

Analysis of Tender Sum Forecasting by Quantity Surveyors and Contractors in South Africa

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Abstract

Although extensive research has been undertaken on the accuracy of quantity surveyors' tender price forecasts, very little of this research contains information relating to the factors affecting tender sum forecasting by quantity surveyors and contractors. The primary objective of this empirical study was to gain insight into the factors influencing both quantity surveyors' and contractors' tender price forecasts. This was achieved through an analysis of tender information relating to 278 projects for a fifteen year period and collected from 30 quantity surveying practices and the tender records of the Cape Peninsula Master Builders & Allied Trades Association (MBATA).

The analysis of South African tender information reported in this paper indicates an average forecast performance by quantity surveyors of 8.33% (std dev. = 11.183, CV = 134.2%). The variability of contractors' tenders ranged from 0.37% to 46.53%, with a mean of 5.65% (std dev. = 5.22, SE = 0.313). Furthermore, there is no evidence to suggest that forecast performance is dependent on type of project, client, function of project, size of project, location of project and number of bidders. The contractor's results suggest that local authority projects are associated with high variability of their tender sum forecasts. The only factor which shows significance for quantity surveyors is the date of tender which may tend to point to the importance of market conditions and economic cycle in the tender sum forecast performance of South African quantity surveyors.

Introduction

Numerous authors (Barnes, 1974; Adams and Busch, 1981; Bennett *et al.*, 1981; Flanagan and Norman, 1983; Betts and Gunner, 1989; Kwakye, 1994) have commented that absolute accuracy is virtually impossible to achieve in building price forecasts. The issue of what comprises an "acceptable" degree of accuracy is inevitably linked to the aspect of expectation of performance by the client on the one hand, and achievement level of the estimator on the other.

Before any analysis of the accuracy of price predictions can logically be undertaken, consideration needs to be given to an appraisal of what is meant by the term "accuracy". Previous attempts at defining accuracy in terms of price forecasting in the building industry are questionable, most being based on the recognition of an "absence of error" when comparing the estimate with the price for which the work is

contracted. Flanagan and Norman (1983) remark that this suggestion that the smaller the error, the higher the accuracy, and *vice-versa*, whilst being partially true, is naive inasmuch as it requires a further definition of error.

Rapier (1990), however, suggests that for capital cost estimating "*estimating accuracy is the degree of conformity of the estimate (our measure) to the final as-built project cost (our true value)*". This definition suffers from the failing that no indication is given of what extent of non-conformity is unacceptable, and would consequently be termed "inaccuracy".

The proposal by True (1988) that accuracy is "*the percent of difference between the estimated value of the product or work as compared to the price for which the product or work is contracted*", although hinting that the process is quantifiable, is incomplete in terms of the need to provide parameters of acceptability.

Raftery (1987) introduces a different approach, when stating that the term should be considered in relation to "*the etymology of the word 'accuracy' itself (exact, correct, from the latin 'accuratus', meaning performed with care)*"; suggesting that it should be used to denote correctness or care in performance.

In this paper it is argued that an acceptable definition of the term, as applied to price forecasting in the building industry, should be based on the rationale of Raftery (1987) given above, but additionally linking the performance to that which could reasonably be expected of an informed and suitably experienced estimator.

Bias, consistency and precision

Forecasting performance is often identified as consisting of two main properties; bias, which is concerned with the average of the differences (error) between prices and forecasts, and consistency, which is concerned with the degree of variation (dispersion) about the average (Skitmore, 1990; Gunner and Betts, 1990; Gunner and Skitmore, 1999).

Many practitioners appear to confuse accuracy with precision (Pearl, 1992). The two principles are totally different; it being quite possible to be precise, but inaccurate, and *vice versa*. The overall quality of performance of the forecaster is usually considered in terms of the relationship between estimates and contract bids. The decision to measure the quantity surveyor's estimating performance against the accepted (normally the lowest) tender, means that the assessment of accuracy is partially dependent upon the variability of the tender(s) chosen for this purpose.

A number of measures of performance such as the range, mean deviation, standard deviation and co-efficient of variation are described in the literature as measures of "accuracy". In effect, however, the

blending of these units of measure tend to reflect **reliability** of estimates, combining precision, bias, consistency and accuracy.

Factors influencing tender sum forecast accuracy

It can be argued that the quantity surveyor's task in producing price forecasts should be to contemplate the same factors as the contractor takes into account in compiling the tender, so that the estimate produced reflects the actual project and its particular context, rather than an ideal or average situation otherwise presented. A brief review of published research on factors affecting the performance of both design team price forecasters and contractors is necessary to identify the principal features requiring detailed study.

Quantity Surveyors

A study by Pearl (1992) indicated that the expertise of the price forecaster and adequate and representative historical price data are the two most influential factors affecting the accuracy of pre-tender price forecasts produced by quantity surveyors in South Africa.

Numerous other studies on the factors affecting estimating accuracy have been undertaken in other countries. Beeston (1975), Bennett *et al.* (1981), Ashworth and Skitmore (1982), Flanagan and Norman (1983), Morrison (1984), Skitmore (1987a), Skitmore and Tan (1987), and Betts and Gunner (1989) address a wide spectrum of issues affecting consultant's price forecasting performance. These are summarised by Ogunlana (1989) in attempting to establish the most important elements with respect to estimating accuracy.

The factors examined in the above studies include those related to project characteristics such as the type, size, duration and geographical location of the development; tender issues, including the number of bidders and the economic state of the construction market; the level of information available; and the ability of the estimator. The factors discussed below are those which have been highlighted by previous researchers as being the most influential in price forecasting performance.

Type of project

An examination of this factor needs to consider, firstly, the form of construction indexing, i.e. a classification structure such as the CI/SfB system, and secondly, what sub-division within each form should be separated.

With regard to the building type to be identified, the researcher is essentially faced with a decision as to whether to use a formally identified structure (e.g. CI/SfB building classification system), or to rely on a subjective classification of building types, based on typical use. Further subdivision such as project value and floor area / volume are dealt with separately under the heading of 'project size'. The issues of

quality, structure type, and plan shape, are considered under the section of 'project complexity'.

A further important consideration is whether any trend specific to a building type is caused by a strong relationship with one of the possible subdivisions referred to above (e.g. power stations being considered structurally complex); or if the trend is essentially due to the specific estimator being more familiar with a particular use of building (e.g. a quantity surveying firm handling many school projects).

A study of the literature reveals numerous examples of variable estimating performance between different forms of construction or building types. However, in many instances it is not easy to clearly determine the primary cause for such variance. For instance, a cause of variability in any set of figures could be that not all the estimates tested are produced by the same estimator, or by estimators with the same background or ability.

The evidence from the studies described below suggests that estimating accuracy achieved by consultants relates directly to project type.

McCaffer's (1976) analysis of 132 Belgian Public Works building projects and 168 Belgian road projects reveals that the estimates for the building contracts are less accurate (5.2% mean underestimation) than those for the road projects (1.5% mean underestimation). Complicating this analysis however, is the fact that the estimates for the building projects are more consistent than those for the road contracts.

The results of Harvey's (1979) analysis of 2401 Canadian Public Works contracts let between 1973 and 1976 indicate that the accuracy levels of the building contracts in the large sample are generally slightly poorer than those for non-building contracts. A report produced in the same year by Merrow *et al.* (1979), describes unusually high inaccuracy levels in nuclear power plant estimates, implying that the level of accuracy achievable on 'new' or unique types of construction is very poor. This assertion is consistent with the record of substantial estimating errors occurring on 'one-off' structures and is ostensibly related to the magnitude of uncertainty on such contracts.

The Property Services Agency (1980) observe, from an analysis of the estimates obtained from six separate UK public sector quantity surveying offices, that housing and school projects are associated with higher degrees of accuracy than other building types. In addition, estimating tends to be better on types of projects on which the estimator has had extensive personal experience, such familiarity being associated with up to 40% improvement in forecasting accuracy.

Similar results are also reported by Skitmore (1985) in experiments conducted with a small number of quantity surveyors in which quite different low bid / estimate ratios are recorded between schools and houses on the one hand, and offices on the other.

The only analysis of this factor found to reflect a contrary opinion to that described above is that of Skitmore (1988). A total of 33 UK local authority building contracts of different types of use were examined, and no significant differences in bias of percentage errors between the project types nor any

difference in consistency was detected. The small sample size is possibly the reason for these different findings.

Project complexity

This is perhaps the most difficult factor to define in terms of a standard for measurement purposes. Tan (1988) states that complexity is also subject to changing technology; what is considered technologically complicated today may well be considered commonplace in a short period, due to advances through research, or continued application and development through experience / expertise.

The limited number of studies pertaining to aspects of this design feature deal either with (a) design aspects such as plan shape or complexity of design detail, or (b) the differences between 'new' building work and alterations to existing structures.

Tan (1988), in analysing the results of his study of 67 construction projects for NASA, contends that the projects classified as "sophisticated" and those with a plan shape described as "very irregular" are the most consistently accurately estimated with an underestimation of less than 0.5%. However, Skitmore (1988), in referring to the same data, presents a contradictory opinion. In his view, consistency of estimates generally deteriorates with increasingly complex designs.

In analysing 33 Local Authority building projects, Tan (1988) indicates that the accuracy of estimates of alteration work is higher than those of new build construction. Skitmore (1988), in commenting on these projects, notes that the alteration work is less biased than the 'new building works', but places the findings in their correct context by observing that, because of the limited sample sizes, in none of the instances quoted is the magnitude of the results significant .

The complexity factor is likely to be more significant in the decision-making process in the very earliest stages of design development than at the pre-tender stage. The ability to conceive, and allow for extra costs due to complexities in the initial phase of project development could be a significant factor in assessing the expertise of an estimator.

Project size

Recognition of the effect that project size has on price forecasting performance appears at first to be easier to establish than for some of the other factors studied. However, closer examination indicates that the forecaster is faced with a complex situation, involving consideration of aspects as diverse as the measurement of the physical properties of buildings, and the psychological approach to the compilation of tenders by contractors.

'Project size' can be construed to mean the physical parameters of the building (e.g. height, area, volume), or a defined interpretation associated with the 'value' (i.e. either cost of erection, price paid by client, or intrinsic value to a party).

The only study found linking price forecasting performance and physical measurements of buildings is that of Tan (1988). Tan notes, from the analysis of the 67 projects built for NASA, that consistency of estimates improves with increasing floor area. However, he also comments that a similar analysis of 33 buildings erected for a local authority in the UK reveals no apparent trend of this nature.

A complication when reflecting on appraisals based on building value, is that many authors refer to 'small' and 'large' projects without due attention to what these terms may convey. From the perspective of the consultant quantity surveyor, a small firm (possibly comprising only a sole proprietor, such as is common in South Africa - see Billett, 1990) may consider a project of R 1 million as a 'large' project, while a larger firm may classify the same project as 'small'.

In searching for reasons why larger projects may attract better estimating accuracy, Ogunlana and Thorpe (1991) suggest that a major cause could be the managerial aspect that favours keener cost estimating (tendering) in high value projects. In support of this theory, it is suggested that as construction cost estimates are costly to prepare, only large projects can justify devoting much time to this activity. Once more, no recognition is given to differing interpretations of worth to other parties. 'Small'

contracting firms may adopt a perfectly acceptable level of attention to the compilation of tender estimates for jobs of lesser value.

A large measure of contradictory opinion, with respect to the effect on forecasting performance of project size, is presented in the literature in both theoretical and empirical studies. A comprehensive literature search reveals that the only researchers suggesting that building size (value of contract) has no effect on the quantity surveyor's accuracy of price forecasting are McCaffer (1976) and Wilson *et al.* (1987).

Even less support is provided for the belief that accuracy of estimates is reduced with increasing project size. The only evidence of such an opinion is provided by Harvey (1979) in her thesis on competitive bidding on Canadian public construction projects.

The vast majority of researchers appear to support the suggestion that quantity surveyors' estimating generally tends to improve with increasing project size. The Property Services Agency's (1980) comprehensive research study is the earliest reliable reference source indicating this opinion, although it is observed that contrasting results are found in different data sources used for the study.

Skitmore (1988), in commenting on Tan's (1988) research, notes that there is a general trend of improving accuracy with increasing contract value. This tendency appears to be fairly widespread, as indicated by the results of a statistical analysis carried out by Betts and Gunner (1989) on projects handled by an international firm of cost consultants in their Singapore offices. Similar results are achieved by Ogunlana and Thorpe (1991), and Mills (1991), in case studies on large numbers of contracts of varying value in the UK and Australia, respectively. In both instances the projects studied are arbitrarily divided into different value ranges.

Further to the above, Skitmore *et al.* (1990) conclude that price forecasters tend to under-estimate smaller and / or over-estimate larger size building projects. No reason is given for this phenomenon but it is possibly due to differing psychological approaches being adopted by estimators; such as the fear of possibly greater magnitude of repercussions relating to 'errors' on large projects - often done for major clients. This does not necessarily imply unprofessional conduct in respect of smaller appointments; merely a possible over-anxiety to perform well on the 'more important' projects.

Another interesting observation of Skitmore *et al.* (1990) is the implication that low price intensity contracts (based on rate per floor area) are more accurately forecast than high price intensity projects. Again, no reasons to explain this phenomenon are provided. However, it is presumed that while this may be relevant in the early stage estimating systems (e.g. single-price rate methods), it is unlikely to be applicable at the pre-tender stage if bills of quantities are utilised.

Notwithstanding the opinions expressed above, it would appear as if project size is strongly linked to other factors such as type of project, complexity, number of bidders, and quite possibly to individual estimators' pricing philosophy. Skitmore *et al.* (1990) reflect a similar view when commenting on the research of Flanagan and Norman (1983). The opinion is expressed that differences in relationships recorded between sets of data "*seem to indicate that, if a contract size (value) biasing effect does exist, it is not universal in either its strength or direction, but somehow dependant on the source of the forecast.*" (Skitmore *et al.*, 1990, p. 9)

Number of bidders

As expected, evidence indicates that the number of tenderers per project fluctuates according to the economic climate being experienced. The study by Hindle (1991), although reflecting a regional condition in South Africa, is likely to fairly represent the national situation, confirming this assertion.

There are mixed opinions with regard to the effect that the number of bidders has on tender prices. Wyskida (1986) is one of the few researchers to suggest that the number of bidders has no effect on tender price. Most researchers, including McCaffer (1976), Wilson *et al.* (1987), Skitmore (1987b), and Mills (1991) contend that, as the number of tenders increases, so the average value of the tenders fall. Runeson and Bennett (1983) observe that as the competition increases, not only does the price level fall,

but the accuracy of the contractors' cost estimates on which the tenders are based, is improved and the mark-up becomes more consistent.

Flanagan and Norman (1985) suggest little is to be gained from inviting more than five contractors with single stage selective tendering. Other authors appear to support this view (Drew, 1990; Mills, 1991), commenting that to call for a larger number of tenderers only adds to the cost of the tendering process. However, the studies conducted to date on the effect of the number of bids on the price forecaster's accuracy have not provided conclusive results.

Ogunlana and Thorpe (1991), in stating that the relationship between number of bidders on a contract and estimate accuracy evolves from the degree of competition amongst bidders, propose that as projects with more bidders are expected to provide wider variability between tenders, design price forecasts may consequently be less accurate. The probable effect of this condition is that prices will be lower than that anticipated by the estimator, possibly resulting in over-estimation.

Other researchers indicate that as the number of bidders increases, price forecasters' accuracy improves. Prominent amongst these authors are De Neufville *et als'* (1977) analysis of data on all new construction costing over \$100,000 by the Commonwealth of Massachusetts Bureau of Building Construction from 1961 to 1974. The result is a curved negative relationship between low bid / engineers' estimate ratios and the number of bids received.

The findings of Harvey (1979), Flanagan (1980), and Hanscomb Associates' (1984) analysis of low bid / engineers' estimate ratios on over 1100 US projects between 1977 and 1983, also indicate a significant trend of improved performance with increasing numbers of tenders.

Contrary to the findings of the majority of previous studies in the field, the results of Skitmore *et als'* (1990) experiments indicate that no correlation exists between competitive intensity and forecasting performance. More recent empirical evidence in support of this theory is provided by an analysis of 51 projects undertaken by Ogunlana and Thorpe (1991), showing no apparent trend in the mean accuracy.

The linkage of this factor with others requires careful consideration - an example being the assertion by Skitmore (1987b), citing De Neufville *et al.* (1977), that the good / bad year effect is separate from the number of bidders. This phenomenon requires to be studied carefully in other geographical locations such as South Africa, in order to establish the validity of their findings under different market conditions. Further, when studying the 'project size' factor, the situation in South Africa regarding the availability of contractors differs significantly from that commented upon in overseas literature. There are very few large contracting firms in South Africa that are able to compete for large projects. Although the effect of large numbers of tenderers on price forecasters' accuracy is expected to be the same as experienced overseas, it is anticipated that the result of combining project size and number of bidders may be entirely different.

Geographical location of project

Location exerts a powerful influence on the major components of construction cost and also on the

manner in which building design is performed. Avery (1982) identifies locational influences which may have an affect on the cost of executing work to any given design and consequently concerns tenderers as well as those engaged in forecasting tender levels. Features mentioned are: (a) remoteness from source of material supply, (b) labour cost and productivity, (c) water, power and sewage supplies, (d) water and power for the works and mechanical plant, (e) security, (f) climate and weather, (g) regional market conditions or climate of tendering, and (h) local tendering customs.

In South Africa, with its wide range of climatic and geographic conditions, virtually all of the above locational influences are considered pertinent. Even within relatively small geographic regions, certain of these factors may play an important part in the tendering strategy (e.g. differences in price levels of construction between neighbouring areas due to political violence). This allowance for 'local area' adjustments is often considered more difficult than that to be made for working in distant regions.

Conclusions drawn from overseas experience (which is minimally recorded) can be considered inappropriate for South Africa. It is of interest, however, to note that whilst Harvey's (1979) analysis of variance shows significant differences in estimating bias across the six Canadian regions studied, the results emanating from Ogunlana and Thorpe's (1991) empirical research are contrary to their expectations. Wilson *et al.* (1987) conclude their study by stating that it would appear as if location has no bearing on the accuracy of estimates.

Contractors

Few published papers reflect the impact of influencing factors on accuracy levels of contractors' estimates (Akintoye, 2000). However, the literature does point to the influence of certain factors such as project size and number of bidders, which are described below.

Project size / value

Only three reference sources dealing with this factor in relation to the tendering performance of building contractors, are referred to in the literature. The first study, presented by Drew and Skitmore (1990) dealing with the bidding performance of contractors on certain public sector projects in Hong Kong between 1982 and 1988, provides a number of interesting results. Their findings confirm Flanagan and Norman's (1982) contention that "tendering strategy in general is affected by the type of project and value range". The study by Shash and Al-Khaldi (1992) which relates to the production of construction cost estimates in Saudi Arabia, similarly indicates that this factor has a major effect on the production of accurate estimates.

Number of bidders

Empirical studies indicate that under conditions where a contractor is forced by competition to lower the mark-up, there is a likelihood that this will be compensated for by attempting to improve the accuracy of

the cost estimate (Runeson and Bennett, 1983). It is reasoned that a greater number of tenders is likely to reduce the lowest bid (Beeston, 1983; Runeson and Bennett, 1983; Flanagan and Norman, 1985) and produce a larger range between the lowest and highest tender (Goh and Teo, 1992).

McCaffer (1976), in a survey of tenders on 168 road contracts, investigated the relationship between the low bid, the mean bid and the design engineers estimate, finding that the standard deviation of the differences decreases with the increasing number of bidders. A possible explanation for this phenomenon is that the nature of the projects leads to greater consistency in tendering on these contracts.

An awareness of the effect that the above factors can have on a tenderers' pricing strategies is important to design consultants. An understanding of these issues may be constructively used to refine pre-tender estimates and to select contractors for inclusion in tender lists.

The preceding review provides a summary of available literature on the measurement of accuracy in both quantity surveyors' and contractors' tender price forecasting. This provides a basis upon which the assessment of an empirical study of South African estimating performance can be structured. The factors identified for this study are those that are indicated by the literature as being the most influential in price forecasting effectiveness.

Methodology

The small size and structure of the typical South African quantity surveying firm (Billett, 1990) results in a relatively low number of building contracts being handled by one practice. In order to gain access to a significantly large amount of data on tenders and related estimates it was necessary to establish contact with a large number of firms. It was thought that support from practitioners in the sensitive matter of tender information (typically confidential), could best be achieved by approaching firms individually. The need to adopt this personalised approach means that the scope of information base for the study is limited to the Cape Peninsula geographic area of South Africa. This area is responsible for a high proportion of construction activity; and apart from this it is an important commercial and industrial centre for the South African economy. .

The projects for which tender information was collected and the names of the quantity surveying firms responsible for these projects were obtained from the tender submission diaries of the Cape Peninsula Master Builders' and Allied Trades' Association (MBATA). The tender database of MBATA contains a total of 1086 projects over a fifteen year period. From the database 38 quantity surveying practices were identified as being currently active and were approached for tender information for projects listed under their names. Thirty practices provided the details requested relating to 278 projects for the period reviewed. A general problem was the difficulty in providing information on projects put out to tender up to

5 years prior to the investigation. Another problem, which may be regarded a shortcoming of this study, is that a small minority of firms appeared to have provided information on a selective basis, by providing information on projects where their forecast is regarded close to the contractor accepted tender sum.

Tender information collected for each project included the location of the project (LOCATION), tender sums submitted by contractors for each project, number of tenders (NOBID), and the quantity surveyor tender forecast. Other information collected comprised TYPE of project (new work or alteration), client or SECTOR (private sector, local authority and central government), name of the contract, date of tender (YEAR), classification of work (CLASSFN - based on CI/SfB classifications), amount of provisional sums and PC sums. Seven locations were identified within the Cape Peninsula for the study.

For the purpose of the empirical analysis, the contractor's accepted tender sum (tender price at which the project was awarded, which was in most cases the lowest tender) formed the basis for the analysis. Based on the tender information for each project the contractors' tender coefficient of variation (CTR.COV) for each project was determined. The contractor's accepted tender sum was used as a measure of the project size (PROJSIZE) and was further classified as a small, medium, large or mega-sized project. Deviation of quantity surveyor's forecast from contractor's accepted tender sum for each project was determined and represented as a percentage. An absolute value of this percentage deviation (QSDEVABS) was used as a measure of the tender forecast performance of quantity surveyors. Deviation of contractor's acceptable tender from the mean tender for each project, expressed as a percentage of the contractor's acceptable tender sum, was also determined (BIDRANG).

The empirical analyses were carried out based on the hypothesis that the factors LOCATION, YEAR, TYPE, SECTOR, NOBID, CLASSIFN, PROJSIZE influence quantity surveyors' forecasting performance (QSDEVABS) and contractors' bids variability (CTR.COV). Inspection of available data for the sample projects revealed that it was possible for a comparative analysis of both consultant and contractor price forecasting performance to be conducted simultaneously.

Data analysis and results

Statistical analyses such as descriptive analysis, cross-tabulation, analysis of variance (ANOVA), and linearity were employed in the empirical analysis of the data. The analyses were undertaken using the Statistical Package for the Social Sciences (SPSS). The empirical analysis produced the descriptive statistics (mean, standard deviation and coefficient of variation (CV)) for each of the independent variables (TYPE, SECTOR, NOBID, CLASSIFN, LOCATION, PROJSIZE, and YEAR) based on the dependent variables (QSDEVABS and CTR.COV). The ANOVA tests the null hypothesis that the mean of the dependent variables is equal in all the groupings defined by the independent variables. Where the null hypothesis is accepted it suggests that the dependent variable is not affected by that independent variable. The ETA statistics produced measure the strength of association between the dependent and

independent variables.

A test of the mean linearity between the dependent and independent variables was produced. This test produces the ANOVA, which tests the null hypothesis that the mean of the dependent variables is a linear function of the value of the independent variable. The correlation coefficients for the relationships are also produced. In both these ANOVA tests, the F statistics and probability were produced; where $p < 0.05$ implies that the null hypothesis is rejected at the 5% significant level, suggesting that the dependent variable is affected by the independent variable. The presentation of the descriptive statistics enables the level of accuracy of the dependent variable to be determined and provides more information when cross tabulated with the independent variables.

Tender sum forecast performance of the quantity surveying practices

Table 1 depicts the accuracy of the quantity surveying price forecasts grouped into 5 categories.

Table 1 Quantity surveyors' level of price forecast performance

Level of performance	Frequency	Percentage	Cumulative Percent
0 – 5%	144	51.80	51.8
6 - 10%	64	21.00	74.8
11 – 25%	48	17.30	92.10
26 – 50%	17	6.10	98.20
Over 50%	5	1.80	100.00

The absolute percentage deviation of the quantity surveyors' forecasts from the contractors' accepted tender sum ranged from 0.00% to 88.37%, with the mean of 8.33% (standard deviation = 11.183; standard error (SE) = 0.671). The forecast performance frequency is positive skewed (skewness = 3.161, SE=0.146) with a high Pearson's coefficient of skewness¹ (SK = 0.745). About 52% of the quantity surveyors were able to forecast the contractor's accepted tender price to within $\forall$ 5%, while almost 75% were able to predict to within the $\forall$ 10% level of accuracy. This result is consistent with Beeston's (1975) opinion that the best that quantity surveying estimating procedures can be expected to produce in practical terms, is 52 per cent of estimates within 5 % and 84 per cent of estimates within 10% of the lowest tender, once the detailed design stage is completed.

Table 2 shows ANOVA and linearity test results, which indicate the extent to which the quantity surveyors' performance in forecasting the contractor's accepted tender is determined by the size of

Pearson's coefficient of skewness, SK, is a measure of skewness that focuses on the difference between the

project, the type of client, type of work, location of project, classification of work, number of bidders and the date (year) of tender.

Table 2 Statistical analysis on forecast performance of quantity surveyors

Dependent Variables	Independent Variables	ANOVA			LINEARITY		
		ETA	F-statistics	Prob.	F-statistics	Prob.	Correlation Coefficient
QSDEVABS	LOCATION	0.182	1.854	0.103	Not applicable		
	CLASSFN	0.186	1.384	0.212	Not applicable		
	TYPE	0.016	0.070	0.791	Not applicable		
	SECTOR	0.028	0.106	0.899	Not applicable		
	PROJSIZE	0.100	0.928	0.428	0.200	0.655	-0.027
	NOBID	0.166	1.532	0.180	1.559	0.213	0.075
	YEAR	0.309	2.134	0.013	8.502	0.004	-0.171
	CTR.COV	0.148	1.006	0.422	1.527	0.218	0.074

The Table shows that the strength of association between the quantity surveyors' forecast performance and each factor listed is generally low (ETA ranged between 0.100 and 0.309). The highest strength of association is due to date of tender (YEAR) with ETA of 0.309. ANOVA results show that, with the exception of date of tender, there is no evidence that the forecast performance of the quantity surveyors is affected by any of the other factors. The linearity tests show no significant linear relationship between quantity surveyors' forecast performance and any of the factors, with the exception of the date of tender. There is insignificant negative relationship between the quantity surveyors' forecast performance and project size.

Tables 3 to 7 indicate the cross-tabulation of QSDEVABS with classification of work (CLASSFN), type of work (TYPE), type of client (SECTOR), size of projects (PROJSIZE) and number of bidders (NOBIDS), respectively. The Tables show that the coefficient of variation (CV), which measures the degree of consistency in projects' tender sum forecasts by the quantity surveyor, is more than 100% in all cases. "Count" in each case refers to the cumulative count.

Table 3 which shows the CV of forecast performance of quantity surveyors in relation to the classification of work, and indicates that the highest degree of consistency relates to residential buildings, followed by utilities projects such as health clinics. The lowest degree of consistency relates to commercial projects,

mode and the mean and then relates it to the standard deviation.

followed by religious buildings. Explanation for the poor price forecast performance relating to religious projects (e.g., churches, mosques) could be that this type of project is not undertaken on a regular basis by the practices. This explanation is supported by the fact that, of the 278 projects spanning 15 years, data relating to only 9 religious projects are included in the analysis. Commercial projects have the highest number of projects (76 out of 278 projects in the analysis). The share number of commercial projects included in the analysis raises the possibility of the inclusion of outliers. Although this share number will tend to suggest that the practices should be more familiar with this type of project with a consequence of better forecasting performance, it not unusual for commercial projects to be more complex in design, scope and construction.

Table 3 Forecast performance of Quantity Surveyors estimates in relation to classification of work

	Mean	Std.	CV	Quantity Surveyors level of forecast performance					
		Deviation			5%	10%	25%	50%	Over 50%
Utilities	5.52	6.41	116.06	Count	10	17	18	19	
				%	52.7%	89.50%	94.80%	100.00%	
Industrial	5.52	6.41	116.07	Count	19	27	36	37	
				%	51.3%	72.90%	97.20%	100.00%	
Commercial	8.33	12.97	155.73	Count	40	57	70	74	76
				%	52.6%	75.00%	92.10%	97.40%	100.00%
Health	5.86	6.57	112.20	Count	17	20	24	25	25
				%	68.0%	80.00%	96.00%	100.00%	100.00%
Recreational	7.74	10.66	137.84	Count	9	14	15	17	
				%	53.0%	82.40%	88.30%	100.00%	
Religious	12.29	18.15	147.62	Count	5	7	7	8	9
				%	55.5%	77.70%	77.70%	88.80%	100.00%
Educational	11.99	14.45	120.53	Count	20	31	42	46	48
				%	41.7%	64.60%	87.50%	95.80%	100.00%
Residential	7.74	8.64	111.57	Count	24	35	44	47	
				%	51.1%	74.50%	93.70%	100.00%	
TOTAL	8.33	11.18	134.23	Count	144	208	256	273	278
				%	51.8%	74.80%	92.10%	98.20%	100.00%

Moreover, commercial projects are usually associated with the use of new materials and technology, all of which could contribute to the comparatively poor forecasting performance by quantity surveyors. The residential, utilities and industrial projects are associated with better forecasting performance than other types of projects, which could be explained by their simplicity in design, construction, and scope.

Table 4 shows, contrary to expectation, that the CV for alteration projects is better than that for new work. Quah's (1988) study suggests that refurbishment work, because of the uncertainty inherent in such work and the problems associated with pricing alterations work is generally associated with a low degree of accuracy of tender sum forecast. The results emanating from the analysis of the South African data do not support the findings from Quah's UK empirical study.

Table 4 Forecast performance of Quantity Surveyors estimates in relation to type of work									
	Mean	Std.	COV	Quantity Surveyors level of forecast performance					
		Deviation			5%	10%	25%	50%	Over 50%
New work	8.4412	11.627	137.74	Count	106	148	186	197	201
				%	52.80%	73.70%	92.60%	98.10%	100.00%
Alteration work	8.0432	9.9955	124.27	Count	38	60	70	76	77
				%	49.40%	78.00%	91.00%	98.80%	100.00%
TOTAL	8.3309	11.1827	134.23	Count	144	208	256	273	278
				%	51.80%	74.80%	92.10%	98.20%	100.00%

Table 5 shows that the highest consistency in the performance of quantity surveyors' forecasts of the anticipated lowest tender figure is associated with local government projects, followed by private sector projects and central government projects. The results should, however, be treated with circumspection given the bias in the raw data towards private sector projects (72%).

Table 5 Forecast performance of Quantity Surveyors estimates in relation to type of client									
	Mean	Std.	CV	Quantity Surveyors level of forecast performance					
		Deviation			5%	10%	25%	50%	Over 50%
Private	8.176	10.968	134.15	Count	101	150	183	196	199
				%	50.70%	75.30%	91.90%	98.40%	100.00%
Local govt.	8.927	11.612	130.08	Count	31	43	54	58	59
				%	52.50%	72.80%	91.50%	98.30%	100.00%
Central govt.	8.109	12.504	154.20	Count	12	15	19	19	20
				%	60.00%	75.00%	95.00%	0.95	100.00%
TOTAL	8.331	11.183	134.23	Count	144	208	256	273	278
				%	51.80%	74.80%	92.10%	98.20%	100.00%

Table 6 suggests that both small and very large projects are associated with poor forecasting performance. The reasons for this are not immediately although the results in respect of large projects are in line with overseas trends. The performance achieved on small projects is not surprising as a feature of these projects is a large number of bidders. This would normally be expected to result in unstable tendering conditions with consequential difficulties being experienced by consultants in estimating tender prices.

Table 6 Forecast performance of Quantity Surveyors estimates in relation to size of projects									
	Mean	Std.	CV		Quantity Surveyors level of forecast performance				
		Deviation			5%	10%	25%	50%	Over 50%
Small	7.92	10.62	134.07	Count	55	82	95	101	103
				%	53.40%	79.60%	92.20%	98.00%	100.00%
Medium	10.02	13.13	130.95	Count	35	56	73	79	81
				%	43.20%	69.10%	90.10%	97.50%	100.00%
Large	7.16	8.69	121.29	Count	28	37	47	50	
				%	56.00%	74.00%	94.00%	100.00%	
Mega	7.50	11.10	148.06	Count	26	33	41	43	44
				%	59.10%	75.00%	93.20%	97.70%	100.00%
TOTAL	8.33	11.18	134.23	Count	144	208	256	273	278
				%	51.80%	74.80%	92.10%	98.20%	100.00%
Note: Small projects (< R1 million); Medium projects (R1-2.5 million); Large projects (R2.5-5 million); Mega projects (> R5 million)									

Given the number of projects involved the analysis, Table 7 suggests that quantity surveyors are most likely to achieve a high level of forecasting performance with 7-8 bidders. The most likely reason for this is the potential for distorted tendering patterns when either very small or very large tender lists are encountered.

Table 7 Forecast performance of Quantity Surveyors estimates in relation to number of bidders									
	Mean	Std.	CV		Quantity Surveyors level of forecast performance				
		Deviation			5%	10%	25%	50%	Over 50%
2 - 4 Bidders	8.39	10.76	128.26	Count	15	21	25	29	29
				%	51.70%	72.40%	86.10%	99.90%	100.00%
5- 6 Bidders	8.42	12.86	152.67	Count	40	61	73	76	78
				%	51.30%	78.20%	93.60%	97.40%	100.00%
7 - 8 Bidders	7.02	7.93	112.97	Count	32	51	64	65	66
				%	48.40%	77.20%	96.90%	98.40%	100.00%

9 - 10 Bidders	6.79	9.09	133.94	Count	36	45	56	57	58
				%	62.00%	77.50%	96.40%	98.10%	100.00%
11 - 14 Bidders	10.97	13.87	126.42	Count	15	23	29	33	34
				%	44.10%	67.60%	0.852	97.00%	100.00%
Over 14 Bidders	14.28	14.62	102.39	Count	6	7	9	13	
				%	46.20%	53.90%	69.30%	100.00%	
TOTAL	8.33	11.18	134.23	Count	144	208	256	273	278
				%	51.80%	74.80%	92.10%	98.20%	100.00%

Overall, these results suggest that the forecast performance of contractors' accepted tender sums by quantity surveyors in South Africa is not affected by any of the independent variables with the exception of the date of tender. Moreover, the fact that date of tender is significant in the analysis tends to suggest that the forecast performance of quantity surveyors is affected by the market conditions dictated by the turbulent economy cycle within South Africa.

Analysis of variability of contractors' tenders

Fine (1974), Beeston (1975), Ashworth and Skitmore (1982), Runeson and Bennett (1983), Hodgetts (1987), Newton (1991) and Betts and Brown (1992) have all commented on the wide distribution of prices between the lowest and highest tenders submitted on projects. The contributing factors responsible for the differences cited were cost structures of firms, disparate competitive strategies, and familiarity with particular type of projects and market conditions.

Table 8 shows the variability of the contractors' tenders grouped into 5 categories. The variability of the contractors' tenders ranged from 0.37% to 46.53%, with a mean of 5.65% (standard deviation = 5.22, SE = 0.313).

Table 8 Variability of contractors' tenders

Variability level	Frequency	Percentage	Cumulative Percentage
0 – 2.5%	40	14.39	14.39
2.6% - 5%	116	41.73	56.12
6 – 10 %	96	34.53	90.65
11 – 25%	22	7.91	98.56
Over 25%	4	1.44	100.00

The variability performance frequency is positive skewed (skewness = 5.012, SE = 0.146). It is noteworthy that 90.6% of contractors' tender variability lies within the 10% accuracy margin, compared to the price forecasting performance of quantity surveyors where 75% of the quantity surveyors sampled forecast the contractor's lowest tender price within the $\forall$ 10% level of accuracy.

Table 9 shows ANOVA and linearity test results which indicate the extent to which the variability of the contractors' tenders is influenced by the size of project, the type of client, type of work, location of project, classification of work, number of bidders and the date (year) of tender.

Table 9 Statistical analysis of variability of contractors' tenders

Dependent Variables	Independent Variables	ANOVA			LINEARITY		
		ETA	F-statistics	Prob.	F-statistics	Prob.	Correlation. Coefficient
CTRS.COV	LOCATION	0.135	1.012	0.411	Not applicable		
	CLASSIFN	0.125	0.608	0.749	Not applicable		
	TYPE	0.043	0.520	0.471	Not applicable		
	SECTOR	0.120	2.010	0.136	Not applicable		
	PROJSIZE	0.103	0.978	0.404	2.007	0.158	-0.085
	QSABSDEV	0.239	2.730	0.014	2.837	0.093	0.099
	BIDRANG	0.629	44.743	0.000	128.412	0.000	0.533
	YEAR	0.232	1.152	0.316	4.986	0.026	0.134
	NOBIDS	0.122	0.816	0.539	1.780	0.183	0.080

The Table shows that the strength of association between the contractors' tender variability and the listed factors (with the exception of BIDRANGE, ETA=0.629) is generally low, with ETA ranged from 0.103 to 0.239. The high strength of association between the contractors' tenders' coefficient of variation and BIDRANGE is not unexpected, given that the two variables can indeed be used to measure contractors' bids' variability. ANOVA results also show that, with the exception BIDRANGE and QSABSDEV, there is no evidence that the variability of the contractors' tenders is influenced by any other factors. The linearity tests show no significant linear relationship between the contractors' bids' variability and any other factors with the exception of BIDRANGE. There is an insignificant negative relationship between the contractors' bid variability and project size. The results suggest that the contractors' tender price variability in South Africa is not affected by any of the listed independent variables.

Tables 10 to 14 show the cross-tabulation of CTR.COV with classification of work (CLASSFN), type of work (TYPE), type of client (SECTOR), size of projects (PROJSIZE) and number of bidders (NOBIDS), respectively. The Tables also depict the CV of the contractors' tender variability.

Table 10 Contractors' bids variability in relation to classification of work									
	Mean	Std.	CV	Contractors' bids variability					
		Deviation			2.5%	5%	10%	25%	Over 25%
Utilities	6.56	3.51	53.53	Count	1	7	16	19	
				%	5.26	36.84	84.21	100.00	
Industrial	5.01	2.59	51.81	Count	7	20	34	37	
				%	18.92	54.05	91.89	100.00	
Commercial	5.30	5.93	111.95	Count	14	50	71	74	76
				%	18.42	65.79	93.42	97.37	100
Health	5.07	2.49	49.08	Count	2	13	24	25	
				%	8	52	96	100	
Recreational	4.53	1.97	43.60	Count	2	10	17		
				%	11.76	58.82	100.00		
Religious	6.62	3.51	53.05	Count		5	6	9	
				%		55.56	66.67	100.00	100
Educational	6.10	6.67	109.39	Count	8	28	43	47	48
				%	16.67	58.33	89.58	97.92	100
Residential	6.44	6.49	100.79	Count	6	23	41	46	47
				%	12.77	48.94	87.23	97.87	100
TOTAL	5.65	5.22	92.43	Count	40	156	252	274	278
				%	14.39	56.12	90.65	98.56	100

Table 10 indicates that the contractors' tender variability in respect of commercial, educational and residential buildings, is highly variable (over 100%). However, the ANOVA tests do not suggest that this is highly significant compared with other project classifications. Further layer cross-tabulation analyses do not show that higher variability of the contractors' tenders associated with commercial, educational and residential building functions could be explained by any other factors other than the higher-than-average number of projects (average per building function = 35) included in the analysis for commercial (76 projects), educational (48 projects) and residential (47 projects). Religious buildings have the highest contractors' tender variability, which could be explained by the low number of projects of this type undertaken by contractors. Utilities projects, typically associated with a wide range of construction methods and the extensive use of mechanical plant, also display a high level of contractors' tender

variability.

Table 11 does not indicate any significant difference in the variability of the contractors' tenders between new work and alteration work. Table 12 shows that the contractors' bids are highly variable in respect of local authority projects compared with private sector and central government projects.

Table 11 Contractors' bids variability in relation to type of work

	Mean	Std. Deviation	CV		Contractors' bids variability				
					2.5%	5%	10%	25%	Over 25%
New work	5.51	4.97	90.16	Count	30	115	181	199	201
				%	14.93	57.21	90.05	99.00	100
Alteration work	6.02	5.86	97.30	Count	10	41	71	75	77
				%	12.99	53.25	92.21	97.40	100
TOTAL	5.65	5.22	92.43	Count	40	156	252	274	278
				%	14.39	56.12	90.65	98.56	100

Table 12 Contractors' bids variability in relation to type of client

	Mean	Std. Deviation	CV		Contractors' bids variability				
					2.5%	5%	10%	25%	Over 25%
Private	5.29	3.54	66.90	Count	32	113	179	198	199
				%	16.08	56.78	89.95	99.50	100
Local govt.	6.83	9.21	134.77	Count	8	36	53	56	59
				%	13.56	61.02	89.83	94.92	100
Central govt.	5.78	1.65	28.64	Count		7	20		
				%		35.00	100.00		
TOTAL	5.65	5.22	92.43	Count	40	156	252	274	278
				%	14.39	56.12	90.65	98.56	100

Further analysis within the confines of the data shows that the only factor that could have explained the high variability associated with local authority projects (mean = R4.65 million, Std = 6.43 million) is the size of those projects compared with those initiated by the private sector (mean = R2.55 million, Std=3.96 million) and central government (mean = R2.45 million, Std=2.06 million) projects. The fact that

large projects are associated with higher variability of contractors' tenders is reflected in Table 13, with mega-sized projects having a CV of 172.48%.

Table 13 Contractors' bids variability in relation to size of project									
	Mean	Std.	CV		Contractors' bids variability				
		Deviation			2.5%	5%	10%	25%	Over 25%
Small	6.33	3.64	57.45	Count	6	44	87	103	
				%	5.83	42.72	84.47	100.00	
Medium	5.39	4.66	86.47	Count	9	46	77	80	81
				%	11.11	56.79	95.06	98.77	100
Large	4.99	4.02	80.57	Count	10	32	46	49	50
				%	20.00	64.00	92.00	98.00	100
Mega	5.31	9.15	172.48	Count	15	34	42	42	44
				%	34.09	77.27	95.45	95.45	100
TOTAL	5.65	5.22	92.43	Count	40	156	252	274	278
				%	14.39	56.12	90.65	98.56	100

Although the small-sized projects display the highest mean variability, the tender sum forecasts by contractors within this group are the most consistent with a CV of 57.45%. Whilst the reason for this performance is not obvious, it is possibly a result of the familiarity that local contractors have developed with this size of project. It is noticeable that 183 of the total sum of 278 projects analysed fall into the "small / medium" categories.

Table 14 Contractors' bids variability in relation to number of bidders									
Bidders	Mean	Std.	CV		Contractors' bids variability				
		Deviation			2.5%	5%	10%	25%	Over 25%
2 - 4 Bidders	5.82	7.46	128.23	Count	9	15	28	28	29
				%	31.03	51.72	96.55	96.55	100
5- 6 Bidders	4.93	5.14	104.18	Count	17	49	74	77	78
				%	21.79	62.82	94.87	98.72	100
7 - 8 Bidders	5.26	2.79	53.00	Count	5	37	60	66	
				%	7.58	56.06	90.91	100.00	
9 - 10 Bidders	6.54	6.82	104.26	Count	6	34	47	57	58
				%	10.34	58.62	81.03	98.28	100
11 - 14 Bidders	6.21	4.34	69.89	Count	3	15	31	33	34

				%	8.82	44.12	91.18	97.06	100
Over 14 Bidders	6.18	2.55	41.26	Count		6	12	13	
				%		46.15	92.31	100.00	
TOTAL	5.65	5.22	92.43	Count	40	156	252	274	278
				%	14.39	56.12	90.65	98.56	100

Table 14 shows that, although the 5-6 bidders range have the lowest contractors' tender variability (mean CV = 4.93), followed by 7-8 bidders (mean CV = 5.26), with the exception of over 14 bidders, 7-8 bidders display the highest consistency of tender sum forecast performance by contractors with a CV of 53%.

Discussion of results

Published research dealing with the variability of contractors' tender sum forecasts tends to suggest that this varies between a 5 % and 9 % coefficient of variation. Beeston (1975) has suggested that, due to several causes of tender variability applying in practice, there is little prospect of reducing the coefficient of variation for tenders to less than 8 %. This view is partially supported by the opinion of Ashworth and Skitmore (1982), who declare that contractors should estimate with an error of considerably less than 10% of their total final cost and generally of the order of + /- 5 %, given a set of quantities and subcontractors quotations.

Flanagan (1980), in a study of 64 projects built by a large contracting firm in the UK, established that the coefficient of variation varied, depending on project value, between 2.85% and 11.55%. The mean for the sample analysis is 8.22%. Flanagan concluded that the best measure of a contractor's ability to estimate their own costs on projects is 6.6% CV.

Barnes' (1974) analysis of 228 projects taken from 10 different contracting organisations found that the coefficient of variation measured between the contractors' estimate and the actual cost of the projects was approximately 7%. Skitmore's (1986) analysis of 269 building projects in the UK shows that the estimating variability of construction contractors has mean CV of 6.5%, while Runeson's (1988) analysis of 1064 building projects produced a mean CV of 4.9%.

Greig's (1981) analysis shows that 72% of estimates produced by quantity surveyors are within 5% when compared with the accepted tender, and 73 % when compared with the final account figure. Morrison's (1984) research, based on an examination of 557 projects from 7 largely public sector sources, deduced that the best performance that quantity surveyors can achieve is in the region of within 15.5% of the lowest acceptable tender. This contradicts earlier opinion held by Beeston (1975) who reasons that, using currently available methods of estimating, the best possible forecast accuracy is in the order of 7

per cent and 8 per cent of the lowest accepted tender. The level of forecast performance was qualified as dependent upon the quantity surveyor's 'intuitive' estimating ability.

A study based on 273 construction projects undertaken between 1974 and 1981 by the National Aeronautical and Space Administration (NASA) in the USA and cited by Tan (1988), indicated that the cost consultants' forecasts average was 7.8 % higher than the low bids accepted.

Skitmore (1988) analysed cost consultants forecasts of the contractors' lowest tender price, the analysis being based on two sets of data. Analysis of the first set of data, based on 67 building and engineering projects in the USA, found their forecasts to be an average of 12.38% higher than the low bids (Std dev. = 21.53, CV = 173.9%). Analysis of the second set of data, based on 33 building contracts executed in the UK between 1983 and 1987, revealed that the estimates were, on average, 4.91% lower than the lowest tenders (Std dev. = 17.22 and CV = 350.7%). In both of these instances there is high inconsistency in the forecast performance of contractors' lowest acceptable tender by the cost consultants.

Conclusions

The analysis of South African tender information reported in this paper indicates an average forecast performance by quantity surveyors of 8.33% (std dev. = 11.183, CV = 134.2%). The results indicate that the pre-tender estimates produced by South African quantity surveyors are less accurate and more inconsistent than those compiled by consultants in other countries. This situation demonstrates that there is considerable potential for improving the pre-tender estimating service provided to clients in South Africa. In the case of these South African data, the link between forecasting performance and the type of project, client, function of project, project size, location or number of bidders was found not to be statistically significant. The only factor which shows significance is the date of tender which may be an indicator of the importance of market conditions prevailing at the time that pre-tender estimates are produced.

The current analysis of 278 projects in South Africa for the period in question shows that the variability of contractors' tender sum forecasts is 5.65% (Std dev. = 5.22, SE = 0.313). Analysis of these data, contrary to the findings of Flanagan (1980), does not conclude that this variability is dependent on project value (Pearson correlation = -0.026, $p=0.668$). Moreover, there is also little evidence, based on these South African data, to suggest that the variability of contractors' tender sum forecasts is (significantly) dependent on building function, type of work (new or alteration), type of client, and the number of bidders. However, the results do suggest that local authority projects are associated with high variability of contractors' tender sum forecasts, while 7 – 8 bidders produced the highest consistency in contractors' tender sum forecasts. Overall, the South African results tend to support randomness of variability of contractors' tenders, a view held by Beeston (1975).

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