should improve as design progresses. Thus, the estimator has more information on which to base predictions and project is better defined than at the early stages of design (Ogunlana 1989). Ideally, this study reflects precisely cost estimating at detail design stage of project development as this clearly demonstrates improvements by showing less values of error than at the previous conceptual and final sketch plans stages. Also, detail design stage reflects the stage at which cost checking confirms full cost plan produced by the quantity surveyor; hence both final cost plan and detailed design cost estimate at this stage could be compared with final tender sum or contract sum.

With reference to (Odusami and Onukwube 2008), accuracy of quantity surveyors’ estimates was defined as the deviation from the lowest acceptable tender received in competition for a project. Following (An et al. 2011) the accuracy of a design stage cost estimate can equally be defined as the difference between the actual cost and design stage cost estimate. The actual cost in this study being the final tender sum or contract sum, while the design cost estimate represents the cost estimate prepared specifically at detail design stage of project development. This, according to them can be measured by the error rate calculated from Equation (1):

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\text{Error rate} \, (\%) = \left( \frac{| \text{Actual Cost} - \text{Design Cost Estimate} |}{\text{Actual Cost}} \right) \times 100.
\]

In the context of this study, design stage cost estimating accuracy is an indication of the degree to which the contract sum of a project varies from the single
point value used as the design stage cost estimate of the project. Meanwhile, (Odusami and Onukwube 2008) opined that design stage cost estimating is usually carried out by the Consultant Quantity Surveyor on behalf of his client and is an attempt to forecast contractor’s tender sum before the design is finalized or before tenders are received. It is therefore important that estimates have to be as accurate as possible since they form the basis for tender comparison or negotiation, and underestimation may lead to difficulty in award decisions, or in some cases unrealistic negotiation targets. To this end, they further maintained that Quantity Surveyors are tasked to improve on the accuracy of their design stage cost estimates in order to ensure clients’ satisfaction.

Factors affecting the accuracy of design stage cost estimating

Accuracy of early cost estimates is a major concern for clients and cost engineers. Though, several researchers have long expressed their concern about cost estimating inaccuracies by recognizing that the accuracy achieved in cost estimating has been less than desirable (e.g. Ashworth and Skitmore 1983; Ogunlana and Thorpe 1987). Most important factors affecting contractors’ cost estimate according to (Enshassi et al. 2005) in their case study are: client’s financial status, type of current contractor workload and project location. In addition, based on (Akintoye 2000)’s findings, the most important factors identified as influencing project cost estimating practice include (1) complexity of design and construction, (2) scale and scope of construction, (3) method of construction, (4) tender period and market condition, (5) site constraints, (6) client’s financial position, (7) buildability, and (8) project location. He further concluded that those factors have a direct effect on productivity levels on site and performance of the construction project. In his work, he analyzed 24 factors that influence project cost estimating practice, but his work and that of (Enshassi et al. 2005) only focused on contractors.

In their study, (Odusami and Onukwube 2008) reported seven most important factors that affect the accuracy of pre-tender cost estimate in Nigeria based on the construction industry experience of Consultant Quantity Surveyors, which include (1) expertise of cost consultants, (2) quality of information and flow requirements, (3) project team’s experience of the construction type, (4) tender period and market conditions, (5) extent of completion of pre-contract design, (6) complexity of design and construction, and (7) availability and supplies of labor and materials. In their work, they highlighted 21 factors but concentrated on the perspective of consultants. According to them, it is believed that these factors may have effect on the accuracy of design stage cost estimate and taking them into consideration will definitely improve the accuracy of Consultant Quantity Surveyor’s preliminary cost advice to his client.

In summary, making reference in agreement to a thorough review of the related literature, (Ogunlana and Thorpe 1991) classified various factors affecting estimating accuracy into three broad categories as documented in (Jafarzadeh 2012) such as (1) project-based, (2) immediate environment-based, and (3) external environment-based categories. The first category reflected such factors as type, size, project duration, and the level of design information available. Factors included in the second category are number of bidders, ability of the estimator, local construction practices (i.e. geographical location of the project), resource availability, site access conditions, and
price movements in the immediate environment. Finally, factors accommodated by the last category are industry structure, state of the market, and price movements in the external environment. A diagrammatical illustration of these categories and their contributing factors is represented in (Jafarzadeh 2012: 16).

Risk estimate and contingency management
Risk estimates in design stage cost estimates are produced to identify the minimum likely, most likely, and maximum likely total costs for a project. The risk items to be considered are usually those which fall within the framework of the design stage cost estimate. In addition, it is also possible to estimate the likely totals for the risks related to the project as a whole thereby giving the client a truer perspective of the total risk he bears on a project. In this context, (Fidgen 1999) maintained that risk estimate is prepared to specifically identify the likely level of contingency fund required for a project. Also, being a schedule of all the identified risks, it is used as a management tool to aid control of the contingency expenditure. Moreover, contingency-fund management according to (Mukhtar 2008) is seen as the process of planning, allocating and controlling contingency fund towards the achievement of pre-determined project objectives. As explained by (Mukhtar 2008) contingency-fund is a special kind of provisional sum, and Clause 13 of Joint Contract Tribunal 1980 form provides that “Architect shall issue instructions with regard to the expenditure of provisional sum included in the contract bill”. Hence, contingency-fund being a special kind of provisional sum is only expended as directed by the Architect. As a result of this, the quantity surveyor is asked to estimate the amount required for the Architect or Project Manager to approve depending on the procurement system and contractual arrangement.

RESEARCH METHODS
This study is a theoretical research based on literature review with a view to examining design stage cost estimating as a function of risk-contingency reserve by demonstrating the theoretical context. In addition, the literature sources were accessed through databases which provided numerous academic journals and conference papers. Also, some textbooks found to be useful to the research process were referenced. A comprehensive literature survey was carried out towards securing the design stage cost estimate as a reliable budgetary tool for building projects through risk-contingency analysis that guarantees cost certainty.

FINDINGS FROM THE LITERATURE
It becomes evident from the review of related literature that the RICS New Rules of Measurement 1 2012 has established a standard comprising the key constituents of a design stage cost estimate which simply illustrates base cost estimate (risk-free) with separate allowances for risk and inflation calculated and added to the base estimate to determine the client’s cost limit for the building project concerned. As can be seen from (RICS NRM 1 2012: 51), the risk elements involved are design development risks, construction risks, employer change risks, and employer other risks. It becomes apparent that the constituents of the risk elements established in the (RICS NRM 1 2012: 51) compare favorably with the risk elements identified by other
authors as reflected in the literature review. Thus, the essence of having an accurate design stage cost estimate as a reliable budgetary tool is defeated if the risk estimates as expressed above are not incorporated or not properly evaluated if incorporated as a contingency-reserve.

Another important outcome of the review of literature is the classification of the various factors affecting design stage cost estimating accuracy into three broad categories. The insight gained from the submission suggested the classification as (1) project-based, (2) immediate environment-based, and (3) external environment-based categories. However, this insight provided direction for positioning this study within the various observable factors for application in professional practice.

In addition, it was explored that majority of quantity surveying practitioners use lump sum and percentage addition approaches for estimating project risk-contingency fund. This probabilistic approach is prominent in quantity surveying practice in New Zealand construction industry. A typical example was the contingency sum of NZ$192 million added as a lump sum to the base estimate submitted as the most likely cost for the Christchurch infrastructure rebuild in 2011. This is an unscientific approach and a reason why so many projects are completed over budget.

CONCLUSIONS AND RECOMMENDATIONS

The aim of this paper is to provide a preliminary literature review, prior to a full research project aimed at developing a predictive model that will assist construction industry practitioners in New Zealand to have a better and reliable prediction of final tender sums of building projects from the elemental cost plans. Extant literature has indicated that risks have an impact on the deviations experienced during the design development stage between design cost estimates and final tender sums. The assessment of these risk elements could assist in determining the final tender sum from the design cost estimates. The review of relevant literature suggests that the essence of having the design cost estimate as a reliable budgetary tool that guarantees cost certainty for building projects is secured if the risk elements are properly evaluated. Hence, project objectives regarding cost, time, and quality targets are threatened. Moreover, the New Zealand Institute of Quantity Surveyors (NZIQS) is therefore tasked to produce a practice standard such as the RICS New Rules of Measurement Order of Cost Estimating and Cost Planning for Capital Building Works for use in quantity surveying practice in New Zealand.

The second conclusion from this preliminary study is that the factors that affect design stage cost estimating accuracy must be given adequate consideration in the construction estimation process to secure an accurate design stage cost estimate as a reliable budgetary tool that guarantees cost certainty for building projects.

The government establishment in New Zealand can also develop a scientific method of estimating risk-contingency reserve that can be used as a benchmark for effective performance of project contingency; this is the practice in the United Kingdom and Hong Kong. Researchers and professional bodies like the New Zealand Institute of Quantity Surveyors can take up the challenge of encouraging the use of scientific methods and developing predictive models that are reliable in forecasting construction contingency.
REFERENCES


AREAS OF CONCERN FOR CORRECTION

Corrections have been effected on the following areas of concern as requested:

Reviewer’s Comments: The paper presents a good overview of the existing studies on the topic. However, as the authors recognized, the paper is preliminary based only on the literature review on the topic that has been widely studied. The importance of the risk analysis and contingencies is well known. There is no original and significant contribution to the state-of-art or practice from this study. Findings have been presented before the methodology – it would have been better to present the methodology before the findings.

Response: Though, this topic has been widely studied but such studies are not based on New Zealand as a study area. This point is clearly noted in the paper. The research in its wider form aims towards developing a predictive model that could assist the construction industry practitioners in New Zealand to have a better and reliable prediction of final tender sum from cost plan. Preliminary research investigations coupled with anecdotal evidences have indicated that such a model will be beneficial. This partly reflects its originality as it is strictly based on New Zealand as a study area. Please check the Abstract, Introduction and Conclusion and Recommendation sections of this piece of work for confirmation. Also, an adjustment has been effected on the paper presenting the methodology before the findings. Thank you.