SCAFFOLDING INDUSTRY KNOWLEDGE ON ERRORS IN CONSTRUCTION ESTIMATES

Oluwole Allfred Olatunji*

School of Architecture and Built Environment, Faculty of Engineering and Built Environment, University of Newcastle, Callaghan, NSW, Australia
** Corresponding author (oluwole.olatunji@newcastle.edu.au)*

ABSTRACT: The construction industry has had considerable criticisms on inefficiencies in the quality and outcomes of professional services in project delivery. These criticisms have spanned design, estimating, procurement and construction, whilst a range of manifestations of inefficiencies have been reported in forms of errors, conflicts, omissions, mistakes and descriptive ambiguities. Although, there is strong evidence in literature regarding how these issues are triggered and how specific efforts can be targeted at some improved technologies and process-driven solutions in the interest of efficient outcomes, however existing knowledge about the forms of each indicator of inefficiency is somewhat superficial. Specifically, issues such as the complex nature of construction risks, slow uptake of some deliverables of digital innovations, professionalism and ambiguity in clients' requirements have been eloquently argued as common triggers of inadequacies in some outcomes of professional services in the construction industry. This studies reviews different forms of estimate errors in construction.

***Keywords**: Construction Costs, Estimating Practice, Errors, Project Delivery, Professionalism*

1. INTRODUCTION

Inadequacies in professional service delivery have many descriptors. In this study, forms and impact of errors in construction estimates are considered. Although, estimators are often blamed for estimate errors, there is no significant evidence to suggest that a particular discipline in the construction industry is guiltier on estimates' errors than others as these errors are possible products of actions and inactions of every stakeholder in the project team. However, there are different opinions in literature on what forms an estimate error and the impact such specific type of error would have on project delivery. For example, a survey by [1] indicates that clients are satisfied with overestimates while [2] argued otherwise that imprecise estimates could trigger outcomes which can jeopardize clients' interests. In a way of exploring how to deal with estimate errors, this study theorizes different forms of estimate errors involving construction costs.

2. FORMS AND NATURE OF ESTIMATE ERROR

Estimate errors are very popular but they are under-researched in construction literature. Instead, research efforts have concentrated on process re-engineering and improvements [3, 4]. Citing [5], [6] indicated that BoQ-generated estimates account for less than five percent of change orders in Australia. This study also cited [7] in identifying some categories of errors in the documentation of construction estimates. Such includes work quantification error in which quantities of work to be executed by the contractor are wrongly measured, under-measured, omitted and wrongly described. The authors also agree that the use of SMMs is problematic as their often too complex and wrongly interpreted. Other authors such as [8, 9] have identified complex problems in pricing and resourcing. Based on this background, these forms of errors are described elaborately below.

2.1 Quantification errors

Estimates are based on the quantity of work to be executed in a contract [10]. However, this important responsibility is frequently compromised in estimating processes. Some studies have provided possible reasons for this; whilst [11] blame this on design errors, [1] argued that some errors are justifiable by ambiguity in client's requirement during very early stages of construction processes. Other studies have also indicated other reasons: [12] and [13] identified estimators' inexperience and tactical deficiencies, whilst [14] identified size and complexity

of projects as factors that could trigger quantification errors. These errors manifest in a wide range of ways, including:

- *Mistakes in measurement:* This is a common problem in estimating practice. It could arise as a result of wrongful application of SMM rules or lack of reference guides on some particular aspects of a job. It includes wrongful deployment of units (e.g. measuring reinforcement in volume instead of weight or paint in volume instead of superficial area). This problem can be reduced drastically by adopting best practice models on knowledge transfer between very experienced estimators and new entrants to the practice, as well as the deployment of suitable technologies which are targeted at these problems.
- *Arithmetic errors*: Simple arithmetic operations are very frequent in quantification processes. It involves simple arithmetic operations on variables of similar attributes, aggregation of page and section estimates, and project summaries. Because of large quantity of data which are used in estimating, and are often presented in manual forms, it is not unlikely that arithmetic errors are frequent. Even when data processing tools are used, there could be data entry problems which would result into unnoticed errors. This problem can also be worsened by excessive pressure under which estimators work, especially when given limited time to turn in bids [15]. To control this, clients often conduct arithmetic checks on bids before contract documentation.
- *Process errors:* There are industry standards on estimating procedures. This includes taken-off, abstracting, working up quantities, bill drafting, cost data collection, resourcing and pricing. [16] have indicated that these processes are instrumental to the accuracy of an estimate. However, an undetected error in any of these process activities could extend to the final estimates. This could be in form of omissions, amorphous descriptions, typographical errors and misplacement of activity descriptors.
- *Data extraction and transfer error:* In estimating, data are often extracted from drawings, specifications, cost and resource databases, and bill of quantities. Once data from these sources have been processed, they are often packaged in project estimates in form of bid price, project, resource, site and management plans. They can also be built into project databases and libraries. In a procedure described by [17], a wide range of errors could be triggered by issues such as programming limitations, incompatibility between data exchange locations, computation and undeliberate errors in data management. [18] and [19] have also identified data management issues in estimating as coding errors, descriptor problems, handler's errors and software limitations.
- *Double or multiple counting:* As estimators attempt to predict the cost of a wide of work items in construction, it is often possible that they consider an item more than once; either as a whole or partially in multiple instances. A typical example of this has been illustrated by [20] while criticising a bid unbalancing model by [21]. It can also extend to multiple provisions for taxes and indemnity against damages, as well vague considerations for spot and provisional items.

2.2 Description errors

Construction project scenarios are uniquely complex. For this reason, effective communication has been a critical issue, especially around economic and product utility expectations. An effectively communicated description of work should be actionable, clear and simple to interpret, unbiased, detailed and undisputable. While communication between process fragments is a frequent problem, more serious concerns have been indicated on the inability of project documents to provide unambiguous descriptions of what is needed to be done and how. As identified by [6], poor description of work items in estimating documents could frustrate contractors and project

goals, and this often occur in a number of ways including the following:

- *Standardization issues*: Estimators often rely on *Standards* to make professional judgments on items of work being estimated. However, these documents are not perfect; they have been criticized to be out of date, not universal, incomplete and easily misinterpreted [6]. A way out of difficulties arising from these has been suggested by [22] as developing an estimate based on the peculiarity of the project. Meanwhile, standardization errors in estimating processes include incomplete and ambiguous descriptions, conflicting and un-actionable reference, and inappropriately worded descriptions.
- *Misinterpretation:* Resource materials on measurement (e.g. SMMs, Contract Conditions, Productivity output rates) can be misleading and misinterpreted. [6] cited [7] in alluding that SMMs are too complex and are easily misinterpreted or may have a wide range of interpretations. There can only be few consequences of this: deficient descriptions which frequently trigger disputes and project failures.
- *Rigidity issues*: Construction innovations are not static; the relevance of construction economics disciplines to other industry has also escalated in the past decades [23]. However, estimating processes are often based on largely rigid resources such as SMMs which are few decades old. In the conclusion of [6], it is clear that SMM-based estimating may lose its popularity unless a more effective alternative is provided.

2.3 Tooling errors

Estimators use tools such as calculators, digitizers, calibrators, printers, computer systems, and a wide range of general and purpose-made applications to do their works. While none of these is immune to technical faults which are likely not to be detected easily and early, these tools could also be susceptible to technical limitations such as inability to work under certain conditions, low work load limit, inability to work well with other tools and limited technical support. These, coupled with possible deficiencies in estimators' knowledge and use of these tools, could trigger severe consequences on estimating processes and their outcomes [24]. The manifestations of tool-based error are described as follows:

- *Software problems*: Software applications are very useful in reducing process times and increasing artificial intelligence. However, it is a common knowledge that there is no perfect software [25]. Although there is no empirical evidence on the extent to which this has affected estimating practice in the construction industry, however in many instances, estimating errors arising from software problems could be traced to:
    - Software construction
    - Faults from programme performance frameworks
    - Errors from a secondary source, including sourced data from other software
    - Hardware problems
    - End-users' inappropriate use.
    - Inability to interact perfectly with other applications.
- *Obsolesce of standards*: As argued earlier, estimators work with standards. [26] have explained the evolution of information technology in the estimating industry, especially the use of description libraries and databases for automatic estimating. This innovation does not also remove the limitations of standards being referred to (See *Section 2.2* above). Moreover, regardless of the goal an estimate is targeted to achieve, estimators' reference to practice standards is predicated on the ability of such standards to drive accuracy. However, these standards are not static. When built into a programme, such applications must be updated frequently as reference standards are reviewed. Apart from the possibility that the program can mis-apply the standards [27], end-users can create similar problems

with the applications and the standards. Therefore, when estimating tools are as obsolete as the standards, certain efficacies of estimating outcomes may be compromised. When standards are reviewed and applications are not, estimating processes can yield contradicting outcomes. When applications are updated and the standards are not, the impact on the efficacy of the estimating processes may be minimal.

2.4 Processing errors

Estimators rely on processing a large proportion of data from a diverse range of sources before they make many of their decisions. These data could be sophisticated, somewhat not definitive and not well connected to a new scenario where they will be applied. Moreover, due to their nature, errors in processing these data often appear in different forms:

- *Data handling errors*: These are not limited to data capture, coding and editing errors; they also appear in form of bias and variance. Processing biases are triggered by inefficiencies in processing systems. An example is when there are errors in the coding system of an application, such errors may be escalated to other parts of the processing system discretely, and this may result into problematic outcomes. On the other hand, errors arising from processing variance are caused by random input errors. Examples include keying mistakes, errors in the use of decimal points and conflicting inputs. It is often possible that these errors are not detected early.
- *System errors*: Estimate data can be processed wrongly due to random system errors [28]. These may lead to omissions, partial inclusion and conflicting outcomes. These problems are relative to latent programming issues than what can be corrected simply by end-users.

2.5 Packaging errors

Packaging is an important part of marketing a professional service. The core of technical services rendered by construction professionals is as important as how it was packaged and presented to the client. An effective way of packaging a construction estimate starts with how trustworthy are what is being presented in the estimate in terms of transparency, language and useability of content and context, and relevance to project goal. It is not impossible that certain contents of a packaged construction estimate could be missing at time of tendering.

2.6 Strategic errors

Some forms of errors are deliberate; some contractors may elect to present a wrongly priced tender in order to fall within a range of competitive bids. Whether contractors are pre-qualified or not, estimating for competition and producing realistic estimates for a job are not quite the same [29]. Parts of the scenarios for this dichotomy, especially as per how errors are deliberately used as bid winning tools have been listed in literature as follows:

- According to separate models for unbalancing a bid by [30] and [31], contractors can identify errors in tender document and take an advantage of this in pricing. In the end, when such items are re-evaluated, the contractor may make substantial profits, over and above what is obtainable when such errors were not present.
- Rather than bothering on what is realistic and what is not, the most important factor for a contractor to stay in business is to overcome competition. According to [29], most contractor will only take note of the production cost to them while the estimated real construction price to the client remains partly undisclosed.
- The cyclical nature of construction economics provides a window of opportunities for contractors to utilize macro-variability in strategizing bid pricing errors. Such errors are only valid for a short time due to rapid price changes in cost determinants. Therefore, determining new prices for these items could be inevitably contractual, and to the advantage of the contractor.

- Another perspective to bid unbalancing has been identified by [32] as some strategic ways of deliberately manipulating the science of tender pricing. According these authors, whichever perspective is adopted while balancing an estimated project price; whether mathematically or *materially*, neither the client nor the project goal is favoured.

3. CONCLUSION

Studies on mitigating the impact of errors have focused on investigating the causes and sources of estimate errors, however there is limited clarity on the form of errors being referred to. This study has reviewed possible forms of error and specified directions of mitigating actions for each type. Studies on the applications of information technology for estimating services appear to be inconclusive to a large extent. Studies like [33-35] have superficially listed how computer applications are used for estimating processes. However, it is yet unclear how these applications definitively impact on estimating process. As pointed out by [36], there can be several negative sides to the proliferation of estimating applications in the construction industry. Therefore, there is need to study estimating applications by their performance framework so that it can become easy to tell whether specific estimating goals can be met or not when such applications are deployed on estimating processes.

REFERENCES

[1] Cheung, F.K.T., M.W.L. Wong, and M. Skitmore, *A Study of Clients' and Estimators' Tolerance towards Estimating Errors. Construction Management and Economics*, 2008. **26**(4): p. 342-362.

[2] Poon, J. *Professional ethics for surveyors and construction project performance: what we need to know*. in *Proceedings of Construction and Building Research (COBRA) Conference*. 2003: Royal Institution of Chattered Surveyors (RICS) Foundation.

[3] Kagioglou, M., R. Cooper, and G.F. Aouad, *Performance management in construction: a conceptual framework.* Construction Management and Economics, 2001. **19**(1): p. 85-95.

[4] Stewart, R.A., *IT enhanced project information management in construction: Pathways to improved performance and strategic competitiveness.* Automation in Construction, 2007. **16**(4): p. 511-517.

[5] Choy, W.K., *The magnitude of errors and omissions in Bills of Quantities leading to variations*, in *Louis Laybourne Smith School of Built Environment*. 1991, University of South Australia: Adelaide.

[6] Davis, P.R., P.E.D. Love, and D. Baccarini, *Bills of Quantities: nemesis or nirvana?* Structural Survey, 2009. **27**(2): p. 99 - 108.

[7] New South Wales Public Works Department (NSWPWD), *Submission to the Royal Commission - Bills of Quantities*. 1992, NSW Public Works Department, : Sydney. p. pp. 1-31.

[8] Sinclair, N., P. Artin, and S. Mulford, *Construction Cost Data Workbook*, in *Conference on the International Comparison Program*. 2002, The World Bank: Washington, D.C.

[9] Sawhney, A., K.D. Walsh, and A. Brown, *International comparison of cost for the construction sector: towards a conceptual model.* Civil Engineering and Environmental Systems, 2004. **21**(3): p. 151-167.

[10] CIOB, *Code of Estimating Practice*. 7th Eds ed. 2009, Ascot: Wiley-Blackwell Publishing.

[11] Acharya, N.K., Y.D. Lee, and H.M. Im, *Design Errors: Tragic for Clients.* Journal of Construction Research, 2006. **7**(1&2): p. 117 - 190.

[12] Ogunlana, S.O., *Accuracy in Design Cost Estimating*. 1989, University of Technology: Loughborough, UK.

[13] Lowe, D.J. *Effective feedback and systematic reflection in design cost estimating*. in *14th Annual ARCOM Conference*. 1998. University of Reading, UK: Association of Researchers in Construction Management (ARCOM).

[14] Aibinu, A.A. and T. Pasco, *The accuracy of pre-tender building cost estimates in Australia. Construction Management and Economics*, 2008. **26**(12): p. 1257 - 1269.

[15] Leung, M.-Y., S.T. Ng, and M. Skitmore, *Critical stressors influencing construction estimators in Hong Kong.* Construction Management and Economics, 2005. **23**(1): p. 33 - 43.

[16] Potts, K., *Quantity surveying tools and techniques - a review of client and contractor requirements*, in *The international construction research conference of the Royal Institution of Chartered Surveyors* R. Ellis and M. Bell, Editors. 2004, The Royal Institution of Chartered Surveyors (RICS): Headingley Cricket Club, Leeds

[17] Sher, W., *Computer-aided Estimating - A guide to Good Practice*. 1996, Harlow: Addison Wesley Longman Limited.

[18] Chou, J.-S. and J.T. O'Connor, *Internet-based preliminary highway construction cost estimating database.* Automation in Construction, 2007. **17**(1): p. 65-74.

[19] Moon, S.W., J.S. Kim, and K.N. Kwon, *Effectiveness of OLAP-based cost data management in construction cost estimate.* Automation in Construction, 2007. **16**(3): p. 336-344.

[20] Cattell, D.W., P.A. Bowen, and A.P. Kaka, *Review of Unbalanced Bidding Models in Construction.* Journal of Construction Engineering and Management, 2007. **133**(8): p. pp. 562-573.

[21] Ashley, D.B. and P.M. Teicholz, *Pre-Estimate Cash Flow Analysis.* Journal of the Construction Division, 1977. **103**(3): p. 369-379.

[22] Ehlen, M.A., *Life-Cycle cost of new construction materials.* Journal of Infrastructure Systems, 1997. **3**(4): p. pp 129 - 133.

[23] Nkado, R. *Competencies Required by Quantity Surveyors in South Africa*. in *Proceedings of ARCOM Conference*. 2000. Glasgow Caledonian University Association of Researchers in Construction Management (ARCOM).

[24] Loehle, C., *Errors of construction, evaluation, and inference: A classification of sources of error in ecological models.* Ecological Modelling, 1987. **36**(3-4): p. 297-314.

[25] Shatnawi, R. and W. Li, *The effectiveness of software metrics in identifying error-prone classes in post-release software evolution process.* Journal of Systems and Software, 2008. **81**(11): p. 1868-1882.

[26] Sher, W., *Computer applications in the construction industry.* The South African Builder, 1982. **61**(4): p. pp 70 - 72.

[27] Deeprasertkul, P., P. Bhattarakosol, and F. O'Brien, *Automatic detection and correction of programming faults for software applications.* Journal of Systems and Software, 2005. **78**(2): p. 101-110.

[28] Arkhipova, T.T. and I.V. Sergienko, *Formalization and solution of certain computing-process-organization problems in data-processing systems.* Cybernetics and Systems Analysis, 1973. **9**(5): p. 727-736.

[29] Skitmore, R.M. and B.R.T. Patchell, *Development in contract price forecasting and bidding techniques*, in *Quantity Surveying Techniques: New Directions*, P.S. Brandon, Editor. 1990, Blackwell Scientific. p. 75-120.

[30] Diekmann, J.E., R.H.J. Mayer, and R.M. Stark, *Coping with Uncertainty in Unit Price Contracting.* Journal of the Construction Division, 1982. **108**(3): p. 379-389.

[31] Yizhe, T. and L. Youjie, *Unbalanced bidding on contracts with variation trends in client-provided quantities.* Construction Management and Economics, 1992. **10**(1): p. 69 - 80.

[32] Arditi, D. and R. Chotibhongs, *Detection and prevention of unbalanced bids.* Construction Management and Economics, 2009. **27**(8): p. 721-732.

[33] Ahuja, V., J. Yang, and R. Shankar, *Study of ICT adoption for building project management in the Indian construction industry.* Automation in Construction, 2009. **18**(4): p. 415-423.

[34] Baldwin, A.N. and A. Thorpe, *Information technology for construction cost estimating.* Habitat International, 1990. **14**(2-3): p. 157-163.

[35] Best, R., et al. *Information Technology and evolution of Quantity Surveying profession - future direction*. in *International Construction Information Technology Conference INCIT 96 Proceedings: Bridging the Gap*. 1996. Sydney, N.S.W: National conference publication (Institution of Engineers, Australia).

[36] Akintoye, A. and E. Fitzgerald, *A survey of current cost estimating practices in the UK.* Construction Management and Economics, 2000. **18**: p. 161-172.