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**FACTORS AFFECTING THE ACCURACY OF QUANTITY SURVEYORS'
PRE-TENDER PRICE FORECASTS IN SOUTH AFRICA**

BY

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Town

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TABLE OF CONTENTS

	Page
SYNOPSIS	viii
DECLARATION	ix
ACKNOWLEDGMENTS	x
LIST OF FIGURES	xi
LIST OF TABLES	xiii
LIST OF ABBREVIATIONS	xiv
GLOSSARY OF TERMS	xv
CHAPTER 1 - GENERAL INTRODUCTION	
1.1 INTRODUCTION	1
1.1.1 General	1
1.1.2 Purpose of research	2
1.2 PROBLEM STATEMENT	2
1.3 HYPOTHESIS	3
1.4 LIMITATIONS AND ASSUMPTIONS	4
1.5 RESEARCH METHOD	5
1.6 STRUCTURE OF THE DISSERTATION	6
CHAPTER 2 - THE PURPOSE AND IMPORTANCE OF ESTIMATING	
2.1 INTRODUCTION	7
2.2 DEFINITIONS	7
2.3 THE NEED FOR PRICE FORECASTS	8
2.3.1 Uses of estimates	9
2.3.2 Serving client requirements	10
2.3.3 Elements of a good / poor estimate	11
2.4 OVERVIEW OF DESIGN PRICE FORECASTING TECHNIQUES	12
2.4.1 General	12

2.4.2 Traditional systems	14
2.4.2.1 <i>Single-price rate methods</i>	14
2.4.2.2 <i>Multi-price rate methods</i>	18
2.4.3 Non-traditional systems	21
2.4.4 Resource based models	23
2.4.5 Usage of estimating systems	24
2.5 CONCLUSIONS	26
 CHAPTER 3 - THE DESIGN PRICE FORECASTING ENVIRONMENT	
3.1 INTRODUCTION	27
3.2 STRUCTURE OF ESTIMATING SYSTEMS	28
3.2.1 Forecasting theory	28
3.2.2 Defining estimating procedures	28
3.3 UNCERTAINTY IN THE PRICE FORECASTING PROCESS	32
3.3.1 The decision making process	31
3.3.2 Measurement of uncertainty	33
3.3.3 Variability of tenders	36
3.3.4 Estimating variability	39
3.3.5 Range estimates	41
3.3.6 Detail level of estimates	43
3.4 DATA / INFORMATION AVAILABLE TO ESTIMATORS	46
3.4.1 Data availability	46
3.4.2 Use of data	48
3.5 FEEDBACK / CONTROL MECHANISMS ON FORECAST PERFORMANCE	50
3.5.1 Monitoring design cost forecasts	50
3.5.2 Control analyses	52
3.5.2.1 <i>Control charts</i>	52
3.5.2.2 <i>Cusum charts</i>	53
3.6 CONCLUSIONS	54

CHAPTER 4 - EVALUATION OF ESTIMATING PERFORMANCE

4.1 INTRODUCTION	56
4.2 DEFINITIONS	57
4.2.1 Accuracy	57
4.2.2 Bias, consistency and precision	58
4.3 METHODS OF MEASURING ACCURACY	60
4.3.1 Range	60
4.3.2 Mean deviation	60
4.3.3 Standard deviation	61
4.3.4 Coefficient of variation	61
4.4 EXPECTATIONS OF ACCURACY	63
4.4.1 Estimating reliability during project planning	63
4.4.2 Price forecasters' expectations	66
4.4.3 Architects' and clients' expectations	68
4.5 LITERATURE REVIEW OF ESTIMATING PERFORMANCE	69
4.5.1 Contractors' construction cost estimates	70
4.5.1.1 <i>General research</i>	70
4.5.1.2 <i>Empirical studies</i>	71
4.5.2 Designers' construction price forecasts	72
4.5.2.1 <i>General research</i>	73
4.5.2.2 <i>Empirical studies</i>	74
4.6 CONCLUSIONS	76

CHAPTER 5 - FACTORS AFFECTING ACCURACY

5.1 INTRODUCTION	78
5.2 CONSIDERATIONS IN CONTRACTOR TENDERING	79
5.2.1 The competitive bidding process	79
5.2.2 Factors affecting the bid	81

5.3 FACTORS AFFECTING ESTIMATING ACCURACY	88
5.3.1 Historical cost data	88
5.3.2 Estimators' expertise / experience	89
5.3.3 Level of design information	91
5.3.4 Market conditions	94
5.3.5 Type of project	98
5.3.6 Project complexity	100
5.3.7 Project size	101
5.3.8 Number of bidders	105
5.3.9 Duration of project	109
5.3.10 Geographical location of project	109
5.3.11 Other factors	110
5.4 CONCLUSIONS	112
CHAPTER 6 - OPINION SURVEY ON PRICE FORECASTING ACCURACY	
6.1 INTRODUCTION	114
6.2 PRICE FORECASTING THEORY - OVERSEAS OPINION SURVEY	115
6.2.1 General	115
6.2.2 Estimate comparisons	116
6.2.3 Parameter used for comparison	116
6.2.4 Useful parameters for cost comparison	116
6.2.5 Recording of estimate details	117
6.2.6 Factors considered to affect estimating accuracy	117
6.2.7 Desirable level of accuracy	119
6.2.8 Datum for assessing estimating accuracy	119
6.2.9 Experience of estimators	119
6.3 PRICE FORECASTING ACCURACY - SURVEY OF SOUTH AFRICAN ESTIMATORS	119
6.3.1 Compilation of the questionnaire	119
6.3.2 Questionnaire distribution	120

7.3.3 Data analysis	152
7.4 ANALYSIS OF SAMPLE OF MIXED TENDERS	154
7.4.1 General characteristics	154
7.4.1.1 <i>Performance of individual firms</i>	155
7.4.1.2 <i>Comparison with bidding consistency</i>	156
7.4.1.3 <i>Effect of 'fixed sums' on performance</i>	158
7.4.1.4 <i>Sundry features at differing performance levels</i>	158
7.4.2 Market conditions	161
7.4.3 Type of project	164
7.4.4 Project size	168
7.4.5 Number of bidders	170
7.4.6 Location of project	171
7.5 ANALYSIS OF PUBLIC SECTOR SAMPLES	172
7.6 CONCLUSIONS	176
 CHAPTER 8 - SUMMARY AND CONCLUSIONS	
8.1 CONCLUSIONS	178
8.2 RECOMMENDATIONS	181
 REFERENCES	182
 APPENDIX 'A' - SOUTH AFRICAN SURVEY DOCUMENTATION	197
 APPENDIX 'B' - SAMPLE OF 243 PROJECTS USED IN EMPIRICAL STUDY	201
 APPENDIX 'C' - SAMPLE OF 45 PWD PROJECTS FOR EMPIRICAL STUDY	207
 APPENDIX 'D' - SAMPLE VALIDATION : NUMBER OF BIDS / PROJECT	209
 APPENDIX 'E' - SAMPLE VALIDATION : MEAN PROJECT VALUE	211

Contents

APPENDIX 'F' - SAMPLE VALIDATION : MEAN RANGE OF BIDS	213
APPENDIX 'G' - SAMPLE VALIDATION : CV OF TENDERER'S BIDDING	215
APPENDIX 'H' - DETAILS OF ESTIMATING PERFORMANCE (FIRM 1)	217
APPENDIX 'I' - DETAILS OF ESTIMATING PERFORMANCE (FIRM 21)	221

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SYNOPSIS

The primary purpose of this dissertation is to identify the factors which affect the accuracy of South African quantity surveyors' pre-tender price forecasts. Prices submitted by bidders at the tender submission stage of project development are utilised as the best practical measure for establishing the degree of accuracy achieved.

A large number of design price forecasting techniques are available to estimators. Many of the techniques used in the early stages of design are applicable for providing budget amounts for design control purposes, whilst others are more appropriate for forecasting anticipated tender sums. Features of price forecasting requiring attention at all stages of design development are identified as: (i) the influence of uncertainty inherent in the process, (ii) data / information availability and management, and (iii) the utilisation of tendering data by means of 'feedback' systems.

The factors affecting the accuracy of price forecasts are examined by means of a literature study, opinion surveys of estimators and empirical research on the results of estimate / tender comparisons. The relevance of the question of pre-tender price forecasts is demonstrated by the results of the study which indicates that the accuracy and reliability of South African quantity surveyors' estimates produced at the tender stage is inferior to that generally found overseas and do not meet the expectations of architects and clients.

The conclusions drawn from this study indicate a distinct potential for improvement in early design stage price management.

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DECLARATION

I hereby declare that this dissertation is my own work and it has not been submitted for a degree at any other university.

Robert Gilfillan Pearl

September 13, 1992

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LIST OF FIGURES

	Page
2.1 Satisfaction with QS cost advice	11
3.1 Profile of uncertainty ranges	34
3.2 Alternative profiles of uncertainty ranges	35
3.3 The normal distribution and standard deviations	35
3.4 Quantity surveyors' prediction of tender methods	37
3.5 Effect of component variability on tender variability	38
3.6 Probability distributions of estimate stages	42
3.7 Accuracy and number of items in estimate	44
3.8 A control chart for estimating errors	53
4.1 Relationship between accuracy and precision	59
4.2 Postulated accuracy improvement in design process	64
5.1 Competitiveness in bidding performance	82
5.2 Average CV of UK tenders: 1969 - 1979	84
5.3 Average CV after removing highest tenders	85
5.4 Low bid as a percentage of designers' estimates	86
5.5 Mean bid as a percentage of designer's estimates	87
5.6 Building projects task environment	92
5.7 Degree of competition in tendering	95
5.8 BER Building cost index / degree of competition	96
5.9 Average annual ratio of tender : estimated cost plan	98
5.10 Effect on tenders of value of project	104
5.11 Effect on price forecasts of value of project	104
5.12 Degree of competition in tendering in Western Cape	106
5.13 Tender / estimate ratio by number of tenderers	107
5.14 Estimating accuracy / number of tenderers	108
5.15 Low bid / estimate for various procurement systems	111
6.1 Bids used for tender analysis	122
6.2 Acceptable levels of accuracy	124
6.3 Opinions of accuracy achievable	125
6.4 Acceptable datums for measuring performance	126
6.5 Use / preference for estimating accuracy datum	126
6.6 Estimating experience of respondents to survey	127

Figures

6.7	Opinions on accuracy by experienced estimators	128
6.8	Importance of factors in price forecasting	129
6.9	Rating profile for historical cost data	131
6.10	Rating profile for estimators' expertise	132
6.11	Rating profile for availability of design information	133
6.12	Rating profile for market conditions	134
6.13	Rating profile for type of project	135
6.14	Rating profile for project complexity	137
6.15	Rating profile for project size	138
6.16	Rating profile for number of bidders	139
6.17	Rating profile for project duration	140
6.18	Rating profile for project location	141
7.1	Comparison of accuracy achieved / anticipated	153
7.2	Estimating performance of individual firms	156
7.3	Nett / gross absolute accuracy	160
7.4	Relative / absolute accuracy: 1982 - 1991	162
7.5	Price forecasting patterns: 1982 - 1991	163
7.6	Estimating performance by client sector	164
7.7	Sample categories by CI/SfB grouping	165
7.8	Estimating performance by CI/SfB grouping	166
7.9	Estimates conducted on typically repetitive projects	167
7.10	Sample categories by value of project	168
7.11	Comparison of survey samples: accuracy divisions	173

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LIST OF TABLES

	Page
1.1 Research Methodology	5
2.1 Estimating systems used at different design stages	24
4.1 Measures of variability	62
4.2 Client / architect expectations of accuracy	69
4.3 Mean coefficient of variation of construction bids	72
4.4 Effects of differing coefficients of variation	73
4.5 Accuracy of consultants estimates at detailed design	75
6.1 Overall importance ranks and strength of feelings	117
6.2 Overall importance rankings of S.A. estimators	130
7.1 Measures of accuracy recorded	159
7.2 Estimate performance viewed on an annual basis	161
7.3 Estimate performance based on project value	169
7.4 Estimate performance based on number of bidders	170
7.5 Estimate performance based on project location	171
7.6 PWD estimate performance viewed on an annual basis	174
7.7 Estimate performance based on PWD project value	175
7.8 Estimates for PWD based on number of bidders	176

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LIST OF ABBREVIATIONS

AACE	American Association of Cost Engineers
ASAQS	Association of South African Quantity Surveyors
BER	Bureau of Economic Research (Stellenbosch University)
CIOB	Chartered Institute of Building
CI/SfB	Construction Index - 'Samarbetskommitten för Byggnadsfrågor'
CV	Coefficient of variation
ISAA	Institute of South African Architects
MBA	Master Builders' and Allied Trades Association
NASA	National Aeronautical and Space Administration
PC	Prime Cost
PWD	Department of Public Works and Land Affairs (Public Works Department)
RIBA	Royal Institute of British Architects
RICS	Royal Institution of Chartered Surveyors
SA	South Africa
UK	United Kingdom
USA	United States of America

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GLOSSARY OF TERMS

Bills of Quantities:

A descriptive list of items forming part of the contract documentation and quantifying the work to be done on a building project.

Building procurement system:

The procedural path or actions undertaken in the planning and development of a building contract.

Client:

The person, or company, or authority for whom a project is carried out; usually the one who pays the capital cost of the project.

Competitive tendering system:

The process of two or more contractors tendering (or bidding) for the same work, often quantified in bills of quantities.

Design phase:

The stage in the life of a project when most of the activity being carried out relates to decisions about its physical nature and performance. Usually (but not limited) to the period between project conception and tender submission.

Estimate reliability:

The confidence level associated with the expected accuracy of a price forecast.

Low bid:

The lowest bid submitted in a competitive tendering exercise. Not necessarily the accepted tender.

Tender / Bid:

An offer to carry out building work at a price determined by a contractor.

Tender estimate:

Estimate of anticipated tender prices, made by members of the design team. Usually the last price forecast prior to tenders being submitted. Often calculated by the consultant pricing project bills of quantities during the tender period.

1. GENERAL INTRODUCTION

*"When a man does not know what harbour he is making for, no wind is the right wind" :
Seneca - Philosopher*

1.1 INTRODUCTION

1.1.1 General

Quantity surveyors in South Africa have traditionally undertaken the construction price forecasting function as an integral part of the package of services offered by them on construction projects.

Conventional theory relating to price forecasting is extensively described by Nisbet (1961), Bathurst and Butler (1973), Seeley (1983), Ashworth (1988a) and Ferry and Brandon (1991). They suggest that a primary aim of construction price forecasting is the provision of an accurate assessment of the market price of construction contracts.

Whilst much research effort has been devoted to the nature and use of price forecasting techniques, less attention has been paid to the quality of the price forecasts produced by quantity surveyors.

Skitmore *et al.* (1990) assert that there are five primary aspects which determine the quality of quantity surveyor's price forecasts. These concern (a) the nature of the target, (b) the information used, (c) the forecasting technique used, (d) the feedback mechanism used and, (e) the person providing the estimates.

The major research endeavours into the quality of price forecasts include the work of James (1955), McCaffer (1976), De Neufville *et al.* (1977), Harvey (1979), Property Services Agency (1981), Jupp and McMillan (1981), Bennett *et al.* (1981) Runeson and Bennett (1983), Flanagan and Norman (1983), Morrison (1984), Hanscomb Associates (1984), Skitmore and Tan (1987), Wilson *et al.* (1987), Skitmore (1988b, 1988c) and Tan (1988).

Chapter 1

More specifically, Ogunlana (1989), Betts and Gunner (1989), Gunner and Betts (1990) and Ogunlana and Thorpe (1991) have addressed themselves to the issue of the factors affecting accuracy of price forecasts.

Whilst the nature of construction activity in certain areas covered by these studies, such as locations around the Asia Pacific Rim, North America and Continental Europe, is dissimilar to that in South Africa, there is similarity between the construction industries of South Africa and the United Kingdom where most of the research to date has been undertaken.

However, whilst providing a useful indication of the accuracy of price forecasting in general, the above publications throw little light on the situation prevailing in the South African context.

Preliminary work by Bowen (1992) indicates that the accuracy achieved by quantity surveyors in price forecasting is consistently lower than the expectations of clients and architects.

1.1.2 Purpose of research

The purpose of this research is to:

- * critically analyse a range of local pre-tender construction price estimates to determine the levels of accuracy which are achieved in practice, for comparison with the results of comparable studies undertaken overseas, and,
- * determine the most significant factors affecting the estimating accuracy of South African quantity surveyors.

1.2 PROBLEM STATEMENT

The main problem to be addressed in this dissertation is:

Pre-tender price forecasts produced by quantity surveyors in South Africa are consistently inaccurate and do not meet the expectations of either architects or clients.

Chapter 1

In addition, the following sub-problems contribute towards unreliable estimates being produced:

- (a) Price forecasters ignore the positive contribution that a structured tender analysis and feedback mechanism can furnish in providing information on the accuracy of previous forecasts, and possible reasons for inconsistent performance. This results in estimators being unaware of the actual nature and magnitude of errors made in price forecasts.
- (b) The parties involved in building developments have different expectations or assumptions with regard to the content and accuracy of tender price forecasts.
- (c) A variable basis is used for reporting to clients on the results of tender submissions; sometimes even within the same organisation.
- (d) Estimators who do not have the necessary ability or experience in building price forecasting are often employed in this activity.

The main problem above will be substantiated by means of a detailed empirical survey, the results of which are presented in Chapter 7. The associated sub-problems are addressed in Chapter 6, listing the responses of South African quantity surveyors to a national opinion survey.

1.3 HYPOTHESIS

Based on an extensive literature review providing an overview of the results of research conducted overseas, the factors considered to affect the accuracy of consultants' price forecasts are:

<i>Project specifics</i>	: Type of project
	: Job complexity
	: Project size
	: Number of bidders
	: Job duration
	: Geographic location
<i>Data / Information</i>	: Nature and quality of historic price data
	: Level of design information available

External economic forces : Market conditions applicable

The estimator : Experience / expertise

The hypothesis to be addressed in this dissertation is that:

The expertise of the price forecasters and the provision of adequate historical price data are the two most influential factors affecting the accuracy of pre-tender price forecasts produced by quantity surveyors in South Africa.

To justify the inclusion of these factors in this study, the influence on estimating accuracy displayed by each factor is investigated in the context of the South African building industry.

1.4 LIMITATIONS AND ASSUMPTIONS

The area of study is limited to price forecasting as executed by quantity surveyors in the South African building industry. Areas of the construction market where estimating is practiced, such as the general residential sector and civil engineering works are not included in this research. The study is based on the building procurement process that is used most widely by quantity surveyors in this country, namely bills of quantities.

* Betts and Gunner (1989) state that the best measure of estimating accuracy is achieved by a comparison of the price forecast with the final agreed price of the completed project. However, implementation of this recommendation is considered impractical due to the effect of design changes and other time-related factors in both the pre-, and post-contract stages.

Researchers have therefore been forced to compare estimates compiled after the design has been finalised with the only suitable approximation of the actual price - the accepted tender submission. As one of the objectives of this study is to compare local performance with that achieved overseas, a corresponding approach has been adopted. Although the accuracy of early design stage estimates is not specifically addressed in this document, it is suggested that this research can assist in establishing a basis for further studies of this nature.

1.5 RESEARCH METHOD

The research originated from the perceived need to improve accuracy in design price forecasting. A thorough review of existing literature on tendering procedures, price forecasting methods, techniques for assessing accuracy in estimates and previous empirical studies of accuracy in design price forecasting establishes the basis for the research. The research methodology is summarised in Table 1.1 below.

Table 1.1 Research Methodology

	Procedure	Purpose
Stage I	Literature review on theory relating to factors affecting accuracy.	To establish a firm basis for research.
Stage II	Practitioners and academics consulted.	To provide a practical research emphasis.
Stage III	Distribute questionnaires to all 557 Quantity Surveying practices in S A.	To compare opinions of S A quantity surveyors on certain aspects of estimating with those expressed overseas
Stage IV	Analyse tenders on 1086 projects over 10 years in the Cape Peninsula submitted by MBA members.	To establish general patterns of bidding in a typical S A building environment.
Stage V	Extract details of estimates submitted on above projects where records are available plus 45 Public Sector jobs.	To determine accuracy actually achieved by estimators in comparison with bids submitted
Stage VI	Analyse Quantity Surveyors' estimates.	To establish factors affecting price forecasting accuracy.

Chapter 1

1.6 STRUCTURE OF THE DISSERTATION

The following chapter breakdown provides an overview of the content and structure of the study.

Chapter 2 - This introductory chapter describes the purpose and importance of the forecasting function. In addition, the section provides an overview of the various techniques used for estimating construction price at various stages of the design process.

Chapter 3 - In this chapter, the environment within which the quantity surveyors' price forecasting activities take place are described. Uncertainty at various levels of design development is discussed, together with possible methods of countering its effects. The availability and use of data in the price forecasting function is presented.

Chapter 4 - The nature of the term "accuracy" and the methods of its measurement are explained. The expectations of the various parties in the building process regarding the estimators' performance are studied in overview. The chapter is concluded by a review of leading research in other countries into the performance of contractors' and designers' estimators.

Chapter 5 - The theory with respect to the impact of various factors on the accuracy of price forecasts is critically examined by means of a commentary on the available published literature.

Chapter 6 - The results of the opinion survey dealing with factors affecting accuracy submitted to South African quantity surveyors is compared with a similar exercise recently conducted in the United Kingdom. The results are evaluated in terms of the theoretical concepts indicated.

Chapter 7 - An empirical study of a sample of contractors' tenders and quantity surveyors' price forecasts is undertaken with a view to verifying the principal factors affecting accuracy.

Chapter 8 - The major conclusions and recommendations resulting from this research are established. Areas of future research are also proposed

2. THE PURPOSE AND IMPORTANCE OF ESTIMATING

"Progress is impossible without change, and those who cannot change their thinking, cannot change anything" : George Bernard Shaw

2.1 INTRODUCTION

Construction management theory traditionally divides the project procurement process into two stages: the design phase and the construction phase. This separation is reflected in the development of contract price forecasting techniques, which are intended to meet the perceived needs of both the client (design) and contracting sectors of the construction industry. Skitmore and Patchell (1990) comment that whereas designers need to inform the client of anticipated financial implications of design decisions, contractors need to be able to assess the income implications to themselves should the contract be acquired.

An overview of estimating systems employed by quantity surveyors during the design stage of building projects is provided in this section. This establishes a background against which the later chapters can be viewed. No detailed descriptions of the techniques listed are given as these are well covered in general literature dealing with building economics (Seeley, 1983; Ashworth, 1988a; Ferry and Brandon, 1991).

The relevance of the subject matter is determined by describing the necessity for compiling pre-tender estimates. Although many diverse uses of price forecasts are presented in this chapter, it is shown that the provision of consistently accurate estimates to clients is of primary importance to the quantity surveying profession.

2.2 DEFINITIONS

Before undertaking a detailed study of the art of estimating it is necessary to define certain pertinent terms. The Concise Oxford Dictionary states :

Estimate - " Approximate judgement of cost, value, size, etc ; a price specified as that likely to be charged for work to be undertaken; make a rough calculation. "

Chapter 2

Forecast - " predict; estimate or calculate beforehand; a calculation or estimate of something future. "

By definition therefore, both the estimate and forecast are approximations. However, whereas the forecast relates solely to future uncertain events, an estimate may also be applied to existing observable circumstances.

The terms *price forecasting* and *cost estimating* are used synonymously in this study. Bowen and Edwards (1985b) assert that although authors such as Skoyles (1977), Morrison (1984), Flanagan and Norman (1983), and Ferry and Brandon (1991) adopt differing approaches in the use of this terminology, both have similar basic meanings and are often used interchangeably in the building industry.

Possibly the most widely known definition of construction estimating is that given by Wexler (1969), sometimes also accredited to George (1973). Their expression is: *"an estimate is the anticipated amount for which some future builder, usually unknown, will agree to execute at some future date, usually indeterminate, certain works which are frequently only partially defined at the time the estimate is prepared "*. The difficulties which potentially face the estimator are well illustrated in this commentary.

The importance of the quantity surveyor's estimating activities is underlined by the fact that all cost planning and control techniques, whether pre- or post contract, are based upon various estimating practices and techniques. Seeley (1983), however, emphasizes the primary objective of the exercise as conducted in the pre-tender stage of project development, by stating that *"estimating aims at providing a preview of the probable tender figure"*.

2.3 THE NEED FOR PRICE FORECASTS

The nature of development (i.e realising the potential of land by planning and constructing buildings thereon) requires the participants in the process to have considerable knowledge of building costs at an early stage; the planning and design stages being considered critical to the success of a project.

Several authors, most notably Raftery (1987b), contend that satisfactory financial management depends heavily upon the services provided by price forecasters. The importance of the price forecasting function within the project development package is

Chapter 2

underlined by the fact that the building price constitutes the major portion of total project development costs (Norval, 1990; Bowen, 1992).

In the construction world, many notable projects provide excellent examples of completed costs differing significantly from initial estimates. Prominent developments frequently referred to include the Westminster Houses of Parliament, Thames Barrier, Barbican Arts Centre, the Australian Parliament Building, Sydney Opera House and the Suez Canal. While the reason for some of the above differences can be ascribed to major contract design changes, it may be assumed that in some instances a flawed initial estimate is the primary cause. (Ogunlana, 1989)

Because the consequences of inaccurate or misleading estimates being presented are far reaching, incorrect forecasts may precipitate a condition for conflict between the parties involved in a building development.

Bennett *et al.* (1981) clearly indicate that one of the most important functions conducted by members of the quantity surveying profession is that of price forecasting. Although the above report, which was concluded a decade ago, applies to the United Kingdom the content is considered no less valid in South Africa today. This view is supported by Davis Langdon and Everest (1991) who state that *"the development need (in the future role of the quantity surveyor) is greatest in areas of early cost advice, cost and market forecasting and cost control"*.

2.3.1 Uses of price forecasts

Price forecasts compiled during the design stage, serve firstly to advise the client on the probable cost of a proposed project, and secondly to assist the design team in their activities prior to awarding a tender. Pre-tender estimates are further employed during the analysis of the tender submissions.

The purpose of estimates is often dependant upon the project development stage. Hemphill (1968) and Ogunlana (1989) list some of these uses as:

- * determining capital investment costs and establish project feasibility
- * preparing a cost budget for the undertaking
- * appraisal of the capability to afford a scheme design
- * assisting in decisions on continuation or abortion of a project

Chapter 2

- * making provision for financing the project
- * using for taxation, insurance and valuation purposes

The most common applications of price estimates by the design team are referred to as:

- * the preparation of a cost plan for the project
- * the distribution of expenditure between the various components of the project
- * the evaluation of the suitability of proposed solutions to design problems.

Skitmore (1990a) postulates that "in commercial terms the quality of construction price forecasts is a measure of the satisfaction obtained by the purchaser of the forecasts". Whilst several factors may determine the extent of the satisfaction gained, it is suggested that one of the primary considerations of quality is the performance of the forecaster in terms of the accuracy of predictions made.

2.3.2 Serving client requirements

An investigation into clients' attitudes towards estimating performance, conducted by the Building Design Partnership on behalf of the Royal Institution of Chartered Surveyors (RICS, 1984), reveals a number of the causes of clients' dissatisfaction with quantity surveyors' price forecasting performance. Two major concerns identified are; firstly, the accuracy of price forecasting is perceived to be poor; and secondly, accurate cost advice, particularly during the initial planning stages, is reported as not being consistently available from quantity surveyors.

This conflicts with Greig's (1981) limited opinion survey suggesting that clients are generally satisfied with the construction cost advice provided by quantity surveyors. Quantity surveyors are, however, criticised for poor advice on cost problems in an extensive survey conducted by Wilson Large and Partners (Anon, 1990), a quantity surveying firm in the UK. The collated responses of over 300 clients strongly suggest that price forecasting and budget planning need to be improved.

A study undertaken by Bowen (1992) provides a detailed disclosure of the attitudes of architects and clients in South Africa towards the adequacy of quantity surveyors' price advice. Responses to a national postal survey were provided by 124 clients, comprising mainly property developers, estate agents and financial institutions, as well as 99 architectural practices. A summary of the responses is shown in Figure 2.1.

Although all respondents indicate that the provision of cost estimates are useful, a difference emerges between the clients and architects with respect to the stages of development that are considered as most important for the utilisation of such advice.

Percentage Assessment

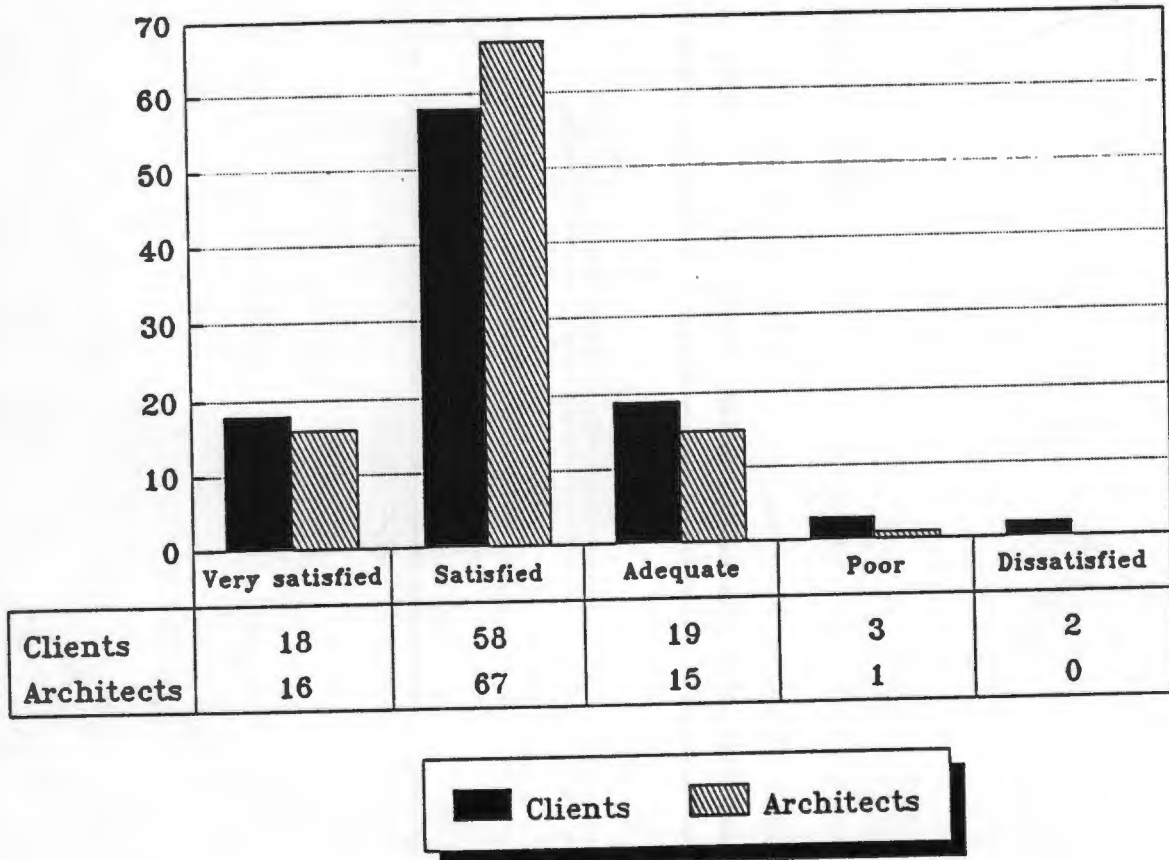


FIGURE 2.1 SATISFACTION WITH QS COST ADVICE

(Adapted from Bowen, 1992)

The survey however, reveals that whilst both clients and architects are generally satisfied with the provision of cost advice from quantity surveyors, certain specific activities provide cause for dissatisfaction. One of the specific features identified as requiring attention is the poor accuracy of price forecasts provided.

2.3.3 Elements of a good / poor estimate

A survey of the relevant literature failed to disclose any authoritative reference to the definition of what constitutes a "good" estimate. While the term is ill-defined, it is

contended that the accuracy of the forecast, which is ordinarily used as the measure of acceptability, should not form the sole basis of assessment.

One of the few authors who attempts to address this issue is Lorenzoni (1986). He elects to interpret estimating performance by itemizing a number of negative standards, resulting in what is termed a "bad" estimate. Some of the items listed are:

- * Significant underestimation (Lorenzoni does not mention the problems experienced by estimating too high a figure)
- * Inconsistent results
- * Poorly documented cost estimates with few details, especially where needed
- * Unreliable for funds allocation

Clearly there are a number of criteria to be met if a price forecast is to fulfill the needs of the intended users. The extent to which these criteria are satisfactorily addressed determines the level of satisfaction displayed by the user. A good estimate may be defined as one where the estimator has a balanced amount of detail in relation to the quality of the estimate essentials, and the product optimally serves the needs of the end-user.

2.4 OVERVIEW OF DESIGN PRICE FORECASTING TECHNIQUES

2.4.1 General

The conventional models of the building design process introduced by the Royal Institute of British Architects (1980), and adapted by the Institute of South African Architects (1981), indicate the practical use of different estimating techniques at various stages of development. Ashworth and Skitmore (1982) cite numerous research reports such as Park (1972), Barnes (1974), Keating (1977), Marr (1977), and McCaffer and McCaffrey (1981), which all reflect differing terminology regarding the stages at which estimates are produced.

During the 1960's and most of the 1970's the reported work in the field of price forecasting was almost entirely deterministic. Largely as a result of the impression that clients wanted the information as firm, authoritative amounts, even when projects were not fully defined, estimates of price were given as single point figures.

Chapter 2

From the early 1980's however, uncertainty in project planning and forecasts has become an accepted component in quantity surveyors' estimates in the United Kingdom (Raftery, 1991a). The extent to which this development has been adopted in South Africa is dealt with later in this chapter.

The choice of which technique should be used at any stage has traditionally been influenced by the theory that extremely limited information is available to the estimator during the early stages. Raftery (1984) states that the extent of development in the design stage should constitute the basis for choosing a forecasting model, noting that the amount of information increases as the design sequence develops.

Factors such as the urgency and use to which the estimate will be put, availability of data, and training and experience of the estimator may further determine the form of the price forecast used. It is recognised, however, that relatively few of the available forecasting models are actually used in practice by estimators (Ashworth, 1988a; Raftery, 1991b).

The result of a postal survey of all quantity surveying practices in South Africa (Bowen, 1992), indicates that the reasons considered most likely to influence the selection of a forecasting technique are the level of information, the time available, and the perceived accuracy of the estimating method.

Evaluations of more than 50 reported pricing models (Newton, 1991), have been presented in diverse ways by many authors (James, 1955; Ashworth & Skitmore, 1982; Raftery, 1984, 1987a; Wilson, 1987; and Newton, 1991). For the purpose of this study, systems are classified under the general headings of 'traditional' and 'non-traditional' models as proposed by James (1955) and Ferry and Brandon (1991).

The detailed workings of each model are however not dealt with in this dissertation as these have been covered extensively in publications such as Cartlidge and Mehrrens (1982), Seeley (1983), Smith (1986), and the thesis of Morrison (1983). A brief summary of the more significant features is examined in the following paragraphs.

Chapter 2

2.4.2 Traditional Systems

2.4.2.1 *Single-price rate methods**(a) Unit Method*

This method allocates a price to each functional accommodation unit of the particular building, the unit price rate usually being derived from an analysis of the unit prices of a selection of similar buildings. Typical examples of the units of allocation are:

Car parks	Cost / car space
Hospitals	Cost / bed
Houses	Cost / occupant
Schools	Cost / pupil
Theatres	Cost / seat

The functional unit forecast is a simple method that takes into account the repetitive nature of accommodation when construction type does not vary greatly. The estimate for the project is calculated by multiplying the total number of units by the unit rate. The unit rate is calculated from information extracted from documentation on recently completed similar contracts, with costs suitably adjusted for cost escalation, design changes, market conditions, etc. (Smith, 1986).

The negative aspects of the method are: (a) rates utilised by the model become obsolete in a relatively short period of time, and (b) because of the relatively large unit values, minimal errors in quantity may distort the final price considerably. In an attempt to overcome this problem, the forecast is sometimes given in price ranges which become more specific as additional detailed information is provided (Seeley, 1983; Smith, 1986).

There are no established rules for measurement; it being considered advisable for the price of external works to be excluded from the estimated price of the building. Data required for the calculation of an estimate utilising this technique would comprise the established price of similar buildings (adjusted for time), and the number of units to be provided.

In addition to being a convenient form of stating a price limit or budget, the technique is realistically only suitable for providing a speedy, simple method of comparison. While the system may be suitable for assisting in long-term forecasts of the price of very similar

Chapter 2

buildings (e.g. a programme of schools), it is totally unsuited for price forecasting of individual buildings (Ferry and Brandon, 1991).

The limitations of the technique are its lack of precision and the difficulty of making allowance for a whole range of factors including shape and size of the buildings, constructional methods, materials, finishings, etc (Seeley, 1983).

Nisbet (1961) suggests that this method should be regarded as a method for facilitating comparisons, rather than a method of price forecasting *per se*, and its application to be limited to establishing a budget at the inception stage of the project.

(b) Cube Method

This method, used extensively between the two World Wars, has diminished in popularity and is now used primarily in the UK for the calculation of heating requirements for buildings, or for fire insurance premium estimates (Cartlidge and Mehrtens, 1982).

Although quick and simple to calculate, it is considered to be inaccurate and unreliable, unless two identical buildings are used as comparisons. The system makes no allowance for variance between plan shape, storey height, number of stories, or different construction techniques. These differences give rise to wide variations in cubic rates (Seeley, 1983). A further problem is that the method does not appear to be widely understood by either clients or the design team.

The method is based upon the price per cubic metre (volume) of the building, and is mainly applicable at the appraisal and definition stage of the project. The measurement of the volume of the building is obtained by the application of measurement rules prescribed by the Royal Institute of British Architects (R.I.B.A., 1954). ^{LAST} As with the superficial floor area method (to be discussed later), where different areas of a building are subject to different uses and specification, these differing parts can be measured and priced separately. Lump sum adjustments are made for special items such as siteworks.

The volume of the building multiplied by the cubic rate, gives the approximate cost of the building. When an estimate for a new project is compiled, an analysis of the updated cubic rates of previous projects of similar nature are used for pricing the volume of the new building.

DIS ADV'S

Chapter 2

This technique is intended to overcome the suggested inadequacy of the superficial floor area method with respect to the vertical elements of the building. However, Flanagan (1980), in an investigation of the relationship between price per cubic metre, building height, and price per superficial area, clearly proves that the cubic method is similarly insensitive to height variability.

(c) Superficial Floor Area Method

In this method, the floor area of the building is measured and multiplied by a rate per square metre. If the quality standards and specifications or constructional details differ substantially within the building, they are quantified separately and appropriate rates are applied to each area. This technique is considered to be one of the most widely used by practitioners (Seeley, 1983). The reasons described as being responsible for its popularity include :

- 20/5
- (a) Calculations are easily computed.
 - (b) Project data is normally recorded in this form, or alternatively, can be easily extracted from existing or previous schemes.
 - (c) It is a form of measurement understood by all parties involved in the design process.

Although no formal rules on the measurement of the building area exist, the procedures set out in the Guide to Elemental Cost Analysis (ASAQS, 1982) are usually applied in South Africa. In this method, the area is reflected by the sum total of the areas measured at each covered floor level, taken over the external walls or lines of the vertical structure. This differs from the procedure normally employed in the UK, where measurements are taken to the internal faces of walls. In South Africa the calculation of building area is measured over all internal walls and partitions, internal staircases, lift shafts and ducts, covered porches and balconies, but excludes any allowance for external steps, roof overhangs, internal open areas and small projections.

The main problem associated with this method is in determining a suitable rate. The usual ^{normally} approach relies on analysis of similar historical projects; the method of selecting an appropriate base project and the means of adjusting the data being of a subjective nature. Lump sum allowances need to be made for external works and other items of work not related to the building area.

Chapter 2

As a result of the square metre rate being determined by the horizontal components of the buildings, no direct account is taken of the vertical components, storey height, shape, construction, finishes, roofs, or density of planning of the proposed project. A further problem arises if the scheme has a variety of different functions within the building (Ashworth, 1988a), with the consequential need to access the data of a similar building for comparison purposes.

The advantages of this system are its ease of application, its relatedness to accommodation, the acceptance and usage by the rest of the design team, and its ability to cater for differences in size, specification and construction. The technique is suitable for application during the inception, appraisal and definition, and design concept stages of the building procurement process.

(d) Storey Enclosure Method

In response to dissatisfaction with the cubic method of price forecasting, the storey enclosure method of estimating was developed by the Wilderness Cost Study Group of the Quantity Surveying Division of the Royal Institution of Chartered Surveyors (James, 1955). This method is considered suitable for use during the design concept, and design development stages.

In this system sections of a building are measured superficially and multiplied by a weighting factor, determined by that section's effect on the total cost. These weighted quantities are then totalled and multiplied by a single rate, obtained from an analysis of previous projects, to arrive at an estimated total for the project.

The technique is not strictly a single-price method of estimating but is considered to be the linkage between single and multi-rate price forecasting systems. Although accommodating the shape, total height, storey height and total floor area of a building, the system has never gained wide acceptance and has been superseded by the elemental method of forecasting (Ferry and Brandon, 1991).

Whilst the method offers an acceptable medium for the quantification and pricing of the structure and finishes, the acceptable incorporation of 'non-standard' items does present a problem. Prices for items such as site works, the additional cost of more expensive components than those normally associated with the type of building, mechanical and

Chapter 2

engineering services and features such as balconies are typically derived by means of approximate quantities.

Adaptations of this technique have been developed in the United States of America (Diehl, 1966), and South Africa. Results obtained from the application of the American model appear to be more promising than those of the original British method (Flanagan, 1980).

In the early 1970's, the Department of Public Works and Land Affairs (PWD), (formerly known as the Department of Public Works) in South Africa produced a variation of the private sector storey enclosure forecasting system for use in public sector contracts under their control. This system (PWD, 1972) is based on the use of a single tariff which is applied in proportion to the horizontal and vertical elements of the building.

The major disadvantage of the method is that it is not easily understood by architects and clients. In addition, quantity surveyors in South Africa appear to have rejected the use of the method for private sector work, possibly due to difficulties experienced in applying the PWD model to any but the simplest types of building.

2.4.2.2 Multi-price rate methods

(a) Approximate quantities method

Approximate, or 'rough' quantities, is a measured combination or grouping of typical bill description items, to form composite items for pricing as an estimate (Ashworth, 1983). The selection of items measured is based on the principle that 80% of the final price is represented by 20% of the quantifiable items (Kelly, 1987; Brandon, 1984). The items not directly measured are usually taken into account by adjusting the individual rates or presenting them as a percentage of the final figure.

This method is regarded by most quantity surveyors as being one of the most reliable methods of forecasting, provided that sufficient information is available at the time of execution (Seeley, 1983; Smith, 1986; and Willis and Ashworth, 1987). As the measurement is handled in much the same way as a typical 'bill' measurement, a reasonably large amount of information needs to be available before a forecast can be produced. The degree of detailed measurement, and the corresponding accuracy and confidence levels, depends largely on the amount of design information available.

Chapter 2

This method involves pricing approximate building quantities at rates produced at the same time that the quantities are prepared. These rates are usually based on those extracted from previously accepted bills of quantities or, less frequently, compiled using first principles. Billett (1990) observes that this method has an advantage over some other techniques as it makes an automatic allowance for plan shape, height and size. Although approximate quantities estimates ordinarily require greater time and effort than single-price rate methods (Cartlidge and Mehrtens, 1982), advances in computer applications have resulted in reductions in production time differences between the various estimating systems.

Whereas in South Africa there are no formal rules of measurement, measurement guidelines for quantity surveyors in the UK are provided by the Royal Institution of Chartered Surveyors guidelines (RICS Pamphlet No. 2, undated). The main advantages of using this system are reliability, compatibility with the overall design procedure, and the fact that adjustments are comparatively easy to make in respect of differing specifications, shape, size and height.

This approximate quantities forecasting model is used principally during the design concept and design development stages, but is suited to use during the latter stages of design as well. It is claimed that this is the most widespread estimating method used in practice in the UK (Property Services Agency, 1980; Bowen, 1982a).

(b) *Elemental estimating system*

This method, derived from the storey-enclosure system, expresses the cost of the project on an elemental basis (Ashworth, 1988a). In this system, the measurable elements and components comprising the building are identified; an element being defined as that part of a building that always performs the same function irrespective of its construction or specification, and a component as a sub-division of an element. These are priced in one of two ways; either by the individual pricing of components using first principles, or by adjusting prices derived from a similar previous project. Measurement of quantities from sketch plan development stage is based on the principles embodied in the document entitled 'Guide to Elemental Cost Analysis' (ASAQS, 1982). The South African method of elemental price forecasting and analysis is similar to the British 'Standard Form of Cost Analysis' issued by the RICS, but reflects a different grouping of elements and components.

Chapter 2

The effective use of this estimating method has been severely hampered by the lack of suitable pricing data for general use. Due to the lack of support of the quantity surveying fraternity, a South African elemental building data service initiated in 1982 was discontinued in 1984.

Advantages of this method are its ease of application, and the ability to undertake price comparisons with other buildings on an elemental basis. Disadvantages associated with this system are, method familiarity, the time required for its preparation and the skill needed for the adjustment of rates.

(c) Pricing Bills of Quantities

The bills of quantities price model is applicable to the technical documentation and approvals stage of the building procurement process. It is regarded as a product-based forecasting model because of its emphasis on measuring the project as 'finished work in place' (Ferry and Brandon, 1991).

The pricing of the bills of quantities by the quantity surveyor immediately prior to the receipt of tenders, constitutes the final price forecast in the pre-contract stage of the building procurement process. In undertaking this task, the quantity surveyor attempts to emulate the pricing actions of contractors tendering for the contract.

The rules of measurement are prescribed in the 'Standard System of Measuring Builders Work' (ASAQS, 1991), sixth edition. This document forms the basis of the competitive form of tendering in the South African building industry and provides a detailed schedule of the quantifiable work for a particular project. Rates are usually calculated from historical cost data, and adjustments based on professional judgement are made for perceived differences in quantity, time and complexity. Alternative pricing methods entail the use of published price books and the compilation of price rates from first principles.

This system currently represents the most detailed form of forecasting in general use. Because it relates directly to the submission of tenders, an evaluation of differences between the quantity surveyor's pricing and that of the successful tenderer is facilitated. Its main disadvantage relates to the timing of its application. Because it occurs at a late stage in the design process it is ineffective in influencing design. Furthermore, the time taken to prepare this form of forecast is usually considerably greater than any of the other methods discussed.

2.4.3 Non-traditional Systems

(a) General

Brandon (1984) presents three systems that he believes assist in modelling the approach used by an expert in compiling a price forecast. These are simulation, regression analysis and expert systems.

The utilisation of various statistical averaging techniques to prepare estimates of price, is considered by Keating (1977), to be of considerable importance. He further states that *"statistical averaging techniques produce higher overall accuracy than detailed estimating techniques based on a great many assumptions"*. The validity of this statement is not considered in this document, but the importance of these systems is signified by this opinion.

(b) Statistical models

(i) Regression models

During the 1970's and the first half of the following decade, regression models emerged as the most popular statistically based technique with researchers such as Tregenza (1972), Kouskoulas and Koehn (1974). McCaffer (1975), Flanagan and Norman (1978), Reynolds (1980), Bowen (1982b, 1984) and others writing at length on the subject.

According to Makridakis (1978), the purpose of regression analysis forecasting is to predict a dependent variable by ascertaining how it relates to one or more independent variables. When a prediction is made on the strength of a single independent variable, simple regression is appropriate. However, if additional independent variables are used, multiple regression analysis is suggested. The mathematics of simple and multiple regression is not dealt with in this dissertation, as it is extensively covered in other publications (Makridakis, 1978; McCaffer *et al.*, 1984; Barron and Target, 1985; Wheelwright and Makridakis, 1985).

Ⓜ While regression models are suitable for application throughout the design stage, they are considered most valuable in the earlier stages when minimal design information is

Chapter 2

available. The main limitation of the technique is the need for the user to possess an adequate grasp of the science of statistics (Bowen and Edwards, 1985a).

(ii) Parametric estimating

Several researchers, including Nadel (1967), Meyret (1969), Tumarkin (1971), Paige (1979), Krieg (1979), and Black (1992) have published documents on the theory and application of parametric price forecasting. The underlying principle of parametric forecasting is that there is a definite relationship in the ratio or proportion between the average price of a particular unit, element or component and the price of the complete building. For example, structural steel costs may be related to the gross area supported, or drywall costs to the internal area. The investigation by Tregenza (1972) into the relationship between building height and cost depicts a particular example of the applicability of this technique.

Parametric price modelling displays several advantageous features such as the speed in which a forecast can be produced, and the ability to produce a forecast without reference to drawings as long as the factors which affect building prices are known, together with details of building size, height, etc. Paige (1979) indicates the primary disadvantages as being its inability to reflect the prices of the various elements of the system, and the need for an extensive source of price data for effective usage.

(iii) Monte Carlo simulation

Monte Carlo simulation is not regarded as a pure forecasting method, in the sense that it may be applied in conjunction with many of the previously identified estimating techniques. Flanagan and Norman (1982a) assert that use of the technique enables the relationship between an estimated price and the chance or probability of the tender price deviating from that amount to be reflected. In addition to identifying the probable price range, the method provides an indication of the risk and uncertainty associated with an estimate.

The study by Bennett and Ormerod (1984) demonstrates that the results of simulated tests conducted were better than those predicted in other ways. Mathur (1989) supports the use of simulation by expressing the view that in the prediction of building costs, so many variables are probabilistic in nature that realistic mathematical models will be too complex to be of practical value.

Chapter 2

(iv) *Expert systems*

Expert systems may be viewed as a 'modelling environment', rather than as a forecasting technique, and as such will not be explained here in detail.

Brandon (1984) states that the expert system environment can be compared with a computer environment, which allows rules to be set up which lead to goals or conclusions. However, expert or intelligent knowledge based systems have two characteristics which distinguish them from other computer programs. Firstly, they attempt to build in 'rules of thumb' (heuristics), and beliefs held by the experts in the field. Further, they should, in theory, have the capacity to 'learn' new rules as they are used. (Raftery, 1990)

No expert system packages are known to be in use by practitioners in the South African construction industry as yet. The well known ELSIE expert system package, available from the Royal Institution of Chartered Surveyors, has been acquired by several university departments for research, and possible development purposes, but immediate application within the local construction industry appears unlikely.

2.4.4 Resource based models

As discussed by Ferry and Brandon (1991), resource-based models are concerned with the duration of construction, the resources employed, the sequence of events, and the inter-relationship between activities. It is suggested by Flanagan (1980), that any system incorporating operational information will provide a more reliable basis for price forecasting.

Two forms of resource-based price models are critical path models and activity bills. In both instances, the forecaster needs a detailed program of the project before the forecast is conducted. In a critical path analysis a project is divided into activities of short duration, thus enabling each activity to be scheduled and priced in a logical manner.

Problems facing the further implementation of resource modelling include the need for the provision of reliable data to be made freely available, as well as the acquisition by professional consultants of the knowledge base relating to resource planning.

Chapter 2

2.4.5 Usage of estimating systems

Limited research has been undertaken to establish the extent of use, and the stages during the building procurement system of implementation of the various estimating techniques identified. The lack of such information relevant to the UK is especially surprising in the light of the amount of research conducted there in the field of building economics.

Bowen (1982a), in a limited postal questionnaire in Edinburgh, found that at sketch design stage the approximate quantities method of estimating is the most popular (57%), with the rate per superficial floor area (27%) being the second most popular.

Billett (1990), in a questionnaire sent to all quantity surveying practices in South Africa, attempts to establish the usage patterns for the commonly identified price forecasting methods. The summary of the 73 responses received is given in Table 2.1.

METHODS	STAGES				
	INCEPTION	FEASIBILITY	OUTLINE PROPOSALS	SCHEME DESIGN	DETAIL DESIGN
Unit Rate	24	9	3		1
Cube Rate	2	2	1		
Superficial Rate	38	17	9	3	2
Storey-Enclosure Rate	5	7	9	9	8
Approximate Quantities	17	37	39	46	52
Elemental Method	23	41	36	41	40

TABLE 2.1 ESTIMATING SYSTEMS USED AT DIFFERENT DESIGN STAGES

(Adapted from : Billett, 1990)

Chapter 2

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TABLE 2.1 ESTIMATING SYSTEMS USED AT DIFFERENT DESIGN STAGES

(Adapted from : Billett, 1990)


Chapter 2

It is noticeable that an exceptionally large number of respondents indicate the use of the "unit rate" system at the inception stage. Billett does not comment on this finding, but a possible reason for the popularity of the 'unit rate' method is that certain of the public sector clients establish project budgets for initial project approval on the basis of "cost norms". The superficial floor area method is clearly the most widely used single-rate estimating system. However, in the main, this form of estimate is limited to the early design stages.

The approximate quantities and elemental estimating methods are used extensively in both the preliminary design stages, and during the design development once detailed information becomes available. The approximate quantities method is used marginally more often than the elemental system in the latter stages of design development. Even though firms were given the opportunity to identify whether they employed other estimating methods such as the non-traditional systems previously discussed, no evidence of utilisation was indicated.

In a questionnaire sent to all quantity surveying practices in South Africa one year later, Bowen (1992) had a slightly better response of 99 firms. Bowen's questionnaire dealt with the use of price forecasting methods in greater depth than Billett's, indicating specifically identified and defined alternative estimating methods. His findings are similar to those of Billett (1990), but indicate a clearer preference for the approximate quantities method.

According to Bowen (1992), the forecasting techniques most widely used by quantity surveyors at the various stages of the design process are:

- * inception stage - superficial area
 - * appraisal stage - elemental and / or approximate quantities
 - * design concept stage - elemental and / or approximate quantities
 - * design development stage - approximate quantities and / or elemental
 - * documentation stage - bills of quantities
- 

It is noticeable from the study of Bowen (1992) that very few quantity surveyors use non-traditional systems such as the statistical models, simulation or resource-based methods of price forecasting. In this regard, Wills (1990) points out that the business world is becoming more and more familiar with decision theory techniques which are inherently probabilistic. He asserts that, in order to satisfy the needs of clients conversant with such techniques, probabilistic techniques will dominate the future construction industry's decision-making processes.

2.5 CONCLUSIONS

Price forecasts are used for a variety of purposes by both the client and the design team. An estimate should contain a balanced amount of detail in relation to the quality of the estimate requirements, and should be aimed at serving the needs of the end-user in the best possible fashion.

Client bodies in South Africa have recently indicated that there is some dissatisfaction with the accuracy of estimates. Since one of the primary objectives of price forecasting is to present the client with reliable cost advice, the need to investigate means of improving this service is clearly established.

Traditional estimating techniques can be divided into single-price rate, and multi-price rate methods; all these methods are however, of a *deterministic* form. Non-traditional systems generally have a foundation in statistical theory, and extend the options available to incorporate *probabilistic* principles.

Skitmore (1985) surprisingly, comments that a justifiable approach to the problem of attaining better estimating performance is to change the emphasis from the investigation of new methods of forecasting, to the examination of better utilisation of estimating methods currently employed in practice.

This dissertation specifically considers aspects relating to price forecasting at the tender stage of projects. It is argued that recognition of the factors affecting estimating performance at this stage, can lead to an improved potential for a reliable price forecasting service to be instituted at earlier stages of design.

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3. THE DESIGN PRICE FORECASTING ENVIRONMENT

"He only moves towards perfection of his art whose criticism surpasses his achievement" : Leonardo da Vinci

3.1 INTRODUCTION

In the previous chapter, the background against which the price forecasting activity during the pre-tender stage of a project takes place is described. While this study emphasizes those factors affecting estimating accuracy at the tender stage, certain conditions can be identified which influence performance throughout the design process. It is to these areas that professional skill and expertise should be directed if the critical challenge described by Davis Langdon and Everest (1991) to *"improve the accuracy of early cost advice and market forecasts"*, is to be realised.

A fundamental requirement for the provision of a satisfactory price forecasting service is the availability of adequate cost / price data information. In order to establish the potential impact on local quantity surveyors' estimating proficiency the availability of such data in South Africa is critically examined. The utilisation of feedback from completed estimates is a further aspect of data that is investigated. This activity is considered by prominent researchers to be one of the most important 'factors' involved in the provision of price forecasts (Skitmore, 1985).

The structure of estimating systems commonly adopted is defined in order to differentiate between budget allocation procedures, and price predictions attempting to represent an anticipated project tender. In using the procedure, the estimator needs to be aware of the significance of major areas of forecasting uncertainty, such as tender variability and the inherent variability of different estimating techniques. An overview of these considerations, indicating some of the problems faced by the estimator at any stage of project design development, is provided in the following paragraphs.

3.2 STRUCTURE OF ESTIMATING SYSTEMS

3.2.1 Forecasting theory

The selection of a forecasting method depends on factors such as the context of the forecast, the relevance and availability of historical data, the degree of accuracy desirable, the cost/benefit (or value) of the forecast to the firm, and the time available for making the evaluation. Georgoff and Murdick (1986) comment that balancing the advantages and disadvantages of techniques with regard to a situation's limitations and requirements is an intimidating but vital management task.

There are three basic types of forecast - qualitative techniques; time series analysis and projection; and causal models (Barron and Target, 1985). Qualitative methods are based on judgement using qualitative data and may or may not take the past into consideration. They are distinguished from guesses by their systematic nature. Time series forecasting methods focus entirely on patterns and pattern changes and involve predicting future values of a variable from observations of its historical behaviour. Causal methods involve the identification of a leading variable which has a causal relationship with the variable being studied (Chambers *et al.* - 1971). As with time series analyses, the past is important to causal models.

3.2.2 Defining estimating procedures

Several attempts have been made to define the differing estimating procedures. While Seeley (1983) mainly differentiates between *single purpose* estimates and *dual purpose* estimates, Ashworth and Skitmore (1982) recognise *traditional* methods which can be of an approximate, analytical or operational nature, and *computer-aided* models which are either based on traditional techniques or have a statistical basis. Bowen and Edwards (1985a) reflect a different view by indicating that the various techniques manifest either a *historical-deterministic* or *inferential-relational* approach.

Wills (1990) groups estimating techniques into two categories; methods in common use in current practice and methods used in research circles but not in current practice. Beeston (1983) elaborates on this aspect of cost model identification by stating that there are two distinct ways of representing costs: the realistic and the "black box" approaches. The latter

Chapter 3

approach is most commonly used by design price estimators. He concludes by stating that "*their only justification is that they work*". However, no evidence in support of this statement is provided.

An indication that the quality of price forecasting systems presently used can be improved, is provided by the numerous researchers investigating alternative forecasting techniques. A unique classification system, based on a three-dimensional framework including data, units of measurement and usage has been described by Newton (1989). In later research into emerging trends in estimating techniques, Newton (1991) proposes a set of 'descriptive primitives' (a 'descriptive primitive' is described as a generally accepted label or term), for establishing a formal classification system as a basis for future cost modelling research.

In comparison with the theoretical models previously indicated, Wilson (1984, p. 24) reflects a practical viewpoint when stating: "*It is useful to categorise cost estimation models according to purpose. Thus, they are either tender price prediction models or design optimisation models. The great advantage of the latter type of model is that many of the major cost uncertainties are greatly reduced or eliminated.*" In this study this approach is considered as being highly desirable, particularly with reference to the matter of analysis of estimating accuracy.

Estimating accuracy depends in part upon the stage of design development. Accuracy is also a function of the degree of project cost control (Rapiet, 1990). It follows, therefore, that where the design of a project has not progressed to a fairly advanced stage, it is unreasonable to expect an accurate definitive estimate of price to be based upon the final design. Therefore it is suggested herein that, in order for the true nature of early design stage cost reports to be clear to the users thereof, estimators should refrain from using the normally recognised terms *price forecast* or *cost estimate* for these cost reports.

A number of authors, although using differing terminology, have suggested that there are conceptual divisions in usage and required accuracy ranges between estimates produced at the feasibility, preliminary design, and tender documentation stages (Layshook, 1969; Marr, 1977; Fiske, 1981; Clark and Lorenzoni, 1985; and Horner, 1991).

Chapter 3

Three types of 'estimate' are defined in the Cost Engineer's Notebook, published by the American Association of Cost Engineers (AACE). These are:

- a) *Order of magnitude reports*. Those done during the initial planning stages to assess project feasibility. (Anticipated accuracy range of -30% to +50%).
- b) *Budget authorisation schedules*. Provided where detailed design is only 5% to 20% complete. (Expected accuracy range -15% to +30%).
- c) *Definitive estimates*. These are produced on occasions after at least 20% of the detailed design is completed. (Expected accuracy range -5% to +15%).

The above approach can be criticised on the basis that while the measure of "accuracy" is not identified, it still implies that these are 100% probability ranges. In addition, the design level after which "definitive estimates" are produced is a debatable issue, particularly if one accepts Humphreys and Wellman's (1986) definition of an estimate as "*An evaluation of all the costs of the elements of a project or effort as defined by an agreed-upon scope*".

Huxley (1991, p. M.1.1) strongly supports the division of purpose related forms of estimating by saying "...this writer believes that the definitive estimate is different from a *"pre-tender" building construction estimate. A pre-tender estimate is based upon 100 percent complete working drawings and specifications.*"

Gonzalez *et al.* (1988) offer a different opinion, by referring to the project estimating requirements of an oil company in Venezuela. They view the cost reporting procedure in a similar manner to that of the AACE, the estimate reports being termed screening, budget and fair price estimates. Their fair price estimates, which can be compared with definitive estimates in the AACE model, are however only produced once at least 80% of detailed design has been completed. This degree of preparation identifies with the previously stated definition that the design should have reached a "fairly advanced stage" before a definitive estimate should be identified as such.

The above indicates a substantial support for the opinion of Bennett *et al.* (1981), who contend that the early stage estimates should be regarded as budget figures, within which costs should be controlled, rather than cost predictions.

3.3 UNCERTAINTY IN THE PRICE FORECASTING PROCESS

By reason of the vast nature of the subject, the commentary on all decision theories related to the assessment of uncertainty and risk is confined to a general overview of the topic. Similarly, the review of probability and statistical concepts supporting many contemporary risk management techniques, is limited to those aspects pertinent to acquiring a broad understanding of the subject matter.

3.3.1 The decision making process

Although the recognition of the concept of uncertainty occurred approximately 60 years ago, Higgin and Jessop (1965a,b) were among the first to document the nature of uncertainty in the building industry. In a report published by the Tavistock Institute of Human Relations in 1965, they refer to the two major characteristics that need to be incorporated in any model of the building process as 'independence' and 'uncertainty'. Authors such as Byrne and Cadman (1984), Beeston (1986), Marshall (1988), Skitmore (1989), Toakley (1989) and Newton (1991) have subsequently addressed specific aspects of the subject within the context of the property market.

Ashworth and Skitmore (1982, p. 10 - 11) in evaluating the uncertainty associated with price forecasting state:

"The construction process is characterised by complexity and uncertainty... It is noted that in a state of complete uncertainty, forecasting fails by definition... It is apparent that the dominating presence of uncertainty in the construction process militates against the production of accurate forecasts of costs by numerical analysis and synthesis alone, in the conventional objective sense."

This view is widely supported, and writers such as Porcher Miles (1980), Owen and Nabors (1983) and Bowen (1984) contend that deterministic estimates incorrectly imply absolute accuracy.

Construction work necessarily involves uncertainty, in addition to containing an element of risk. However, the need to distinguish between risk and uncertainty is not universally accepted. Whereas authors such as Whittaker (1973), Byrne and Cadman (1984), Bowen and Edwards (1985b), and Flanagan and Stevens (1990) differentiate between risk and

Chapter 3

uncertainty in construction contracting, the terms are often used interchangeably by others such as Hillebrandt (1985).

Several definitions of the two terms are suggested by the above authors, the main argument being that uncertainty arises where the occurrence of an event can be reasonably anticipated but the magnitude is indeterminate. Bennett and Ormerod (1984) further interpret uncertainty as comprising interference (e.g. those external factors affecting the project which disrupt work on a particular task), and variability (which typically refers to the rate of productivity with which work is executed). In contrast, Stevens (1992) identifies risk as a quantifiable element that may be calculated in terms of the probable outcome of a decision.

Whilst cognisance is taken of the opinion that the terms should be separately identified, the terms are used interchangeably in this study, both indicating the extent to which the actual outcome may differ from what is initially anticipated.

Price forecasts as reported to clients, traditionally reflect a single predicted sum of money without reference to risks or uncertainties. If uncertainties are reflected, they are typically addressed by qualifying statements that indicate inclusions and exclusions from the estimate. This procedure does not, however, quantify the extent of the uncertainty. The most commonly used method of allowing for uncertainty in estimates is to simply add on a percentage figure to the calculated estimate of final cost as a design contingency. Hayes *et al.* (1987) claim that this rather unsophisticated yet widely used approach has a number of weaknesses:

- a) The percentage figure may be arbitrarily arrived at and not appropriate for the proposed project.
- b) There is a tendency to double-count risk because some estimators are inclined to include contingencies in their 'nett' estimate. In addition, consultants providing Provisional Sums for specialist services often include undeclared contingencies within the estimates of cost for their particular section of work.
- c) A percentage addition still results in a single-figure prediction of estimated final price, implying a degree of certainty that is not achievable.
- d) Because it only reflects the potential for detrimental or "downside risk", the approach does not offer potential for price reduction, and may be used to conceal inadequate management performance.

Chapter 3

The quantitative analysis of risk is an even greater problem. Hawkins and Solomon (1989) point out that the variety of uncertainty in the construction industry means that, in mathematical terms, the analytical methods of risk analysis drawn from classical probability theory cannot be used in a general way.

The 'paradigm shift' referred to by Brandon (1982), has led to a greater emphasis being placed on the probability of the outcome of the forecast, rather than the deterministic approach that has been followed in the past. Newton (1991, p.102), in assessing the uncertainty associated with predictions comments:

"The nature of cost is known to be uncertain. The only question is whether that uncertainty is best formally assessed in the model, or dealt with intuitively by the user. The classification here distinguishes between those models without a formal measure of uncertainty (deterministic) and those with (stochastic). Formal measures of uncertainty may be such metrics as the associated coefficient of variation (as in regression analysis) or the cumulative frequency distribution (as in Monte Carlo simulation)."

Birnie and Yates (1991) illustrate potential hazards associated with judgements made intuitively when noting that it would seem unlikely that cost prediction in construction should be immune from common biases such as *representativeness* (people attach much more significance to certain stimuli than to others); *availability* (because of limited memory capacity, people depend on associations which are not reliable), and *adjustment and anchoring* (this refers to the process of using a previous piece of information as an anchor point and then adjusting from same to take account of any special considerations).

The greater the risk and uncertainty in the financial outcome, the greater the need for using the formal techniques of decision / risk analysis. Decision analysts argue that by using formal methodologies in decision-making, less bias and better judgements result.

3.3.2 Measurement of uncertainty

Probability theory is introduced into the evaluation process as a means of measuring uncertainty which cannot be expressed in single figure terms. Probability concepts applied to risk appraisal intrinsically involve estimating the anticipated prospect of an event occurring, and determining a probability distribution which reflects the entire occurrence of probabilities and likely frequencies.

Chapter 3

Beeston (1983) contends that estimates and estimating errors, when expressed as proportions of the target, usually conform to the "normal distribution". Although other researchers such as Skitmore (1988a) question this view, Beeston's opinion forms the basis upon which arguments in this dissertation are presented. Stacey (1980) states that the larger the range of uncertainty for an event, the less likely it becomes. He also recognises that the distribution is symmetrical about the average value. This condition is illustrated in Figure 3.1.

Furthermore, if Monte Carlo simulation type approaches are adopted, the central limit theorem is recognised as being applicable (Flanagan *et al.*, 1989). The central limit theorem states that as the sample size is increased, the sampling distribution of the mean approaches the normal distribution regardless of the form of the population distribution.

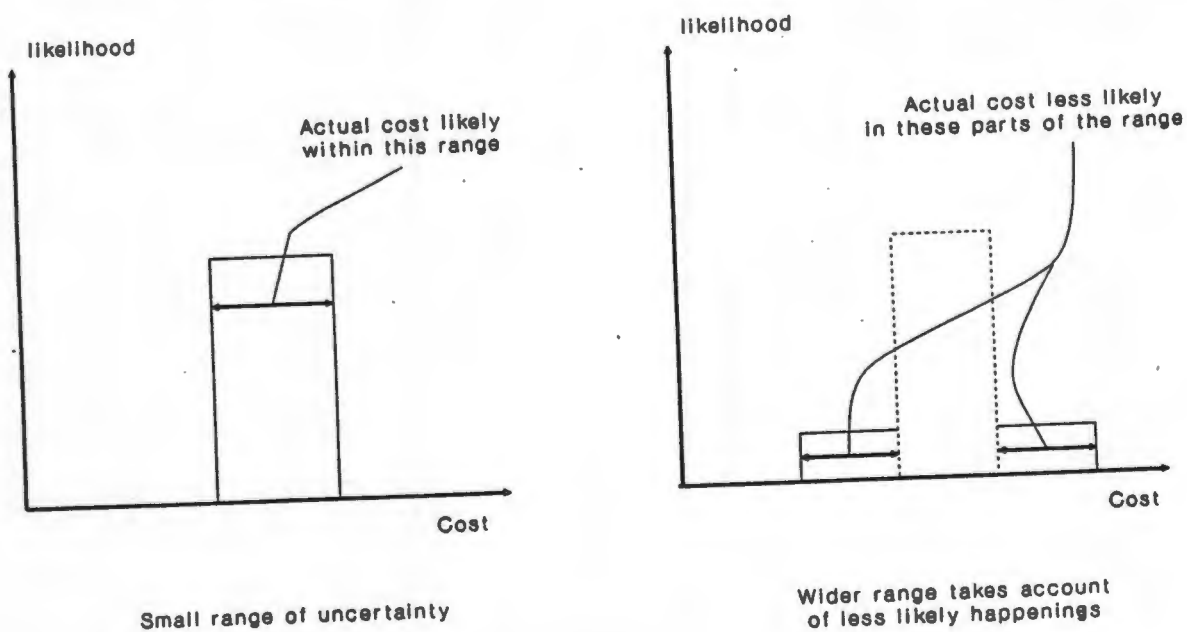


FIGURE 3.1 PROFILE OF UNCERTAINTY RANGES
(Adapted from Stacey, 1980)

The graph of the likelihood of the cost being a certain amount could be plotted as a histogram, or more conveniently this could be approximated by a continuous curve as indicated in Figure 3.2.

Chapter 3

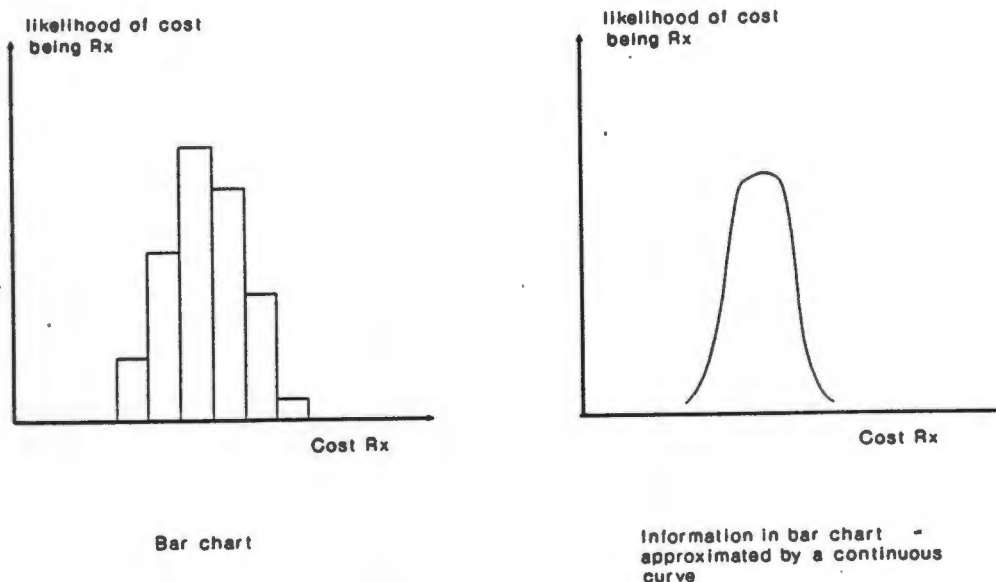


FIGURE 3.2 ALTERNATIVE PROFILES OF UNCERTAINTY RANGES
(Adapted from Stacey, 1980)

With a "normal" distribution the established measure of potential variability is the "standard deviation". When this measure is expressed as Rx about the central value, about 68% of outcomes fall within its range. Furthermore, two standard deviations each side of the central value include 95% of all outcomes, and three standard deviations include 99.75% of all outcomes. This is graphically portrayed in Figure 3.3.

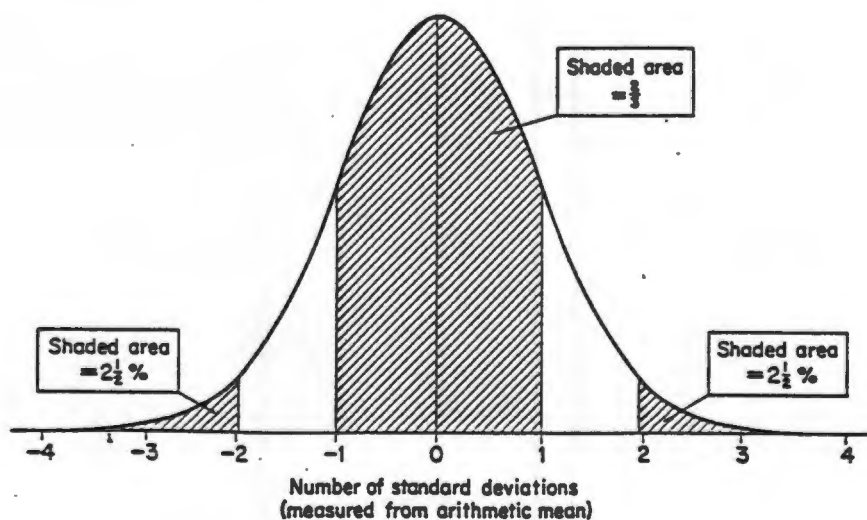


FIGURE 3.3 THE NORMAL DISTRIBUTION AND STANDARD DEVIATIONS
(Source : Beeston, 1983)

Chapter 3

Measuring uncertainty in standard deviations reflects a precise range of uncertainty. It also provides a suitable method of presentation and analysis of data in estimating.

3.3.3 Variability of tenders

An important contributor to the difference between the quantity surveyor's forecast and the lowest acceptable tender is the variability of the lowest bid. To deduce this, the nature of the environment within which the tendering activity occurs needs to be considered. This is followed by an examination of the reasons for and extent of the variability of tenders between contractors bidding for the same contract.

Raftery (1990) suggests that the characteristics of a perfect market include:

- (a) A large number of buyers and sellers, so that each transaction produces a very small share of total output.
- (b) Free entry to the market.
- (c) Perfect knowledge of the prices and quantities sold in all transactions.

The perfect market criterion of a large number of suppliers is seldom met in the construction industry. One of the foremost reasons is the highly fragmented structure of the construction industry, construction work being segmented by factors such as size of the firm, geographical area and the type of work.

There is seldom 'perfect knowledge' due mainly to the tendering methods generally utilised. In the context of the theory of price determination, bidders have no information about the prices being asked by their competitors.

Hindle (1991) notes the distinct growth of the institutional clients and the decline of the public sector client in South Africa over the past decade. His analysis of information, derived from the Bureau of Economic Research - Stellenbosch University, reflects a clear shift from open bidding to selected tendering and negotiation. Quantity surveyors' responses to his national survey, which are indicated on Figure 3.4, indicate that this trend is likely to continue in the future. This tendency will undoubtedly hinder the prospect of promoting "free entry to the market" for tenderers.

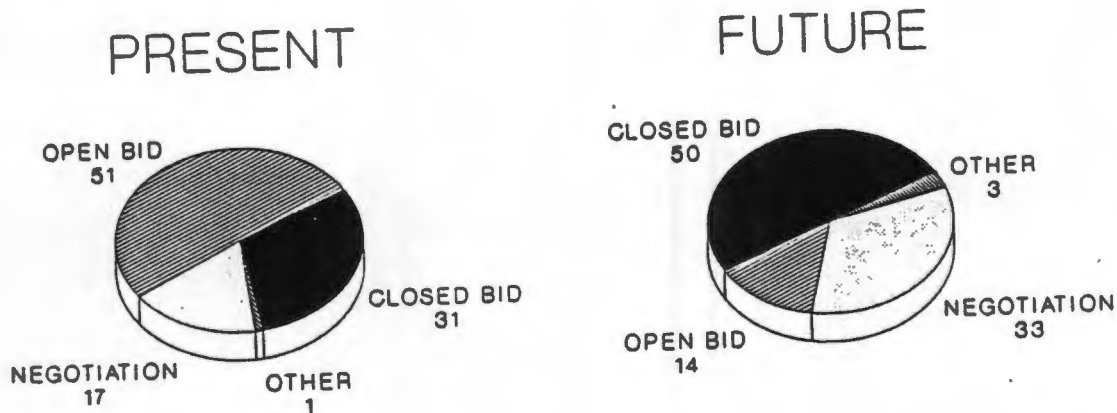


FIGURE 3.4 QUANTITY SURVEYORS PREDICTION OF TENDER METHODS
(Adapted from Hindle, 1991)

Flanagan and Norman (1985) indicate that variability in tender pricing is to be expected because main contractors do not have perfect knowledge of the direct costs of a building contract. They submit that even if tenderers have perfect knowledge of the direct costs that they incur in undertaking a contract, tender price variability can arise as a consequence of the normal practice of subcontracting parts of building contracts.

Flanagan and Norman (1985, p.156) observe:

"Increasingly, the proportion of work undertaken by the contractor's own directly employed operatives is becoming smaller... When compiling his estimate, the contractor may not necessarily always choose to incorporate the lowest bid for any particular subcontract work package. Tender price variability by the main contractors is, therefore, likely to arise simply because they employ different subcontractors and split the contract into different subcontract work packages."

Writers such as Fine (1974), Beeston (1975), Ashworth and Skitmore (1982), Runeson and Bennett (1983), Hodgetts (1987), Newton (1991), and Betts and Brown (1992), comment on the wide distribution of prices between the lowest and highest tenders submitted on projects. Such differences are attributed to factors such as different cost structures of the tendering firms, disparate competitive strategies, and familiarity with the particular type of projects or markets. Runeson (1988, p. 364) also expresses the commonly held view that :

"Some bids are undoubtedly based on mistakes in the cost estimates while others are so-called 'cover bids' not intended to win the contract and therefore above the

expected price and submitted to recover deposit moneys or to 'keep faith' with the issuing authority or consultants."

Skitmore (1981) asserts that, because it is impossible to predict the lowest tender with any certainty, the best that can be achieved is a range of values within which the lowest tender can be expected to fall. The research undertaken by Beeston (1983) indicates that a typical distribution of competitive tenders for the same contract is almost symmetrical and closely approximates the normal distribution. He notes that while there is usually a very slight skewness to the right, this is so insignificant that for practical purposes it can be ignored.

It is frequently theorised that tenders are comprised of two major, mutually exclusive elements, namely the estimate of actual cost to the contractor plus the mark-up required. The resultant possible combinations of these elements, as modelled by Skitmore (1981), is shown in Figure 3.5. Mark-ups are assumed as being drawn from a distribution between 0% and 15%. The mean is indicated as $7\frac{1}{2}$ % with variability in the cost estimate of 10%.

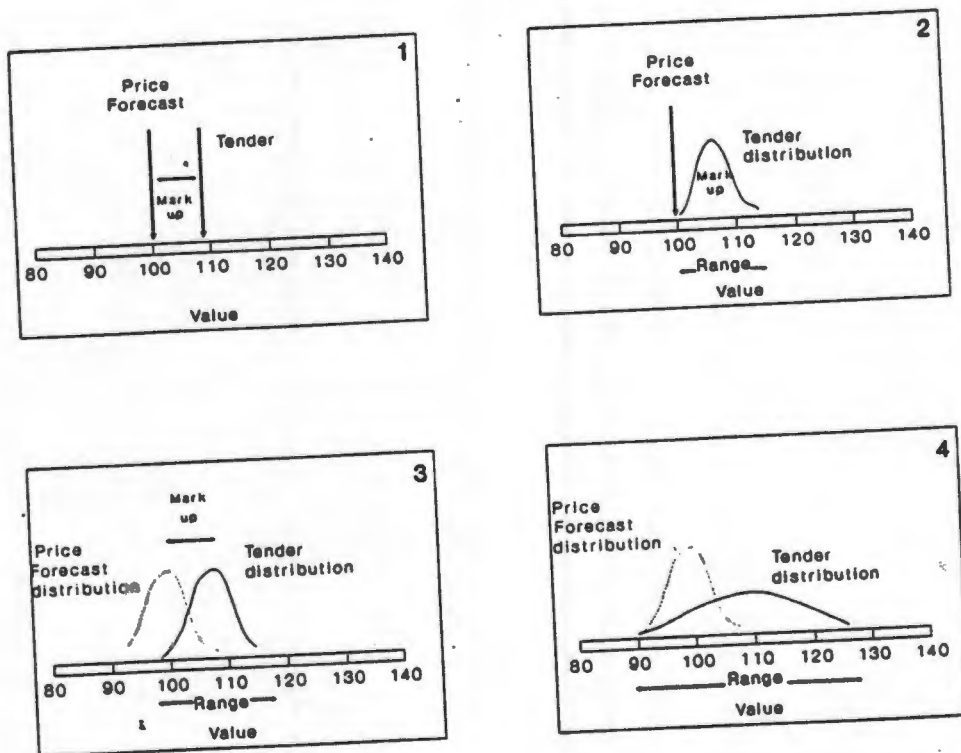


FIGURE 3.5 EFFECT OF COMPONENT VARIABILITY ON TENDER VARIABILITY
(Adapted from Skitmore, 1981)

Model 1 represents the tender value as a single determinable figure whereas models 2, 3 and 4 are probabilistic in the sense that a range of prices is realised. Model 1 demonstrates

Chapter 3

a theoretical but impractical situation where, as a result of the cost estimates and mark-up being fixed for each tenderer, identical tenders are attained. Model 2 indicates the traditionally held view that all cost estimates are assumed to be equal, whilst model 3 illustrates the alternative position where the cost estimate is variable and the mark-up is fixed. Since it is considered unlikely that these variables would be identical for different tenderers, the models are regarded as practically inappropriate. Model 4, which is regarded as representing the situation closest to that found in reality, indicates the composite position where both the cost estimate and mark-up are considered as variables.

The above model, whilst possibly being perceived as too simplistic, does illustrate the potential for variability of tenders as well as providing an indication of the complex nature of the product for which the quantity surveyor is required to forecast a final cost.

3.3.4 Estimating variability

Morrison (1984, p. 66) highlights one of the central problems faced by quantity surveyors in improving the accuracy of their estimates when stating:

"The importance of the variability in the lowest tenders received in competition lies in the fact that quantity surveyor's estimates of these tenders cannot, except by chance, be more accurate than this variability. If quantity surveyors were able to estimate consistently at a price level equivalent to the mean of the lowest tenders, then the accuracy in estimating would be identical to the variability in lowest tenders".

Just as contractors' estimates vary, so different quantity surveyors produce different estimates for the same work. The term 'estimating variability' alludes to the variability found in the price forecasts recorded by a number of quantity surveyors when performing the same estimating task, using currently acceptable methods and having access to common data.

Most traditional price forecasting systems comprise two stages, i.e. the quantification of the design and the pricing of the measurements generated. Since most of the estimating methods previously reviewed are not subject to formal systems of measurement, significant variability in the quantification function performed could arise. The paucity of references to this issue in the literature survey indicates a potential for research in this area.

Chapter 3

Because bills of quantities are usually compiled in accordance with formalised instructions such as the Standard System of Measuring Building Work in South Africa (1991), the potential for variability in measurement is greatly diminished. Notwithstanding, research by Fine and Hackemer (1970) reveals that both bill rates and bill quantities are extremely variable.

As each building project tends to be a unique event, it is virtually impossible to establish the variability or otherwise of estimates in practice. The limited research undertaken in this field has therefore concentrated on utilising the 'experimental method' in a laboratory type situation: However, the experimental method is subject to criticism with respect to the inability in recreating the competitive environment in which estimators normally work.

Ashworth *et al.* (1980) tested the ability of nine contractors' estimators to forecast the cost of bricklaying by comparing their forecasts with actual performance on several completed projects. The results of the investigation indicate the highest estimate as being 1.88 times the lowest forecast and the mean estimated figure to be in excess of 27% higher than the actual cost.

One of the few attempts to measure forecasting accuracy of quantity surveyors under experimental conditions is that conducted by Skitmore *et al.* (1990). A total of 60 estimators were split into three groups of 20. Each group was allocated 5 specific construction contracts depicting the distinctive groupings of housing, factory and office contracts. Forecasts based on a rate per superficial area basis and reflecting 4 distinct information availability conditions, were undertaken. The forecasts reflected estimates derived on the basis of: (i) no additional information; (ii) details of the contract type only; (iii) 5 random pieces of contract information, and (iv) 20 items of contract information. It was found that significantly different forecast results were obtained between contract types and all specific contracts at all information levels.

In practice it is usual for quantity surveyors to use price data generated from previous lowest tenders (Property Services Agency, 1979) for estimate pricing. Morrison (1984) notes that the price level of the data used by the quantity surveyor naturally influences the generation of the price forecast. The effect of this on the variability of the price forecast can be significant. Results published in the Second Annual Report of the Property Services Agency (1980) demonstrate that, whilst contractors price construction work in a reasonably

Chapter 3

consistent manner, they adopt many different ways of presenting their costs in the bill of quantities.

The only report uncovered which deals with an experimental analysis of variance in pricing tender documentation, is that of Jupp and McMillan (1981). Their study required three estimators to price bills of quantities from a controlled data source of five bills of quantities for similar previous projects. Compared with previously published reports of empirical studies, the level of accuracy as measured against the accepted tender was poorer than that which the researchers anticipated. In addition considerable variation between the total prices forecast was evident.

Based on the limited evidence relating to the existence of variability in quantity surveyors' estimates, indications are that the extent of the problem could be significant. There is therefore a clear need for further research to be conducted into this subject.

3.3.5 Range estimates

A major conclusion of a report by Hayes *et al.* (1987) is that *"more effort should be devoted to risk management as a continuing activity throughout the life of a project."* The implementation of a risk management system during the design development phase of any building project should ideally be structured in a style that enables the identification, control and exposure of risk on a systematic basis as a continuing activity throughout the life of a project.

Monitoring the effectiveness of price forecasts is undoubtedly facilitated when contingencies and tolerances within such estimates are clearly linked to specifically identified potential risks.

Ideally the levels of contingency and tolerances that are set in the early stages of a project should be sufficient to give a reasonable upper limit for the project. As risks and uncertainties are removed or reduced, the level of contingency allowances should decrease accordingly. Figure. 3.6 illustrates the so-called 'torpedo' effect of risks on cost predictions. This process is well detailed by Barnes (1974).

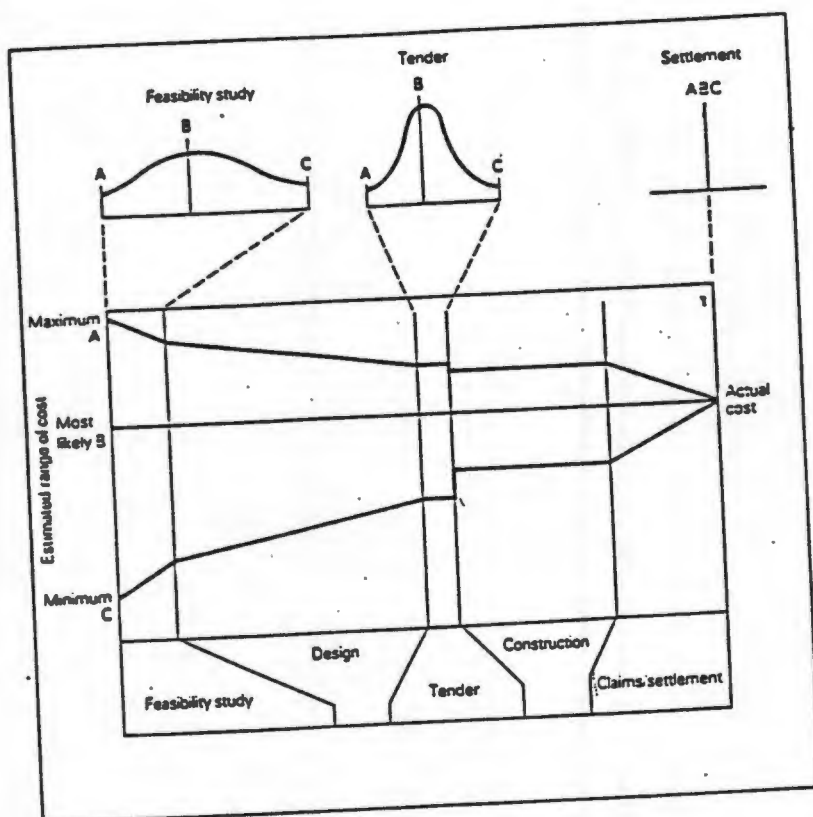


FIGURE 3.6 PROBABILITY DISTRIBUTIONS OF ESTIMATE STAGES
(Adapted from Hayes *et al.*, 1987)

Case studies and associated work carried out by Hayes *et al.* (1987) indicate that the character of the dominant risks changes as the project proceeds through its stages, suggesting that the continuous reduction of risk shown in the torpedo diagram may not necessarily occur. The likely reasons for this anomaly are interpreted as being caused by inadequate risk management in the early stages, and the likelihood of new risks emerging at a late stage in the project.

Risk analysis, which is a fundamental component of risk management, provides the data necessary for effective decision making. The system identifies the most likely range within which the tender price will fall and the probability that it will not exceed a given limit. Flanagan and Norman (1982a) and Artto (1988) stress that while risk analysis does not improve accuracy as such, it does improve discernment of the target area.

As previously indicated, many researchers argue that the traditional system of reflecting a single deterministic estimate is inappropriate. Notwithstanding, several studies such as those of Bowen (1982a), Brandon and Newton (1986), Billet (1990) and Bowen (1992) suggest that the use of deterministic forms of estimating by quantity surveyors, particularly

Chapter 3

the approximate quantities method, is deeply entrenched and unlikely to be replaced in the near future by probabilistic techniques.

A possible alternative solution to the problem of furnishing price forecasts which indicate uncertainty and risk is provided by 'range estimates'. The procedure is well established in the USA and comprehensively described by authors such as Spooner (1974), Hayes *et al.* (1987), Curran (1988), Stevens and Davis (1988), Arto (1988), Townley (1991) and Rowland and Curran (1991).

Range estimating is not universally regarded as a pure estimating system. Curran (1988) describes it as *"a decision technology which is employed as an adjunct to traditional estimating."* Range estimating, which requires the input of the three prices of minimum, most likely and maximum, indicates the probability that the actual value will be equal to or less than the target value. The lowest and highest estimates establish the boundaries of the range. The greater the uncertainty, the broader the range.

In assessing possible alternative methods of predicting construction prices, Ogunlana and Thorpe (1990) identify two important considerations. It is anticipated that although these may have a constraining influence on the rapid implementation of probabilistic estimating systems, they could support the extended use of range estimating. Firstly, to ensure that a method is adopted by design cost estimators, it should deviate as little as possible from current practice. Secondly, any proposal should permit the in-house generation of cost data as quantity surveyors have been shown to be unwilling to use information produced by others (Jupp, 1984).

3.3.6 Detail level of estimates

The inherent variability of an estimating technique is dependent upon three factors (Morrison, 1984):

- * the number of sub-estimates which form the total estimate,
- * the size distribution of the 'items' forming the estimate, and
- * the variability of the sub-estimates.

Many authors have discussed the variability of both individual trades and independent items (Beeston, 1975; Ashworth, 1983; Mathur, 1982; Morrison, 1984; Raftery, 1987a;

Chapter 3

Accuracy
 Gonzalez *et al.*, 1988; Hardcastle *et al.*, 1988; Marston, 1988;). Research conducted by the Property Services Agency (1980) clearly demonstrates the possibility of severe variability at the micro level, with individual items varying by as much as 100%, even in instances where the tender variation is relatively low.

Researchers such as Ashworth (1983), Skitmore (1988a) and Ogunlana (1989) theorise that accuracy improves with increasing volume of data incorporated within the forecast, with bills of quantities normally containing in excess of 1000 measured items (Skinner, 1982). However, Bennett *et al.* (1981) indicate that the effort expended in pricing more than about 100 items of work is not rewarded by any significant increase in accuracy. These results are illustrated in Figure 3.7.

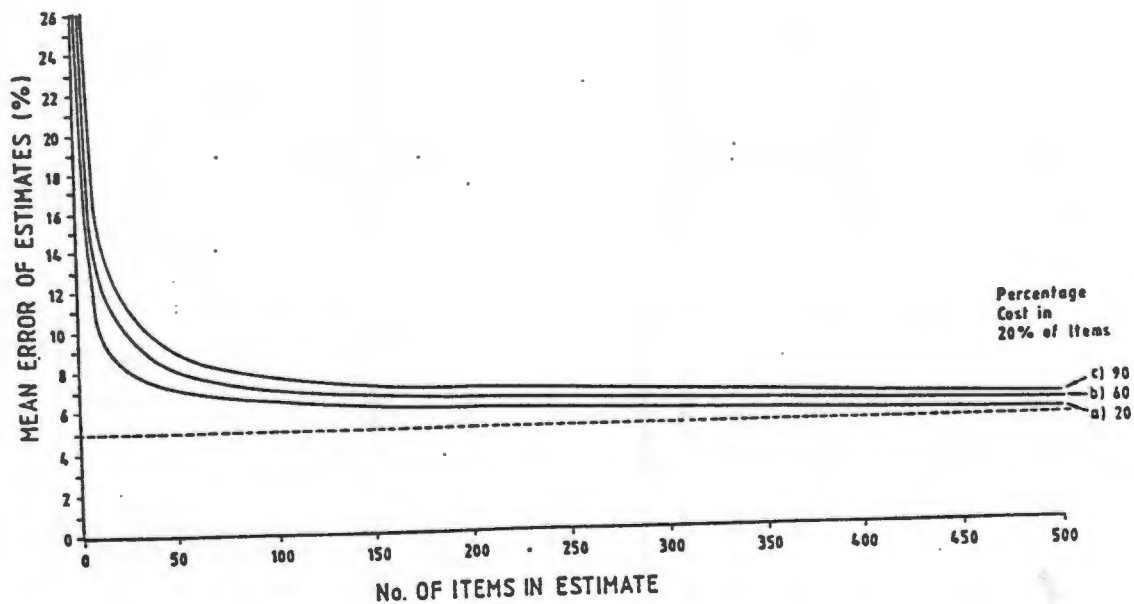


FIGURE 3.7 ACCURACY AND NUMBER OF ITEMS IN ESTIMATE

(Source : Bennett *et al.*, 1981)

Bowen (1992) comments on the tendency for estimators to use detailed forecasting methods at the earliest possible stage of the design sequence. This trend, which is presumably undertaken in anticipation of greater accuracy being achieved, impacts directly on the aspect of number and size distribution of items referred to by Morrison (1984).

Bennett *et al.* (1981) indicate that there is some danger in this practice by stating that

" Construction is inherently uncertain and cost can be estimated only within margins defined by this uncertainty. Methods of estimating which are more detailed than this uncertainty warrants are wasteful. "

A major factor contributing to the difference between actual accuracy of estimates and what is theoretically possible, is the choice of items or elements to measure and price. These are often chosen on the understanding that a large percentage of the total cost is attributable to a small percentage of the constituent items. The hypothesis underpinning this practice, which is known as Pareto's Law of distribution, represents an adaptation of a theory developed by Vilfredo Pareto, an Italian economist, at the end of the nineteenth century. The adapted postulation states that in a situation where a large number of elements is involved, a small number of elements (20%) contains the greater percentage of costs (80%) (Kelly, 1987). Several authors (Moyles, 1973; Barnes, 1974; Skinner, 1982), have tested the validity of the theory within the context of measured items in construction work.

More recently, Horner *et al.* (1986), have described a contractor's estimating system based on pricing only the cost-significant 20% of measured work items. They claim that there is no undue loss of accuracy whilst a considerable saving in time is achieved. The analysis reveals that if the measured work items are ranked highest value first, the removal of the last 5% of the monetary value from any contract bill results in a reduction of between 52% and 84% of the items originally measured.

One of the dangers associated with pricing estimates is that it is fairly common for reasonably accurate detailed forecasts to be invalidated by a single lump sum addition made hurriedly, and with little consideration of the resultant cost implications (Bennett *et al.*, 1981). The 'preliminaries' have been identified as one such area, especially in projects that demonstrate great potential variability.

Although representing only one of the essential components in price forecasting, data is the cause of much uncertainty. Its reliability and suitability at the various stages of design needs to be greatly enhanced if price forecasting performance is to be improved.

3.4 DATA / INFORMATION AVAILABLE TO ESTIMATORS

3.4.1 Data availability

Since some part of almost every contract can be expected to lie outside the experience of any one estimator, or that of other people with whom they have to communicate, the provision of relevant alternative sources of price information is of paramount importance to the success of the price forecasting function.

According to Raftery (1984), a forecast will have at least the same uncertainty as that applying to the data on which it is based. By stating that they represent the most likely area for improvement in the performance of their estimating duties, Morrison (1984) implies that the quantity surveying profession uses poor methods of selection, manipulation and application of cost data.

Morrison (1984), as cited by Betts and Gunner (1989), further suggests five major factors accounting for inaccuracy in design stage estimates. These are:

- (i) the effect of variability in lowest tenders,
- (ii) the effect of using price data from variable tenders,
- (iii) the inherent variability of the technique used,
- (iv) the variability due to making adjustments to data, and
- (v) the variability due to imperfections in the price data.

The pivotal role of price data is emphasized by the above list. Furthermore, the final factor is considered the most consequential of all five (Betts and Gunner, 1989).

Price information available to the quantity surveyor is often classified into two main categories. These are 'in-house' price data obtained from projects previously handled by the quantity surveyor's own organisation, and published price information (Property Services Agency, 1980; Stevens, 1983; Ashworth, 1988a; and Ferry and Brandon, 1991).

In-house price data ordinarily consists of priced bills of quantities submitted by successful tenderers, and project price analyses of previous projects. Price data contained in the bills of quantities of successful tenderers is generally considered to be the primary source of price information available to the quantity surveyor in South Africa. The reasons for this are twofold. Firstly, in terms of the Quantity Surveyors' Act (Act 36 of 1970), practices

Chapter 3

are required to retain all contract documentation for a period of not less than three years after conclusion of the final account on any project. This requirement has the effect of forcing quantity surveyors to establish a form of data bank, however informally controlled. The second reason is the almost complete lack of published price information in the preferred form of reference, namely item rates.

As previously noted, South African quantity surveyors have failed to support the establishment of a central research bureau storing elemental price data. Furthermore, local trade journals do not contain published elemental price analyses such as those published overseas. Consequently, the only real source of elemental price data accessible to the quantity surveyor in South Africa is that compiled from in-house priced bills of quantities.

South Africa is, moreover, poorly served by published sources of price information, other than a reasonable distribution of building price indices and general economic reviews. Only one price book, Merkel's Builders' Pricing and Management Manual, is produced annually and the data included in the overseas price books is unsuitable for local use. The dearth of locally published price books may, however, not be a crucial problem, especially if one considers the opinions of Ashworth *et al.* (1980) and Bennett (1984). These authors reveal that there is great variability between individual rates contained in the various price books produced in the United Kingdom.

In South Africa three cost / price indices for use in the building industry are published. These are: (a) the Building Industries Advisory Committee's contract price adjustment provisions (Haylett Formula - P1051), (b) the Contract Price Index for Buildings (P0153), compiled and published by the Central Statistical Services, and (c) the Building Cost Index of the Bureau for Economic Research, University of Stellenbosch. A major problem relating to the use of these indices is the irregular publication patterns (particularly that of the Central Statistical Services' documentation), and the fact that there is an average delay in publishing data of between 3 and 6 months.

A number of local commercial publications reflect the present, and forecast the future patterns of activity in the building industry. The best-known are: (i) the quarterly analysis of building and construction activity in South Africa, compiled and published by the Bureau for Economic Research, University of Stellenbosch, (ii) reports of Medium-Term Forecasting Associates C.C., and (iii) Rode's reports on the South African property market, published by Real Estate Surveys C.C.

3.4.2 Use of data

As reflected above, local quantity surveyors have access to a limited number of sources of cost data providing several different types of information. Several studies of the patterns of usage of such data for forecasting purposes by quantity surveyors have been conducted both in the UK and South Africa.

The study of estimators' procedures undertaken by the Department of the Environment in the United Kingdom (Property Services Agency, 1979), shows that quantity surveyors demonstrate a noticeable preference for using price data derived from projects with which they are personally involved. Only if the required information is not available from these sources are other alternative avenues pursued. Firstly, information from other sources within the same organisation are entertained. These are followed by reference to the British Building Cost Information Service or published data such as price books.

Another major feature of the estimating techniques is represented by the approach adopted by quantity surveyors in the utilisation of cost data. Unit rates used to price a new project are normally derived from a single project. Current practice is to identify a previous contract which most closely resembles the project to be estimated, either from the surveyor's own files or from the immediate office files, and to price the new project with rates taken almost exclusively from the selected priced bill of quantities.

Ordinarily, the number and diversity of projects that are available from one quantity surveying office are not sufficient to provide a satisfactory data base for effective cost management, including the price forecasting function (Bennett *et al.*, 1981). This situation is presumably exacerbated in South Africa, where firms are generally smaller than their counterparts in the United Kingdom (Billett, 1990). Additionally, when estimators employ a project in their data base which most closely resembles the proposed scheme, it is likely that only a limited number of the building's characteristics can be considered. In order to allow the majority of items on a new project to be priced reliably from a single completed project, a massive data base of information on completed projects is required (Bennett *et al.*, 1981).

Detailed research was undertaken by Jupp (1984), to assess the degree of reliability that can be attached to rates in bills of quantities for price forecasting during the design process. The research comprised two elements. Firstly, an exercise conducted within the author's

Chapter 3

own firm on 18 bills of quantities. Secondly, a postal questionnaire to quantity surveying firms in England. Eighty six firms were contacted and responses were received from 49 organisations. Based on the submitted responses a number of conclusions were reached. These included:

- (a) The preference for bills of quantities as the main source of cost information is marked, although there is also a tendency for referring to more than one type of source. This contrasts with the research of Bennett *et al.* (1981) who conclude that bills of quantities are almost the sole reference source used.
- (b) Most estimators use more than one reference when bills of quantities are used as a data source. In these instances appropriate rates are derived by interpolation. This represents a further contradiction to the findings of Bennett *et al.* (1981). The results of Jupp's exercise does, however, indicate that whilst there is an improvement in consistency in using two bills over one, and in three bills over two, there appears to be no advantage in using more than three bills.
- (c) Most estimators consider bills as too old to be reliable if they are two years old or more. This opinion, which is attributed primarily to the effects of changes in tendering climate and differential inflation on prices, presumably indicates a lack of confidence in the reliability of price indices normally used for updating purpose.
- (d) Seventy three per cent of the respondents value preliminaries by reference to percentage preliminaries in other projects. Only abnormal items are priced individually. The remainder indicate that they undertake detailed pricing of preliminary items on all projects (Jupp, 1984).

Data use studies by Billett (1990), and Bowen (1992) have recently been conducted in South Africa by means of postal surveys. Both questionnaires were submitted to all quantity surveying practices in the country. Billett (1990) received 73 replies while Bowen's (1992) findings are based on the response of 99 quantity surveying offices.

The response to comparable questions incorporated within the two questionnaires is generally similar. In the later study, Bowen investigates the availability of data and indicates that, with the possible exception of price books, almost all the firms retain all the various forms of price data previously discussed. A significant feature of Billett's survey is the indication that only 23% of firms have a library of rates for estimating purposes.

The studies confirm that quantity surveyors demonstrate a distinct preference for in-house data. The most popular form is price rates obtained from bills of quantities and is followed

Chapter 3

by elemental / component rates derived from price analyses of previous projects. Both studies clearly indicate that rates from previous similar projects, obtained from bills of quantities and suitably updated, are used extensively by estimators throughout the various stages of design.

One of the few areas of difference relates to the use of 'first principle' pricing. Whereas Bowen's study reveals that this approach seldom occurs, Billet's evidence shows that up to 38% of the firms calculate new rates during the later stages of the design phase.

Billett's study also suggests that 'gut-feel' rates are used fairly extensively (up to 34% of firms indicated its usage) during the inception and feasibility stages of the project. This aspect is considered in greater detail when discussing the importance of estimator's expertise and experience later in this dissertation.

3.5 FEEDBACK / CONTROL MECHANISMS ON FORECAST PERFORMANCE

3.5.1 Monitoring design cost forecasts

A study of the literature on price forecasting performance in the building industry indicates that there is a distinct need for the quantity surveying profession to pay greater attention to the analysis of its performance (Flanagan and Norman, 1983; Raftery, 1991a). Bennett *et al.*, (1981, p. 27) identify this requirement when stating :

" It follows that good estimating practice will monitor its own performance and when problem areas are identified, will engage in research aimed at finding better methods. "

The monitoring of performance and provision of feedback mechanisms is closely related to achieving a desired level of expertise. Ogunlana (1991) provides a comprehensive commentary to the following questions :

- * Why is the estimator unaware of the magnitude of the error made in estimating ?
- * Why are tender values not routinely compared with estimates ?
- * Why are estimators unable to achieve expected accuracy levels ?

The issues involved are psychological in nature and concern the learning process at three levels. These are, the awareness of errors / mistakes, judgment of what is to be learned and

evaluation of the extent of learning achieved. There appears to be widespread ignorance of the magnitude of estimating error prevalent in the industry, even though numerous researchers have written on the subject.

Ogunlana (1991) suggests that unless inaccurate predictions are brought to the attention of the estimator, either by threatening the continuance of the project or eliciting a rebuke to the estimator, the need for learning is not recognised. For such an event to occur, the extent of deviation from the prediction must be perceived as significant.

The two forms of feedback of benefit in design cost estimating are : (i) process feedback dealing with the conditions under which the estimate is prepared, and (ii) outcome feedback which is limited to the results of tenders predicted by the forecaster.

Ogunlana (1991) argues that only when tenders differ significantly from estimates are detailed cost comparisons undertaken. The significance of this assertion, indicating that comparisons are made to detect errors in tenders rather than estimates, supports the view that forecasts are regarded as being 'correct' and the tenders, when they differ from the forecast, are regarded as being 'wrong' (Azzaro, 1976). This contention may be totally incorrect, especially when forecasts differ from low bids in a consistent fashion (Flanagan and Norman, 1983). They argue that design estimators are unlikely to recognise their own limitations when concentrating on other people's mistakes.

Notwithstanding the fact that the collection and analysis of pertinent data appears to be a relatively simple task, a number of studies suggest that formal monitoring and feedback procedures are rarely employed in construction price forecasting in practice (Bowen, 1982a; McCaffer *et al.*, 1984; Morrison, 1984; Skitmore, 1990a). The failure by practitioners to recognise that a consistent error trend has developed in their estimating performance is attributed to the absence of a critical examination of estimating performance (Morrison, 1984).

Few papers examine the development of monitoring and feedback systems for assessing forecasting performance and, in particular, providing advance warning of consistent bias that may characterise building price estimates. In the development of any such system, a prime consideration should be simplicity of use if it is to gain acceptance by the quantity surveying community.

Rapier (1990) proposes a system of analysing estimates at separate stages of design with special emphasis placed on establishing possible bias. The recommended procedure is based on the North American style of building procurement, and is more suited to projects planned without the use of bills of quantities. Formally structured systems of staged approvals of estimates as employed by an Australian government department (Wilson *et al.*, 1987), and similar client bodies elsewhere, do in effect establish a form of performance appraisal.

Two reports which can be applied in the South African context have been compiled on control systems (Beeston, 1983; Flanagan and Norman, 1983). The systems are examined in the following paragraphs.

3.5.2 Control analyses

3.5.2.1 Control charts

Control charts which were originally devised for monitoring quality in production processes (Beeston, 1983), have subsequently been successfully adopted by many industries, thus demonstrating the potential for use in the field of forecasting (Lau and Lau, 1986).

(a) Error graphs.

A simple form of recording performance is proposed by Beeston (1983). The graphic illustration, which is shown in Figure 3.8, represents a profile illustrating the differences between estimate and lowest bid, as well as indicating the variance from established estimating norms if the long-run mean error and probable upper and lower limits of acceptable performance are incorporated.

Ordinarily, two sets of limits are indicated on the graph, the outer limits being designated *action limits*, and the inner being described as *warning limits*. If the percentage difference between the estimator's forecast and the lowest tender remains within the defined limits, the estimating process is regarded as being under control. If not, the process is taken to be out of control, requiring remedial action to be taken.

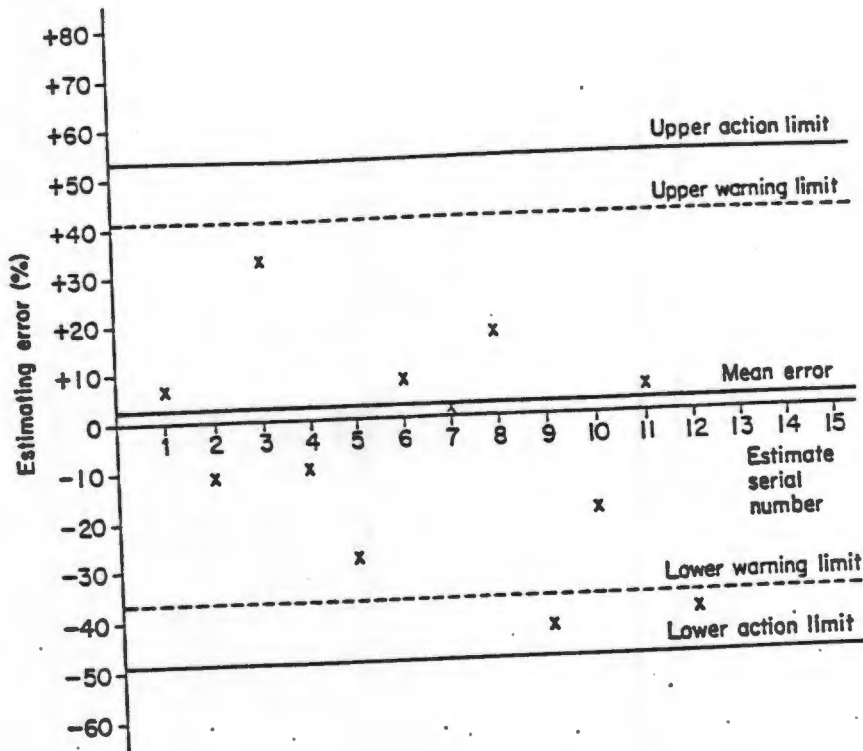


FIGURE 3.8 A CONTROL CHART FOR ESTIMATING ERRORS
(Source : Beeston, 1983)

3.5.2.2 *Cusum charts.*

Cusum charts introduce a further technique designed to provide feedback on estimating results. This system which is particularly suitable for monitoring estimating variance involves recording cumulative differences from a target figure. However, the primary function of cusum charts is to indicate trends rather than provide definitive values. The two types of cusum charts are examined below.

(a) *Trend control analysis.*

The objective of trend control analysis is to identify whether estimating errors exhibit a consistent trend over time. Estimates and low bids are listed in chronological order, the percentage deviation for each project and cumulative deviation being graphically recorded. Projects are evenly spaced on the horizontal axis, the line joining the various points identifying the trend of estimating performance. The nearer the line is to the horizontal, the nearer the estimate is to the lowest bid. A rising line indicates a bias towards over-estimating while a falling line demonstrates a bias towards under-estimating (Betts and Gunner, 1989).

This technique enables the estimator to identify a consistent trend in forecasting results within a specified time frame. When no clear trend is discernable the deviation control chart is employed to indicate the extent of deviation of estimates from the low bid (Flanagan and Norman, 1983).

(b) Deviation control analysis.

The deviation control chart (sometimes referred to as the variation control chart) assesses the accuracy of estimating. In the deviation control chart the slope of a line from the origin to any point on the curve furnishes the variance of the estimate about the low bid for all projects up to that point. (Flanagan and Norman, 1983; Betts and Gunner, 1989).

Combined use of the two cusum charts indicated on page 53 provides a complete representation of both the accuracy, and trend details of estimates. Full descriptions of the various control systems are provided in the foregoing research paper references, together with graphically presented examples of utilisation. Selected examples of the estimating performance of local quantity surveying firms are illustrated by cusum charts in the appendices to this document.

3.6 CONCLUSIONS

Estimating models, which are logically categorised according to use functions, are separated into *design optimisation models* and *price prediction models*. The last named models establish the category being assessed in terms of this dissertation.

Three vital factors to be considered in regard to improving price forecasting performance are (a) uncertainty and risk, (b) data / information used for estimates, and (c) feedback and control systems for future estimates. These aspects require careful consideration at all stages of design when price prediction models are utilised.

The construction process is complex and fraught with uncertainty. In particular, the variability of tender submissions requires the estimator to be conversant with the theory relating to uncertainty, and the analysis thereof. It is likely that in the future quantity surveyors will be forced by client pressures to devote greater attention to addressing

Chapter 3

uncertainty in price forecasts. The implementation of *range estimates*, used as an adjunct to traditional estimating techniques, is identified as a potential solution to the problem.

In South Africa, a factor limiting the improvement of forecasting accuracy is the dearth of reliable estimating data available. The most popular source of pricing information used by quantity surveyors is "in-house" priced bills of quantities. The size and nature of local practices further influences the availability of relevant data sources of this kind.

A possible cause of estimators being unaware of the perceptions of clients regarding estimating accuracy is the lack of widespread use of feedback mechanisms to indicate details of performance as well as any trends in bias or consistency.

The following chapter deals with the accuracy of the estimate, considering the expectations of parties using the product, and methods of performance appraisal. Finally, a review of published records of accuracy achieved by both contractors' estimators and design price forecasters is undertaken.

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4. EVALUATION OF ESTIMATING PERFORMANCE

"Our best is bad, nor bears Thy test; Still, it should be our very best" : Robert Browning

4.1 INTRODUCTION

Users of price forecasts have a common objective in requiring the best possible reliability and accuracy. One of the main areas of confusion between members of the building team hinges on what is meant by terms commonly used such as '*precision*' and '*accuracy*'. The introductory section of the chapter is devoted to a clarification of these issues, as well as providing an indication of the most commonly used methods of measuring the estimator's performance. The accuracy of price forecasts made at any point of design development can theoretically be measured and the discussion of accuracy is intended to reflect this broad vision.

The primary purpose of this chapter is to provide a perspective on expectations of reliability, and more importantly accuracy, of quantity surveyors' estimates. Opinions of parties regarding the accuracy achievable, and the actual performance levels achieved internationally, establish the basis for the development of the empirical study of estimating performance of South African quantity surveyors dealt with in Chapter 7 of this dissertation.

The chapter concludes with a review of the literature reflecting the estimating performance of quantity surveyors internationally. Notwithstanding the possible measurement of estimating accuracy at early stages of the building procurement process, practical considerations usually prevent meaningful evaluations of the estimating stages prior to tender documentation. The assessment of performance reflected in empirical studies is therefore based on price forecasts made after detailed design is completed.

In order to evaluate the effectiveness of the estimating activity, it is necessary to introduce measures of performance that rely on statistical means of assessment. However, as the emphasis of the dissertation is on the factors that affect accuracy, and not on accuracy *per se*, the presentation of such material is confined to broad principles only. Detailed

Chapter 4

reference sources such as Beeston (1983) and Skitmore *et al.* (1990) should be consulted for more extensive descriptions of the statistical appraisal techniques.

4.2 DEFINITIONS

Numerous authors (Barnes, 1974; Adams and Busch, 1981; Bennett *et al.*, 1981; Flanagan and Norman, 1983; Betts and Gunner, 1989) 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 quantity surveyor's price predictions can logically be undertaken, consideration needs to be given to an appraisal of what is meant by the term "accuracy".

4.2.1 Accuracy

The following definitions of the term 'accuracy' are to be found in the reference sources listed :

Webster's (1981) - " (1) Freedom from mistake or error; conformity (2.a) Conformity to truth or to a standard or model; exactness (2.b) Degree of conformity of a measure to a standard or a true value "

Concise Oxford (1990) - " Exactness or precision, esp. arising from careful effort "

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 of the smaller the error, the higher the accuracy, and *visé-versa*, whilst being partially true, is naive inasmuch as it requires a further definition of error.

Basing his argument on the alternative definition offered by Websters, Rapier (1990) suggests that for capital cost estimating *"Estimating accuracy is the degree of conformity of*

the estimate (our measure) to the final as-booked 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 (1987a) 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 dissertation 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 (1987a) given above, but additionally linking the performance to that which could reasonably be expected of an informed and suitably qualified estimator.

Ogunlana (1991) affirms that at present, no limit of acceptance as to what constitutes an 'accurate enough' estimate has been set by any professional body concerned with estimating. However there seems to be general agreement amongst practitioners in the UK that a figure of +/- 10% accuracy at the detailed design stage is appropriate (Ogunlana and Thorpe, 1987; Ogunlana, 1991). No reference is made to the point of reference, but it is assumed that it refers to the lowest acceptable bid.

4.2.2 Bias, consistency and precision

Forecasting performance is 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, 1990a; Gunner and Betts, 1990).

Many practitioners appear to confuse accuracy with precision. The two principles are totally different; it being quite possible to be precise but inaccurate, and *vice versa*. The relationship between accuracy and consistency as originally expressed by Flanagan (1980),

is illustrated in Figure 4.1. It should be noted that consistency can only be measured for a range of estimates whereas accuracy can be determined for every single forecast.

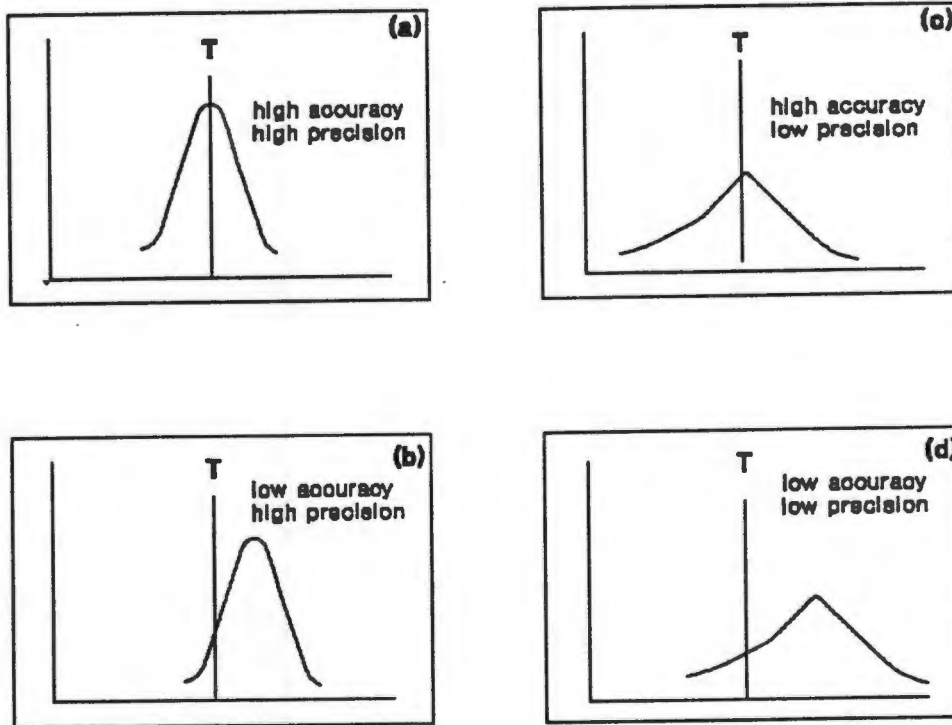


FIGURE 4.1 RELATIONSHIP BETWEEN ACCURACY AND PRECISION
(Source: Ogunlana, 1989)

The alternative options indicated in Figure 4.1 are :

- (a) High accuracy and high precision
- (b) Low accuracy and high precision
- (c) High accuracy and low precision
- (d) Low accuracy and low precision

Criticism of quantity surveyors' estimating performance centres on the insinuation that model (c) is being achieved in deterministic forecasts, whilst clients wish to attain model (a) with high accuracy and precision levels. Proponents of probabilistic forecasting techniques assert that a better service to the design function will be provided by a combination of models (a) and (b).

Skitmore (1990a) summarises the relationship between these elements by reflecting that measures of accuracy are concerned with the combination of bias and consistency into a single quantity, which can be measured in several ways as indicated hereafter.

4.3 METHODS OF MEASURING ACCURACY

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.

Although the following measures of performance are all described in the literature as measures of "accuracy", confusion still remains regarding acceptable terminology. In effect, the blending of these units of measure tend to reflect **reliability** of estimates, combining precision, bias, consistency and accuracy.

4.3.1 Range

The range, which reflects the difference between the highest and lowest figures, is considered the simplest form of measuring variability. It is often used when the superior accuracy of other methods is not required, as it has the great advantage of being easy to calculate. For small samples (fewer than about 6 items) the range is almost as good a measure of variability as any other, only displaying inferior capability when sample sizes exceed about 15 (Beeston, 1983).

4.3.2 Mean deviation

The mean deviation is generally considered a better measure of variability than range. The system is based on deviations from the arithmetic mean (commonly called the average). The mean deviation does not distinguish between positive or negative variance, making the result difficult to use mathematically. When variability needs to be measured only for comparative purposes, the mean deviation is adequate due to it being easy to visualize and simple to calculate.

4.3.3 Standard deviation

The standard deviation is a further related measure of dispersion. The mathematical inconvenience of the mean deviation, caused by neglecting the positive or negative variance, is overcome in this method. In accord with the mean deviation, the deviations are also measured from the arithmetic mean. However, prior to addition they are squared, the difficulty of sign thus being removed. The arithmetic mean of these squared deviations is calculated and its square is taken (Beeston, 1983). The sign σ is the universal symbol for the population standard deviation and is the lower case Greek letter 'sigma'.

4.3.4 Coefficient of variation

The coefficient of variation is the unit of measurement that is most often used when quoting the accuracy for a series of building price forecasts. It is recognised however, that the coefficient of variation is not a measure of accuracy *per se*, but rather a measurement of the degree of consistency in pricing.

A relationship can therefore be established between consistency amongst tenderers and the accuracy of pre-tender price forecasts. High correlation between tenderers (i.e. low coefficient of variation) on a scheme should be associated with a low forecast error in the consultant's estimate (Ogunlana, 1990).

An extended use of this measure reflects the coefficient of variation for a range of pre-tender price forecasts. This approach indicates the consistency of price forecasting undertaken in any given sample. Beeston (1983) confirms that the coefficient of variation is the measure of variability that is of the most statistical value.

There are times when the standard deviation, being an absolute measure of dispersion, is inadequate and a relative form becomes preferable. In order that the variability of populations can be compared when the arithmetic means differ substantially, the standard deviation can be expressed as a percentage of the arithmetic mean, this percentage being the coefficient of variation.

The example in Table 4.1 serves to illustrate the measures of accuracy that have been introduced to this point.

Estimated Outcome X	Actual Outcome Y	Overall Deviation A	Difference Squared B	Relative Deviation A%	Absolute Deviation C%
75	90	-15	225	-17%	17%
94	100	-6	36	-6%	6%
132	115	+17	289	+15%	15%
102	100	+2	4	+2%	2%
65	75	-10	100	-13%	13%
Means	96	-2.4	654	-3.8%	10.6%

TABLE 4.1 MEASURES OF VARIABILITY

(Adapted from Betts and Gunner, 1989)

The following results can be deduced from the table :

- (a) The range measure of accuracy is between -15% and +17% (or a range of 32%).
- (b) The mean error is -3.8%.
- (c) The mean deviation is 10.6%.
- (d) The standard deviation is the square root of $654/5 = 11.44$.
- (e) If the standard deviation of the range of A is now divided by the mean value of the actual outcomes (Y) (in this case, this is dividing 11.44 by 96 and expressing it as a percentage), the coefficient of variation of 11.92% is calculated.

Although the measurement methods indicated above describe "accuracy" in a slightly different form, they are considered by researchers to be valid ways of describing the relationships between sets of estimates and actual outcomes (Betts and Gunner, 1989). In practice, the 'mean error' or 'relative deviation' represents the most common method of indicating estimate accuracy. Arithmetically it is represented as:

$$\text{Accuracy of Estimate} = \frac{\text{Estimate Value} - \text{Low Bid}}{\text{Low Bid}} \times 100\%$$

Because this study is partly concerned with a comparison between estimating accuracy in South Africa and that found elsewhere, and because most authors use the coefficient of variation (CV) to express their results, both the CV and 'mean error' are used to describe the accuracy of estimating in this dissertation.

4.4 EXPECTATIONS OF ACCURACY

As previously stated, the parties involved in a building development may have different expectations with regard to the content and accuracy of a price forecast. Although Greig (1981), Jupp (1984) and Bowen and Edwards (1985a) have examined the expectations of some participants in building projects on the accuracy of quantity surveyors' price forecasts, published research findings in this subject are nevertheless extremely limited.

A study of the difference between the objectives of estimators and the expectations of their clients is fundamental to the problem. If differences of opinion and uncertainty as to the intentions and requirements of design stage estimates are discussed and identified at an early stage, potentially harmful consequences can be avoided.

4.4.1 Estimate reliability during project planning

A fundamental premise *apropos* the pre-tender price forecasting function is that the accuracy of the estimate is directly correlated with the amount of project data available (Skitmore, 1988a). Compatible views are expressed by Ashworth and Skitmore (1982), Skitmore (1988b), and Horner (1991), when stating that the accuracy of the forecast improves as the design sequence progresses. Their opinions coincide with the standard construction price forecasting texts which assert that more detailed estimating methods such as those using approximate quantities are *ipso facto* necessarily of better quality than the single price rate systems used earlier in the design process. Morrison (1984, p. 71-72) supports this view by saying :

"Since we would not expect the suitability of cost data taken from the same source to be any worse when differing estimating techniques are used, we reach an exceptionally important conclusion. Given that quantity surveyors are consistent in the manner in which cost data is selected for use in cost estimating, only the inherent

variabilities of the different estimating techniques will cause the performance of these techniques to differ from one another."

This implies acceptance of the model shown in Figure 4.2, in which the extent of errors (inaccuracy) reduces as more information on the proposed project is made available (Layshook, 1969; Ashworth and Skitmore, 1982; Skitmore, 1988c; Horner, 1991).

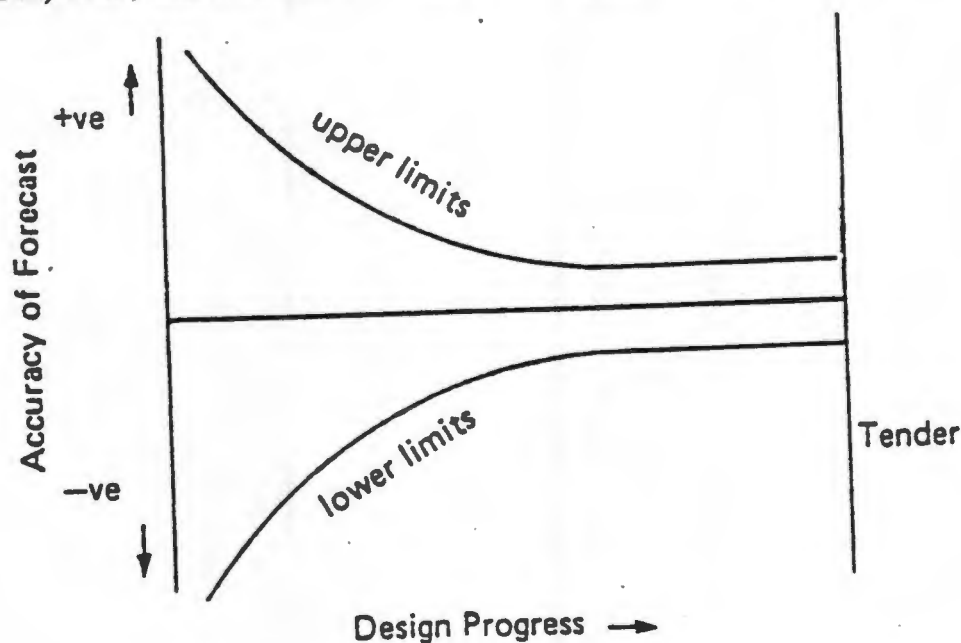


FIGURE 4.2 POSTULATED ACCURACY IMPROVEMENT IN DESIGN PROCESS
(Source: Ashworth and Skitmore, 1982)

Owen and Nabors (1983), Lorenzoni (1986), and Rapier (1990), utilise a similar graphical representation of the increasing accuracy of forecasts in the pre-tender period, although only reflecting one half (the overrun), and not indicating the opposite (bottom half) of the diagram.

Skitmore (1985), and Ogunlana and Thorpe (1991) adopt a similar representation to those mentioned above by using the "torpedo diagram" of Barnes, referred to in Hayes *et al* (1987), to indicate that cost estimating accuracy improves with the development of the project.

The graphical illustrations of this characteristic vary markedly, inasmuch as the slope of the curve and the extreme conditions shown on the different examples are concerned. In particular, the papers presented by North American authors show a far higher percentage inaccuracy level in the preliminary design stages than those produced in the UK.

It is contended in this dissertation that the foregoing examples referred to are incorrect in depicting the 'inaccuracy' of the forecast as represented. In the majority of the models the curve does not *necessarily* indicate inaccuracy in terms of the 'errors' made. Rather they indicate diminishing probability of risk and uncertainty and not "error" or "accuracy". Lorenzoni (1986) provides an indication of the true nature of the trends by noting that the earlier in a project development that an estimate is prepared, the less reliable that estimate will be. While the difference is subtle, distinction needs to be made between the characteristics of price forecasts if correct estimating practice is to be formulated.

In support of the contention that the term 'accuracy' is being misused in respect of the above examples, the following extracts are employed to underscore contradictions with respect to interpretations of the "torpedo" diagram:

"Ashworth and Skitmore's (1982) review of the literature revealed a wide variety of opinion of accuracy levels (over time / information release periods), usually lacking any supporting evidence." - Skitmore, (1988c, p. 12).

and

"The surprisingly slight increase in accuracy of designers' estimates over the design period, together with the lack of any reliable empirical evidence of the means whereby effective estimates can be generated, suggests the need for serious fundamental research in this area." - Ashworth and Skitmore, (1982, p. 12).

and

"The major conclusion, therefore, is that forecasting accuracy does not improve with additional project information in the manner expected, particularly when experienced estimators are used." - Skitmore, (1988c, p. 17).

Indicative of the confused thinking in this area, the same authors indicate below that there is little basis for either the above statements, or adoption of the "torpedo" principle in the early stages of design.

"It is considered imperative that the potential accuracy of price forecasting models other than the priced bill be determined and that the question of the uncertainty associated therewith be addressed." - Morrison, (1984, p. 60).

and

Chapter 4

"Apart from the limited informational studies mentioned ... (in Skitmore, 1990a),... very little research seems to have been attempted in establishing the validity of this assertion (of the relative accuracy of different estimating techniques)." - Skitmore, (1990a, p. 11). /

✓ Research undertaken by Morrison (1984) shows that when using very simple estimating techniques such as elemental estimates, the performance is only likely to deteriorate from a level of 15.4% coefficient of variation to approximately 16.3% - 17.8%. According to this finding, the accuracy of price forecasting does not improve appreciably during the development of the design process.

4.4.2 Price forecasters' expectations

A study of the available literature on this subject reveals a wide ranging set of opinions relating to desired and attainable accuracy levels. The following is a brief summary of opinions expressed and the results of research surveys undertaken. Although the literature sources do not state the unit of measurement quoted, it is assumed that the mean error (relative deviation) is reflected.

One of the earliest sources of reference is that of Marr (1977), who suggests that initial estimates can range from -20% to +40% whilst estimates at tender stage should be in the range of -5% to +10% of the accepted tender.

The results of a survey of 30 quantity surveyors conducted in Edinburgh (Bowen, 1982a), indicate that a substantial number of estimators (23%), are of the opinion that they are capable of estimating the cost of concrete framed structures at the sketch design stage to within 5% of the "actual" cost. A further two-thirds of respondents indicate their ability to estimate the cost to within 10%; seven percent to within 15% of cost and the remaining 3% to within 20%.

A more extensive survey carried out by Jupp (1984) indicates the following response from a selection of quantity surveyors in England with respect to their expectations of accuracy in forecasting tender prices of projects (excluding PC and Provisional Sums):

- within 1% either way = 2%
- within 2½% either way = 22%
- within 5% either way = 63%
- within 7½% either way = 4%
- within 10% either way = 9%

Bowen and Edwards (1985a) reveal that the results of a set of similar questions put to 12 architects and 35 quantity surveyors at a seminar in Durban, indicate that a significant number of respondents expect a greater degree of accuracy from quantity surveyors' price forecasts than that indicated by the mean value of the survey.

Skitmore *et al.* (1990) in a postal survey responded to by 98 estimators in the UK, disclose that 63% of estimators expect to be within 5% of the accepted tender in early stage estimates on general building work when cost planning is utilised. This figure drops to 17% without cost planning. Twenty-five percent of respondents expect to be more than 10% out if no cost planning is undertaken, as opposed to the 9% that express the same opinion even when cost planning is exercised.

The Cost Engineers Notebook (AACE), cited by Huxley (1991) indicates that a definitive (i.e. late design stage) estimate accuracy range is from +15% to -5%. In the same study the author also identifies the level of accuracy expectation for estimators and project managers to be:

- * Order-of-magnitude-estimate
 - estimators +/- 35%
 - project managers +/- 18½%
- * Design estimate
 - estimators +/- 15%
 - project managers +/- 10%
- * Pre-tender estimate
 - estimators +/- 7½%
 - project managers +/- 7½%

The above figures are pertinent to the estimates of cost engineers in the USA, and indicate the previously noted tendency to accept a high degree of 'inaccuracy' in the early stages of the project. However, the expected accuracy range once the design is substantially complete, is similar to the opinions given by quantity surveyors using their traditional procurement systems (i.e. bills of quantities).

The most comprehensive research undertaken to date is that of Bowen (1992) who undertakes an extensive investigation of the expectations of South African quantity

Chapter 4

surveyors, architects and clients with respect to estimates undertaken at the various stages of design development.

The results of the survey, which reflect the opinions of quantity surveyors regarding their mean expected accuracy levels at the various design stages, is as follows:

- * inception stage - within 17%
- * appraisal stage - within 9%
- * design concept stage - within 9%
- * design development stage - within 9%
- * documentation stage - within 5%

It will be shown later in this chapter that the above expectations are optimistic when compared with the results of empirical studies conducted overseas. A possible explanation for this optimism is that the stated accuracy levels represent desired levels rather than a reflection of actual performance. The expectations of architects and clients, which follow hereunder, are indicative of what these parties expect to be achieved. If quantity surveyors are unable to meet the standards indicated, the potential for disputes referred to earlier in this chapter is accentuated.

4.4.3 Architects' and Clients' expectations

Although limited literature exists on the level of satisfaction experienced by architects, Shannon (1978) infers that architects are not always satisfied with the construction price advice provided by quantity surveyors. Ferry (1978) indicates a low level of client satisfaction by suggesting that the more contact the client has with building professionals, the lower the expectations are likely to be.

A study of both clients' and architects' expectations of accuracy derived from the survey of Bowen (1992), is illustrated in Table 4.2. The expectations of both rise as the design process progresses, as does the subjective reported accuracy received. It is noticeable, however, that clients consistently expect higher levels of accuracy than architects at all design stages.

Expected Accuracy	0 - 5%		6 - 10%		11 - 15%		16 - 20%		Over 20%	
	Arch %	Client %	Arch %	Client %	Arch %	Client %	Arch %	Client %	Arch %	Client %
<i>Inception</i>	5	14	16	47	48	22	25	12	6	6
<i>Appraisal</i>	14	49	31	31	44	14	7	1	4	6
<i>Design Concept</i>	20	53	53	34	24	8	0	1	3	5
<i>Design Development</i>	46	77	46	14	6	3	1	0	1	6
<i>Documentation</i>	72	86	23	9	5	1	0	0	1	4

TABLE 4.2 CLIENT / ARCHITECT EXPECTATIONS OF ACCURACY
(Adapted from: Bowen, 1992)

A comparison of the above expected (or required) levels of accuracy with the subjective assessments of what accuracy is actually attained, discloses that many recipients of price forecasts are dissatisfied with the estimating performance of consultants. This is confirmed by Bowen (1992), who indicates that clients are generally dissatisfied with the accuracy of price forecasts provided by quantity surveyors from the inception stage through to the detailed design stage. In contrast, architects appear to be satisfied with the accuracy levels during the equivalent stages. However, at the tender stage the expectations of both clients and architects appear to be unfulfilled.

4.5 LITERATURE REVIEW OF ESTIMATING PERFORMANCE

The following review provides a summary of available literature on the measurement of accuracy in both quantity surveyors' and contractors' estimates. The intention of this section is not to prove that estimates compiled by contractors are more, or less, accurate than those of quantity surveyors, but rather to provide a basis upon which the assessment of an empirical study of South African estimators (see Chapter 7 of this study) can be structured.

The review is divided into sections separating opinions and opinion surveys from empirical studies. The report is not confined to any particular sector of the construction industry nor

Gunner and Betts (1990) for fuller descriptions of the research undertaken in this field to date. The evidence presented in numerous papers such as those of Ashworth and Skitmore (1982) and Ogunlana and Thorpe (1987) suggests that informally structured studies yield estimating performance levels better than those achieved in empirical studies. It should be noted that one of the main reasons why quantity surveyors' and contractors' reported estimating performance cannot be compared, is because in some studies contractors' tenders are compared with actual cost / final account figures, whilst consultants' estimates are generally compared with the lowest tender.

4.5.1 Contractor's construction cost estimates

A distinction needs to be drawn between the terms "estimating" and "bidding" (or "tendering"), which are often misinterpreted as having the same meaning. "Estimating" is normally understood to be the technical process of establishing the predicted costs of construction. "Tendering" or "bidding" is the related subsequent activity, based upon the estimate, of allowing for profit mark-ups and adjustments to allow for the competition with other contractors. However, in the literature studied, the term "estimating" is frequently used to denote both activities. As the main use appears to be that relating to the actual tender computation, this approach has been similarly adopted in this document.

Any assessment of the accuracy of cost prediction methods must ultimately rely upon quantitative techniques. Either of two approaches are generally taken in assessing the accuracy of cost estimates made by the contractor (Ogunlana, 1991):

- Where the contractor is the lowest tenderer, the estimate may be compared with either actual construction cost or the final account figure. Comparing the bid with actual cost may be difficult because of problems in obtaining reliable data, whilst comparison with the final account figure requires complicated adjustments to be made for design changes.
- The alternative technique is to compare the contractor's tender submitted with the lowest bid from another contractor, or even the mean bid.

4.5.1.1 General research

The accuracy of contractors' estimating has not been widely researched. Analysis of researchers' opinions regarding the accuracy of contractors' estimates, as discussed in the

Chapter 4

following paragraphs, indicates that accuracy of between 5% and 9% coefficient of variation (CV) is achievable.

Beeston (1975) proposes that the ideal data for an analysis aimed at measuring the inherent variability of whole building prices is a large number (more than 10) of repeat prices independently obtained for the same design, in the same locality, at about the same time. He cites an example of this occurrence which has produced a coefficient of variation of just under 10% for the lowest tenders. Due to several causes of tender variability applying in practice, Beeston (1975) suggests that 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 $\pm 5\%$, given a set of quantities and sub-contractors 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 11.55% and 2.85%. The mean for the sample analysis is 8.22%. Flanagan concludes that the best measure of a contractors' ability to estimate his own costs on projects is 6.6% CV.

If the assumption is made that this level is accomplished by both the successful and unsuccessful tenderers, Morrison (1984) claims that this factor alone results in an overall range of tenders of approximately 22%. This conclusion corroborates the contention of Barnes (1974), wherein he states that the major portion of the spread of tender prices is due to the probability distribution, which is a measure of the accuracy with which the contractor is able to predict the cost of the work.

4.5.1.2 Empirical studies

A limited number of empirical studies on the variation of constructional bids have been undertaken. Their findings support the opinions cited above that an accuracy level of between 5% and 9% CV is possible.

A typical example of studies conducted is that of Barnes (1974), who, in an analysis of 228 projects taken from 10 different contracting organisations, found that the coefficient of

Chapter 4

variation measured between the contractors' estimate and the actual cost of the projects was approximately 7%.

Table 4.3 reflects a summary of the published findings of empirical studies conducted. No reference to any empirical studies of contractor's estimates subsequent to those listed, which are extracted from Ogunlana (1989), have been found.

Author	Source of Data	Mean CV (%)
Gate [1967]	110 Highway Contracts	8.0
Fine & Hackemar [1970]	Adequate sample of projects	5.0
Barnes [1971]	160 construction contracts	6.5
Grinyer & Whittaker [1973]	153 Public Sector contracts	6.04
Beeston [1974]	Large sample of PSA contracts	5.2 to 6.0
McCaffer [1976]	185 Belgian building contracts	6.5
AICBOR [1976]	213 Motorway contracts	6.8
McCaffer [1976]	16 Belgian bridge contracts	7.5
McCaffer [1976]	385 road contracts	8.4
Benjamin & Meador [1979]	131 Contracts	6.6
Skitmore [1986]	269 building contracts	6.5
Runeson [1988]	1046 Building projects	4.9

TABLE 4.3 MEAN COEFFICIENT OF VARIATION OF CONSTRUCTION BIDS
(Source: Ogunlana, 1989)

The results of the surveys reflected above are remarkably consistent in that limited variance is displayed by any of the values. This is considered important, as the contracts listed are diverse in terms of size, type of project, and year constructed.

4.5.2 Designer's construction price forecasts

Since Beeston (1975) has demonstrated that any lowest tenders' relationship to the mean of lowest tenders is random, it must be concluded that quantity surveyors can only follow this relationship by coincidence. Morrison (1984) concludes that the best performance which can be achieved by quantity surveyors attempting to consistently predict the value of the lowest tender, is equal to the level of variability found in the lowest tenders.

Beeston (1975) graphically portrays the nature of the effect of achieving different levels of accuracy as signified by the coefficient of variation. This is reproduced in Table 4.4. If Morrison's hypothesis is correct, quantity surveyors can expect to be within 5% of the lowest tender in 52 per cent of projects forecast, and within 10% in 84 per cent of contracts.

Coefficient of variation	Within 5 per cent	Within 10 per cent	Within 30 per cent
4 per cent	79 per cent	99 per cent	100.0 per cent
6 per cent	60 per cent	90 per cent	100.0 per cent
7 per cent	52 per cent	84 per cent	100.0 per cent
10 per cent	38 per cent	68 per cent	99.7 per cent
15 per cent	26 per cent	50 per cent	95.0 per cent

TABLE 4.4 EFFECTS OF DIFFERING COEFFICIENTS OF VARIATION
(Source: Beeston, 1975)

Examination of the table discloses, however, that at 7% CV all estimates will be within 30% of the lowest tenderer. In practice this is unlikely to be achieved, leading to the conclusion that a CV closer to 10% is the best consistency that can practically be accomplished.

4.5.2.1 General research

In the concluding chapter of his Msc. Thesis, Greig (1981) states that respondents to his survey of clients, subjectively assessed that 86% of estimates performed by quantity surveyors are within 5% of both the accepted tender and final account. In conducting a closer examination of the recorded responses, however, (Greig, 1981 - p. 106 and 107), the writer notes, that the figures given are incorrect. Whilst still reflecting favourably on the performance of the estimators, the corrected figures should be 72% when compared with the accepted tender (not necessarily the lowest tender), and 73% when compared with the final account figure.

A more recent example of a study concerning the accuracy of estimator's price forecasts is cited by Tan (1988). The study relates to 273 construction projects undertaken between 1974 and 1981 by the National Aeronautical and Space Administration (NASA) in the

USA. Although no indication of achieved CV is indicated, the estimators' forecasts average 7.8% higher than the low bids accepted. For comparative purposes, an analysis of 22 more recent projects reveals forecasts on average 7.49% higher than low bids, with a given CV of 16.77%.

The above examples illustrate the need to ensure that stated figures are comparable. For instance, the effect of Greig's incorrect figures on the CV percentage and therefore the probability distribution can be derived by interpolating Table 4.4. A potentially greater hazard is created when comparing the opinions of accuracy as normally referred to by quantity surveyors (mean "error" as previously indicated), with the coefficient of variation. As can be seen in the recent NASA projects indicated above, it is quite possible to experience a significant difference in the percentage levels of these units of measurement. It is suggested that whenever the CV is given by researchers for estimate performance, the "mean error" ("relative deviation") be stated for comparative purposes.

The most recent observations on estimating performance are to be found in Skitmore (1988). Two sets of data are analysed. The first set of data reflects details of 67 building and engineering projects in the USA. Forecasts are on average 12.38% higher than the low bids, with poor consistency indicated by the standard deviation of 21.53. The second set of data is extracted from the records on 33 building contracts executed in the UK between 1983 and 1987. In this instance, forecasts are on average 4.91% lower than the lowest tenders. A relatively high inconsistency factor is evidenced by the standard deviation of 17.22. In neither instance is the CV percentage given.

4.5.2.2 *Empirical studies*

When forecasting performance is formally examined, it usually indicates a far poorer performance than is subjectively believed (Azzaro, 1976). Table 4.5, which is compiled from information contained in two recent research reports, namely Ogunlana (1989) and Gunner and Betts (1990), presents a summary of major empirical studies of accuracy of price forecasts at the detailed design stage.

The figures provided by Gunner and Betts (1990) are extracted from the records of a single international firm of construction cost consultants with 26 offices spread mainly around the Asia Pacific Rim. The results are based upon pre-tender estimates and awarded contract amounts. PC and provisional sum allowances are excluded. The CV for Singapore is based upon a comparison of the estimate with the lowest tender. The figures for the Property

Services Agency (1981) report also exclude PC and provisional sums. The basis for calculation of the other figures is not known.

Author	Source of Data	Mean CV (%)
Park [1972]	100 Projects	10 - 15
Beeston [1974]	Large sample of PSA projects	7
McCaffer [1975]	Office buildings	15
McCaffer [1976]	132 Belgian buildings	13.13
Mead [1977]	12 Major construction works	73
Hanscomb Associates [1976]	52 North American projects	7.7
Merrow et al [1979]	10 Energy process plants	20
Brown [1979]	22 Projects	16.77
McCaffrey & McCaffer [1981]	Data on 15 school projects	6
Morrison & Stevens [1981]	557 Construction projects	15.5
Darko [1985]	33 Projects	12
Gunner & Betts [1990]	46 Projects in Singapore	19
Gunner & Betts [1990]	9 Projects in Auckland	6
Gunner & Betts [1990]	5 Projects in Canberra	3
Gunner & Betts [1990]	27 Projects in Hong Kong	8
Gunner & Betts [1990]	3 Projects in Kota Kinabalu	4
Gunner & Betts [1990]	9 Projects in Kuala Lumpur	11
Gunner & Betts [1990]	4 Projects in Melbourne	41
Gunner & Betts [1990]	4 Projects in Perth	6
Gunner & Betts [1990]	4 Projects in Townsville	2

TABLE 4.5 ACCURACY OF CONSULTANTS ESTIMATES AT DETAILED DESIGN
(Adapted from: Ogunlana, 1989; Gunner and Betts, 1990)

The adjustment for "fixed" sums referred to above is imperative if a true measure of accuracy is to be portrayed. The extent of these sums can be considerable, particularly in alternative procurement systems that have recently been utilised in South Africa. In the Singapore samples the amounts represent 50% of the value, the deduction resulting in an inferior level of accuracy being discernible. The wide differences between figures can be due to a number of factors, one of which is the small data samples for several of the

Chapter 4

Gunner and Betts records. Comparisons between all figures are for indicative purposes only.

Morrison (1984) concludes the examination of 557 projects from 7 largely public sector sources, by deducing that the best performance that quantity surveyors can achieve is a coefficient of variation of 15.5%. A contrary opinion is given by Beeston (1975) who reasons that, using current available methods of estimating in the best possible way, the best CV possible is in the order of 7 per cent or 8 per cent. He qualifies this opinion by stating that the accuracy is dependent upon the quantity surveyor's 'intuitive' estimating ability.

Beeston's opinion reflects an accuracy level similar to that anticipated from an examination of the performance levels of contractors' estimators earlier in this chapter. This means 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.

4.6 CONCLUSIONS

The communication process relating to the submission of price forecasts is impeded by a lack of understanding by the participants in the building procurement system, with respect to the degree of accuracy of estimates.

This can be ascribed to many reasons, foremost amongst which is the lack of a clear definition of the term "accuracy" as related to building estimates. In addition, no measure of what constitutes an acceptable level of performance is available, although it is commonly suggested that a figure of +/- 10% mean deviation from the lowest bid at the pre-tender stage of development is suitable. An alternative form of reference to this issue is the coefficient of variation, used mainly by researchers to indicate the degree of consistency in pricing. The combination of alternative forms of measurement generally reflect reliability of the model, and not accuracy.

There are many instances of research papers confusing estimating accuracy with reliability of forecasting and the diminishing extent of uncertainty as the design sequence evolves. Contrary to expectations, there are indications that the accuracy of price forecasting does not vary significantly during the design process. This aspect does, however, require further

Chapter 4

research to be conducted. The expectations of pre-tender estimating accuracy by quantity surveyors, which appear to be optimistic, are identified as generally being within 5% of the lowest tender.

Previous research suggests that the lowest possible level of accuracy which contractors' estimators can consistently achieve is between 5% and 9% CV. Quantity surveyors cannot, other than by chance, be expected to consistently produce estimates more accurately than contractors. Estimators who produce 85% of their estimates (excluding PC and other fixed sums) within 10% of the tender figure, are achieving as good a performance as the dispersion of tender prices permits.

Whilst studies of price forecasting reflect a wide variability of results, general research and empirical studies indicate that quantity surveyors should be able to produce estimates with a coefficient of variability of between 12% and 19%.

The following chapter deals with the factors affecting tender prices.

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5. FACTORS AFFECTING ACCURACY

"The bitterness of poor quality is remembered long after the sweetness of the cheapest price is forgotten" : Anon

5.1 INTRODUCTION

As indicated in earlier chapters, most researchers recognise that the nature of quantity surveyors' price forecasting is such that it is virtually impossible to achieve absolute accuracy in deterministic estimates. Chapter 4 provides an indication of the extent of the inaccuracy of both contractors' and quantity surveyors' estimates, as reflected in published reference sources.

Betts and Gunner (1989) are of the opinion that the form of the inaccuracy is of equal, if not greater importance, than its magnitude. It is suggested that by establishing the amount of inaccuracy, and identifying any relative causative factors, specific procedures for improving estimating performance can be adopted. This can, in turn, be used to identify means of improving accuracy of price forecasts in the early stages of design development.

Researchers generally agree (Bowen, 1982a; Flanagan and Norman, 1983; O'Dean, 1984; Ashworth, 1988b; True, 1988; Flanagan and Stevens, 1990; and Horner, 1991) that the design phase estimating process is not a precise scientific exercise, but an art combining the application of several facets such as data, technique, calculation, analysis, intuition and expert judgement.

Skitmore *et al.* (1990) assert that there are five primary aspects which determine the quality of quantity surveyors' price forecasts. These concern (a) the nature of the target, (b) the information used, (c) the forecasting technique used, (d) the feedback mechanism used and, (e) the person providing the estimates. Skitmore's broadly based approach to providing a satisfactory price forecasting service incorporates characteristics that can be further subdivided into definitive features. This facilitates the linkage of performance evaluation with factors identified in the literature as possibly contributing to the attainment of excellence.

Ashworth and Skitmore (1982) contend that, in order for the quantity surveyor to upgrade his estimating performance, the ability of the contractor's estimator to improve the

accuracy of tender estimates must first be addressed. Further, Bennett *et al.* (1981) theorize that the quantity surveyor's task in producing price forecasts should be to contemplate the same factors as the contractor takes into account, so that the estimate produced reflects the actual project and its particular context, rather than an ideal or average situation otherwise presented.

The first part of this chapter considers this aspect in the context of the use by contractors' estimators of cost-based pricing structures within the environment of the competitive tendering market.

The balance of this chapter is devoted to a review of the findings of researchers dealing with those factors affecting design team price forecasters in particular. The objective of this section is to determine the factors considered most likely to affect estimating accuracy. In Chapter 6 of this dissertation, the views of quantity surveyors in South Africa with respect to the relative importance of these factors are compared with the results of a similar survey recently conducted overseas.

5.2 CONSIDERATIONS IN CONTRACTOR TENDERING

5.2.1 The competitive bidding process

It is not the intention in this document to enter the area of bidding models, which involves the development of probabilistic strategies to derive the association between the number of bids (tenders) and the chances of winning a contract. The well known bidding model controversy between the approaches of Friedman and Gates in the *Journal of the American Society of Civil Engineers* started in 1956 and continued until the early 1980's (Raftery, 1987b). With little support from industry, the field of bidding models has remained largely academic (Cattell, 1985), this well researched topic having resulted in the production of over 1000 papers and theses.

The development of bidding research differs fundamentally from that of estimating research. Bidding research is firmly anchored in economic theory with very little empirical support, whilst estimating research has no formal theoretical base at all (Skitmore and Patchell, 1990). Although bidding research is ostensibly unrelated to practical quantity surveying activities, there is an important linkage with design price forecasting as, unlike

Chapter 5

construction estimating which attempts to reflect a cost-based structure, bidding is directly concerned with market prices.

In essence, competitive market-based bidding concerns each contractor's attempts to anticipate the bids of others. This strategy results in the tender being largely independent of the cost of production (Skitmore, 1987b). The alternative process of cost-based price determination is conventionally recognised as the more common procedure (CIOB, 1979). In this system, the market effect is recognised by means of adjustment to the mark-up, after having conceptually established the anticipated cost of executing the work.

Skitmore (1981) suggests that a tenderer has four options available when initially deciding upon a strategy to employ when submitting a bid:

- (a) decline to submit a tender,
- (b) submit a 'cover price',
- (c) generate a rough estimate and add a high mark-up,
- (d) produce a detailed estimate and add a low mark-up.

For purposes of this study, it is assumed that the tenderer exercises the last option, although it is noted that the mark-up applied should be appropriate to the bidding market, and may not necessarily be low. Adoption of this approach enables an examination of the factors affecting the accuracy of the estimate to be conducted.

Numerous authors have addressed the decision-making environment surrounding tendering strategy, with Ashworth (1988b) pertinently stating that the decision to tender is made on the basis of the firm's current workloads, future potential, and the attractiveness of the scheme being considered. Marsh (1987) summarises the typical opinions regarding the factors to consider in deciding whether or not to bid as:

- (i) the likelihood of the project ever happening,
- (ii) the value of the opportunity, either in profitability or provision of work
- (iii) the costs of trying to be the successful tenderer,
- (iv) the chances of success,
- (v) the risks to the tenderer if the bid is successful.

Traditional theory states that contractors' estimators calculate the costs of proposed projects from recorded and reported information emanating from actual site activities. Whilst this procedure certainly does occur, it is considered unlikely that this procedure is followed by every contracting firm. Ashworth (1988b) alleges that even in some cases where feedback does reach the estimator, it is ignored. A primary reason given why estimators do not avail themselves of the use of site feedback, is that there is often a lack of confidence in the data provided as a result of poor recording systems employed by contractors.

One of the more disconcerting aspects of tender preparation is the tendency, first referred to by Fine (1974), for estimators to present "socially acceptable" forecasts, i.e. providing a cost estimate that is merely a target figure on which management may base their final tender mark. Such tenders are not attempts at accurate estimating but rather portray the alternative "market-based" stratagem of obtaining the contract at the highest possible price after allowing for prevailing market conditions.

Converting the estimate into the bid in the traditional sense requires the appraisal of the profit mark-up to be considered and applied to the estimate. This decision, based upon a general re-examination of the project, the firm itself, and the market, is a very subjective operation, adopted largely on intuition and anticipation rather than of knowledge.

5.2.2 Factors affecting the bid

It is a commonly held opinion of both quantity surveyors and contractors that the major portion of the range of tenders found on actual projects is characteristic of the prevailing market conditions. Barnes (1974) challenges this assertion by indicating that the greater part of the spread of bids is due to the probability distribution, which denotes the accuracy with which the contractor is able to forecast the cost of the work.

A study of the literature reveals several examples of researchers attempting to categorise the innumerable factors which affect the cost of a new project (Pegg, 1985; Beeston, 1987; Rapier, 1990). The various features which influence a tenderer's mark up can be construed as the factors which influence the competitiveness of a single tender. These factors may be grouped into those affecting (1) group behaviour; (2) individual behaviour; (3) contract characteristics (Drew, 1990). This division is illustrated in Figure 5.1.

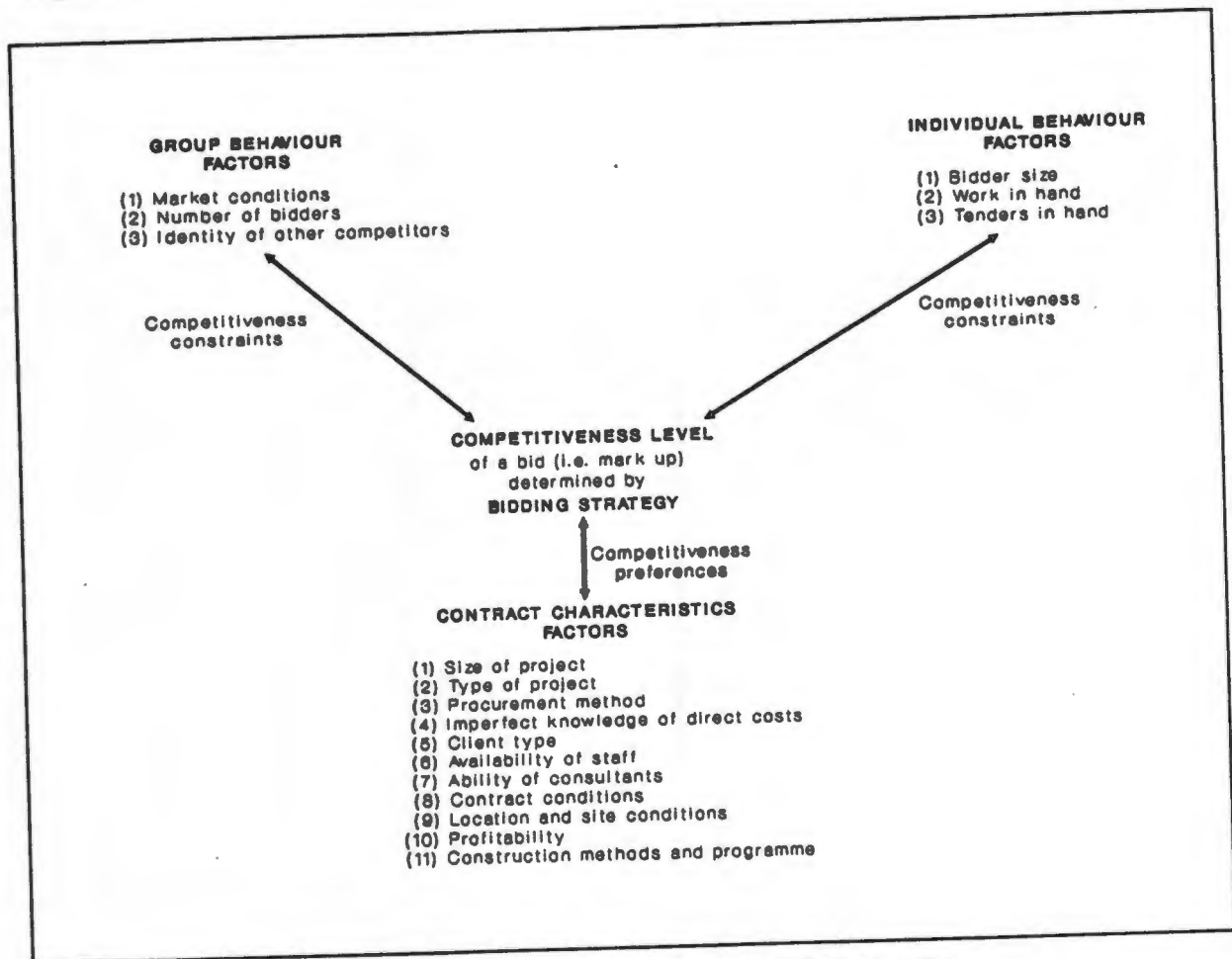


FIGURE 5.1 COMPETITIVENESS IN BIDDING PERFORMANCE.

(Source: Drew, 1990)

The degree to which these factors influence the competitiveness level is dependant on the level of mark up applied as part of the contractor's bidding strategy. The figure clearly shows the potential for skillful manipulation of tendering constraints and preferences to achieve cost effective procurement solutions.

Deviation from established procedures, such as inviting more bids, introducing open tendering, planning off-season procurement, and providing simpler contract arrangements in an attempt to lower the market price is seldom contemplated (Skitmore, 1988a). Industry in general believes such actions will either not achieve their aim, or will result in counter productive reactions from contractors. In the few instances where these opinions have been tested, the conventional view does not appear to be supported.

Five factors are identified by Flanagan and Norman (1982c) as being most likely to affect tendering behaviour. These are: (a) size / value of the project, and construction or managerial complexity required; (b) regional market conditions; (c) the current and projected work load of the tenderer; (d) the type of client, and (e) the type of project.

The foregoing closely correspond with the results of a study undertaken by Sey and Dikbas (1990) to determine the importance of the factors which affect the tender price of contractor organisations in Turkey. They rank firms by size and the results of their findings include the following:

- (a) Factors related to finance assume the highest importance. Reliability of client appears to be significant for all sizes of firm, possibly due to economic instability in Turkey at the time of the study.
- (b) Firms which are described as 'large' in terms of capital and the value of contracts undertaken, attach the greatest importance to type and size of job, and project suitability, while financial factors, technological experience, resource availability and capacity appear to be more vital for small firms.
- (c) Site conditions and procedures related to the tendering process are described as being unimportant.
- (d) Appointment on prestige projects seems to be meaningful for big firms, while small firms do not consider this factor in the bidding process.

It is clear that factors such as those above can affect the decision-making process of tenderers in the application of their mark up. However, the influence on the accuracy of submissions is more difficult to establish. Few papers have been published on the impact on accuracy levels of contractors estimates of independent factors. Although each bidding event is unique, many factors are common and the results of the few instances of such studies are summarised below.

(a) Market conditions

The appropriate tender price for a specific tenderer is considered to be significantly influenced by market conditions. This refers particularly to the current and projected workload of any tenderer. When a recession occurs there is normally less work available, inevitably leading to greater competition between contractors, whilst the higher the workload, the higher will be the bid price (Flanagan and Norman, 1985; Drew, 1990). A multivariate analysis of contractors' bids referred to by Skitmore (1990b), reveals that the year of tender is a major influencing factor determining the profile of the distribution of

Chapter 5

tenders. Beeston (1975) states that the spread of tenders increases under competitive conditions.

Figure 5.2 illustrates the mean value of coefficients of variation for 293 tenders for a variety of projects in the UK between 1969 and 1979. The 95% confidence interval is also shown.

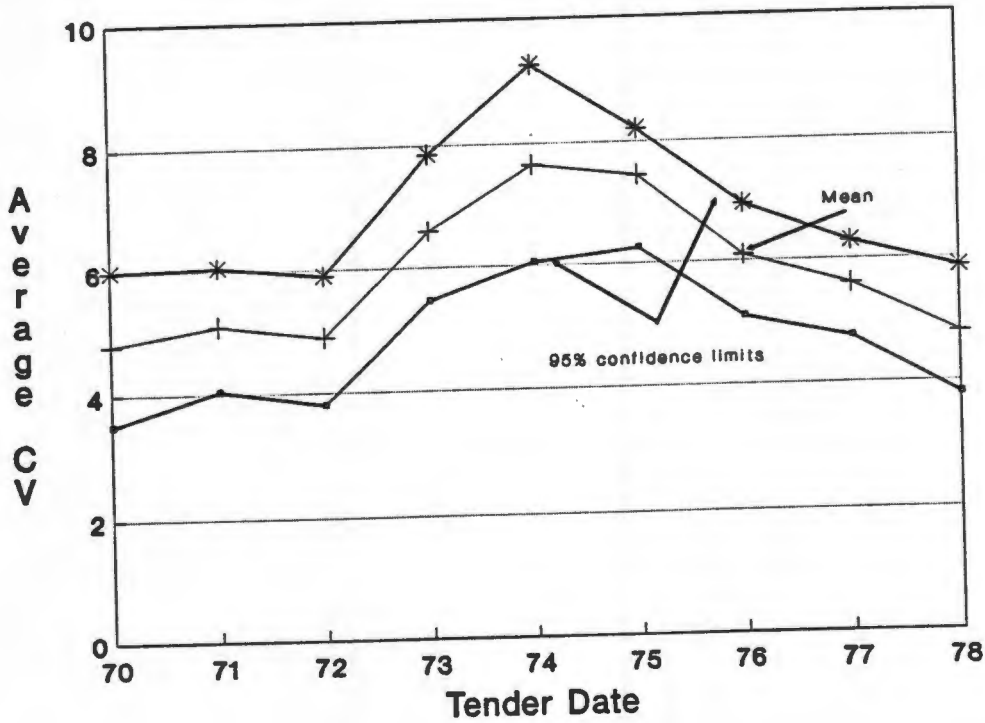


FIGURE 5.2 AVERAGE CV OF UK TENDERS: 1969 - 1979.

(Adapted from: Skitmore, 1987c)

The visible 'hump' between 1972 and 1976 coincides with an extremely 'poor' economic period in the UK (as measured by a drastic fall in demand) experienced in 1974 (Skitmore, 1987c, p. 180). Skitmore's explanation of this phenomenon is:

"The start of the steep fall in orders at this time suggests the interpretation that bidders had substantially different workloads or perceived future workloads, resulting in widely differing pricing strategies. An alternative explanation is that bidders were simply uncertain of the 'going price' for the projects at that time."

A further analysis of the annual CV's, after extracting the three individual highest tenders, is given in Figure 5.3.

Chapter 5

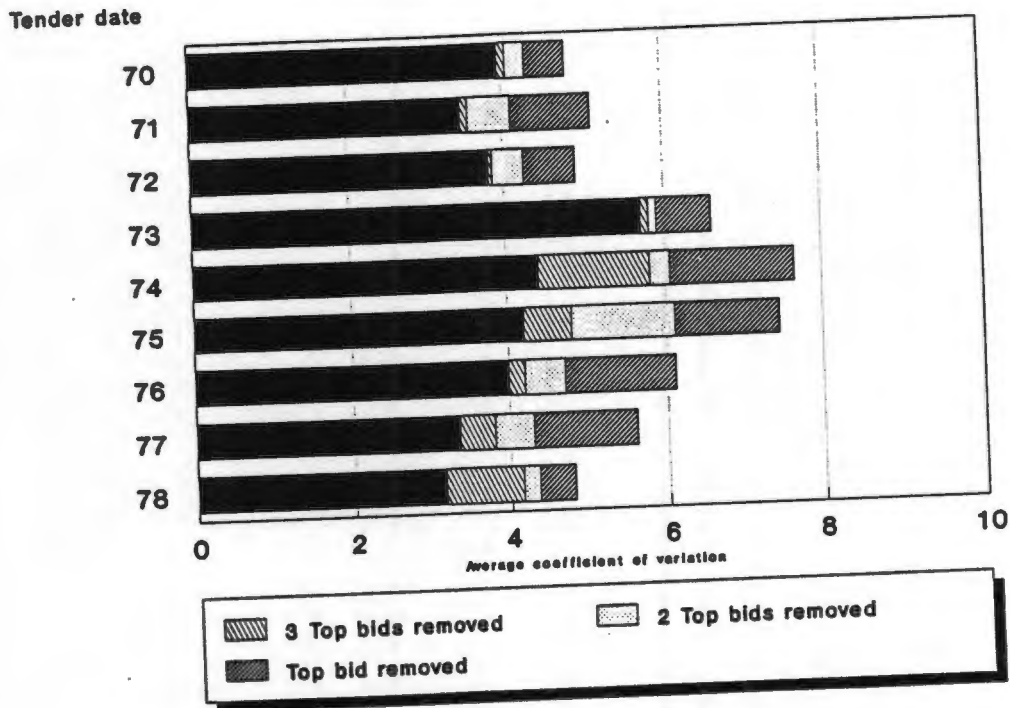


FIGURE 5.3 AVERAGE CV AFTER REMOVING HIGHEST TENDERS.
(Adapted from: Skitmore, 1987c)

The assessment of variance provides evidence that the highest tenders have a major impact on the spread of tenders, particularly in times of unstable economic conditions.

(b) Project size / value

Only one reference source dealing with this factor in relation to the tendering performance of building contractors, is referred to in the literature. The study, presented by Drew and Skitmore (1990) of 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 (1982b) contention that *"tendering strategy in general is affected by the type of project and value range"*. The main conclusions of the Hong Kong investigation are:

- (a) the competitiveness of individual tenderers is influenced to varying degrees by contract type and size,
- (b) large contractors appear to be more competitive on large contracts.

Chapter 5

(c) 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.

Flanagan and Norman (1985) observe that although large tender lists might imply the automatic securing of competitive prices, there is little to be gained by having more than about four or five tenderers on any list.

McCaffer (1976), in a survey of tenders on 168 road contracts, investigates the relationship between the low bid, the mean bid and the design engineers estimate. As indicated in Figures 5.4 and 5.5, 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.

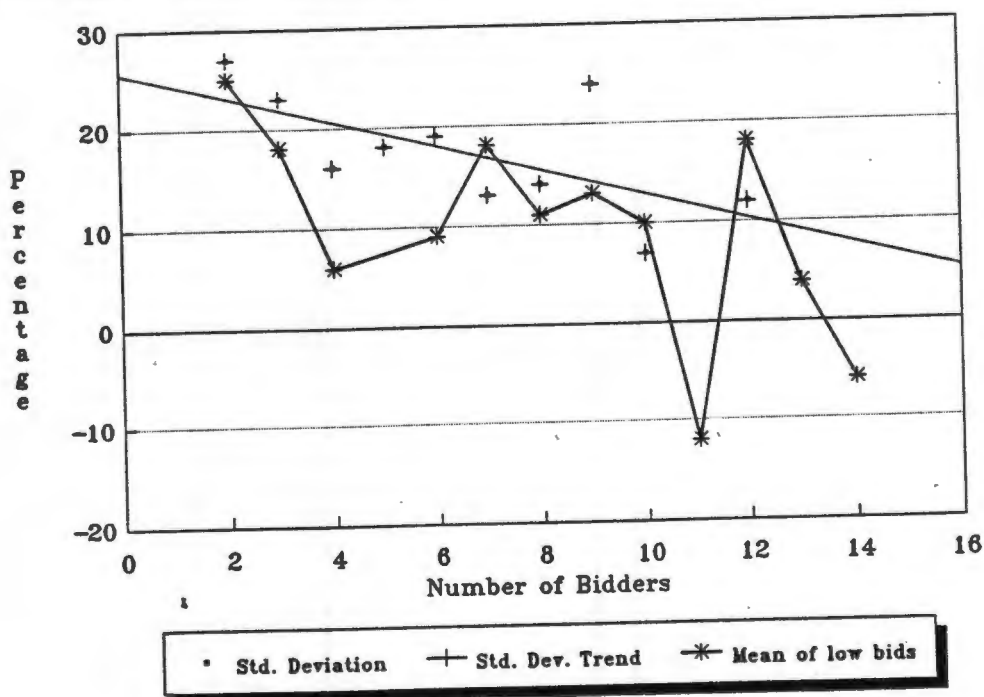


FIGURE 5.4 LOW BID AS A PERCENTAGE OF DESIGNER'S ESTIMATES.
(Adapted from: McCaffer, 1976)

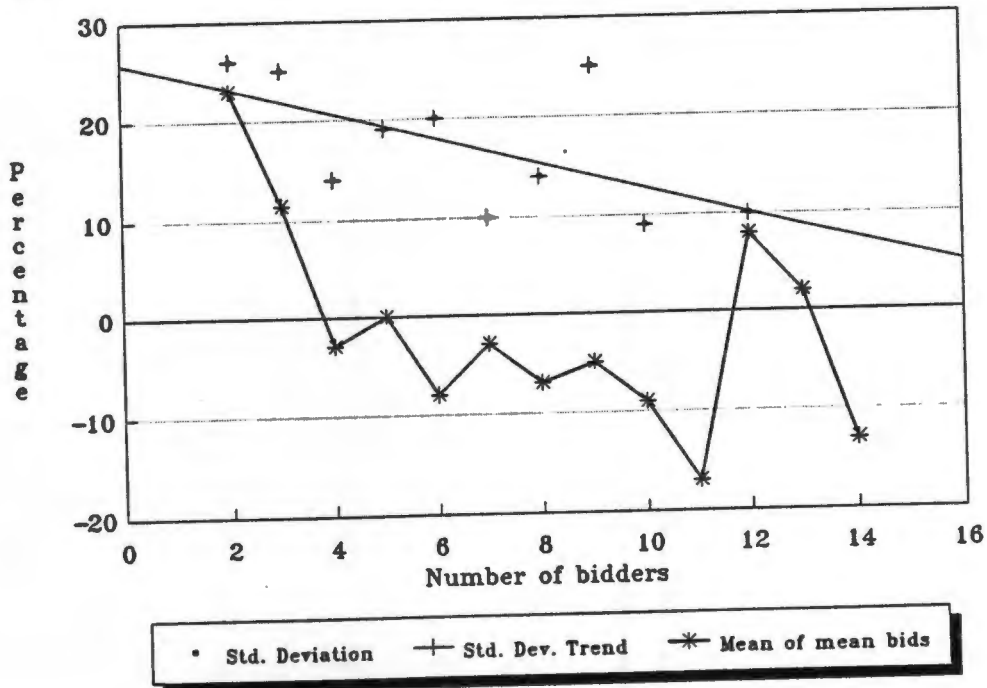


FIGURE 5.5 MEAN BID AS A PERCENTAGE OF DESIGNER'S ESTIMATES.
(Adapted from: McCaffer, 1976)

It is noticeable that the pitch of the trend line flattens as an increasing number of bidders per project is reflected. This supports the proposition that large tender lists do not produce significant benefits in terms of lower tenders.

(d) Other factors

Few other factors which could conceivably affect contractor's tenders appear to have been seriously investigated. One of the few exceptions is the study conducted by Wilson *et al.* (1987). Their study of 410 projects for a public sector client in Victoria, Australia reveals that, contrary to industry opinion, open tendering does not produce more tenders (and therefore competition) per project than selected tenders.

Flanagan and Norman (1985), in a study of the relative efficiencies of firms on the tender list conclude that the inclusion of contractors considered by their peers to be efficient tenderers leads to lower bid prices.

The awareness of the effects that the above factors can have on a tenderer's pricing strategy 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.

5.3 FACTORS AFFECTING ESTIMATING ACCURACY

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

The factors considered in these reports include those related to project specifics 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 following factors highlighted in a Doctoral Thesis by Ogunlana (1989), are presented as the basic listing for detailed examination. Additional items that have been analysed by other researchers are presented separately. Whilst the likelihood of any one of the listed factors acting independently of others is very small, the number of possible combinations prevents multivariate analysis being applied, prior to the factors being identified.

5.3.1 Historical cost data

Although virtually no research seems to have been conducted to test the relationship between estimating accuracy and the availability or use of different forms of historical cost data, there appears to be a degree of common influence between this factor, the experience of the estimator, and the level of design information available for price forecasting.

As indicated in Chapter 3, Jupp and McMillan (1981) is the only study which attempts to ascertain the impact on estimating accuracy of using different levels of cost data for pricing purposes. The findings of Jupp's (1984) research, confirming that priced bills of quantities are the most widely used source of price information by quantity surveyors, and that preferably three bills, not more than two years old should be used for this purpose, sets the foundations upon which any test can be applied. This is especially relevant in South Africa where the availability of both 'in-house' and published price data is extremely limited.

Chapter 5

In addition to research of this nature, attention needs to be paid to the fallibility of the published 'price books' that are available locally, and the validity of using indices which are often based on very small and statistically suspect samplings.

When applying historical cost data it is important that the prices being compared be carefully studied to determine the influence of 'preliminaries' on rates used (Bennett *et al.*, 1981; Betts and Gunner, 1989). The same authors stress the vital need, when using total contract values, to differentiate between those including the value of PC and Provisional Sums or not.

5.3.2 Estimator's expertise / experience

A number of studies have been undertaken on this aspect, although none of the research has been conducted in South Africa. As few of the studies differentiate between 'experience' and 'expertise', some comments in this regard follow.

Skitmore (1985), in examining the influence of professional expertise in building price forecasts, indicates that notwithstanding some improvement in estimating performance with increasing experience being evident, no definitive trend for differing levels of experience can be proven. In a later, more extensive study, Skitmore *et al's* (1990) subjects are categorised in five groups, based on length of experience. These are, (a) 5 to 14 years, (b) 15 to 24 years, (c) 25 to 29 years, (d) 30 to 34 years, and (e) 35 to 44 years. Observations of the estimating performance of the groups reveal that the least experienced group display a high degree of variability in expertise level. While demonstrating an above average performance on certain building types, this is counterbalanced by extremely poor performance on others.

The variability in expertise level of group (b) is minimal for all building types investigated. The group with between 25 and 29 years experience generally display a highly variable degree of expertise, having the lowest level of competency for several building types. The most experienced groups generally exhibit low expertise variability with building type and demonstrate a high level of expertise for all building types. It is surmised that the poor performance of group (c) is due to subjects possibly lacking sufficient practice, due to involvement in other office activities such as management. The groups are ranked by Skitmore *et al.* in terms of suitability to estimating as follows:

1	Experience 35 to 44 years
2	" 15 to 25 "
3	" 30 to 34 "
4	" 5 to 14 "
5	" 25 to 29 "

Some of the other findings of the above research are:

- 1) There is a tendency for estimators to specialise more in early stage forecasting as greater experience is gained.
- 2) The number of forecasts produced by an estimator and the length of experience do not necessarily determine the level of expertise attained. These two factors must be considered together with other factors such as the type of experience and personality characteristics.

Estimator experience and expertise are widely considered as being of primary importance. This viewpoint is supported by the findings of a survey on early design stage conceptual estimating practices of 29 companies in the USA conducted by Ashley *et al.* (1988), as cited by Ogunlana and Thorpe (1991).

Experiments conducted (Jupp, 1981; Skitmore, 1985), suggest a distinct difference in accuracy levels between forecasters. Skitmore's (1985) experiments with "experts" and "novices" indicates that the most consistent forecasters are found to be associated with, in order of importance, high recall abilities, self-professed expertise, low mental imaging of physical characteristics of the building, high general and specific project estimating experience (Tan, 1988).

Some of the findings of Skitmore *et al.*'s (1990) extensive report on the expertise of construction estimators are:

- * Forecasters are generally optimistic in their expectations relating to their own forecasting quality.
- * There are indications that as soon as the forecaster is given an indication of the size and type of building, an opinion of the nature of the building and its associated market price is formed.

- * The acquisition of expertise seems to be an ongoing process, i.e. there is no time limit after which forecasters will have acquired all the necessary skills.
- * A limited number of estimators receive any post qualification training in forecasting skills. The degree of accuracy of forecasts found to apply to Skitmore's subjects increases with greater claimed post qualification training in early stage forecasting.

Feldman (1986), as cited by Ogunlana (1991), recommends the following four steps for improving learning from experience:

- (1) increasing the amount and immediacy of useful feedback,
- (2) creating a social environment that requires learning,
- (3) training workers to be experts in both the substance and process, and
- (4) not expecting infallibility.

Skitmore *et al.* (1990) imply that better performance is obtained from estimators that specialise in this activity. However, a tentative attempt to test this hypothesis in Singapore, as cited by Gunner and Betts (1990), provides inconclusive results.

In neither of the price modelling research programmes carried out recently in South Africa (Billett, 1990; Bowen, 1992), has this aspect been dealt with. However, since at least 75% of South African quantity surveying practices consist of 5 members or fewer (Billett, 1990), it is unlikely that many firms are able to use 'dedicated' estimators.

5.3.3 Level of design information

Hammond's (1980, 1981) cognitive continuum model identifying 'analytical', 'intuitive' and 'semi-rational' tasks is cited by Ogunlana (1991) when offering the view that building price forecasting is " *a semi-rational task, combining intuitive judgements of the market and cost relationships, with the analytical task of calculating quantities and rates*" as illustrated in Figure 5.6.

The figure portrays the situation that a pre-tender estimate is more analytical than an early stage budget estimate and that all estimates combine analysis with intuition (Ogunlana, 1991).

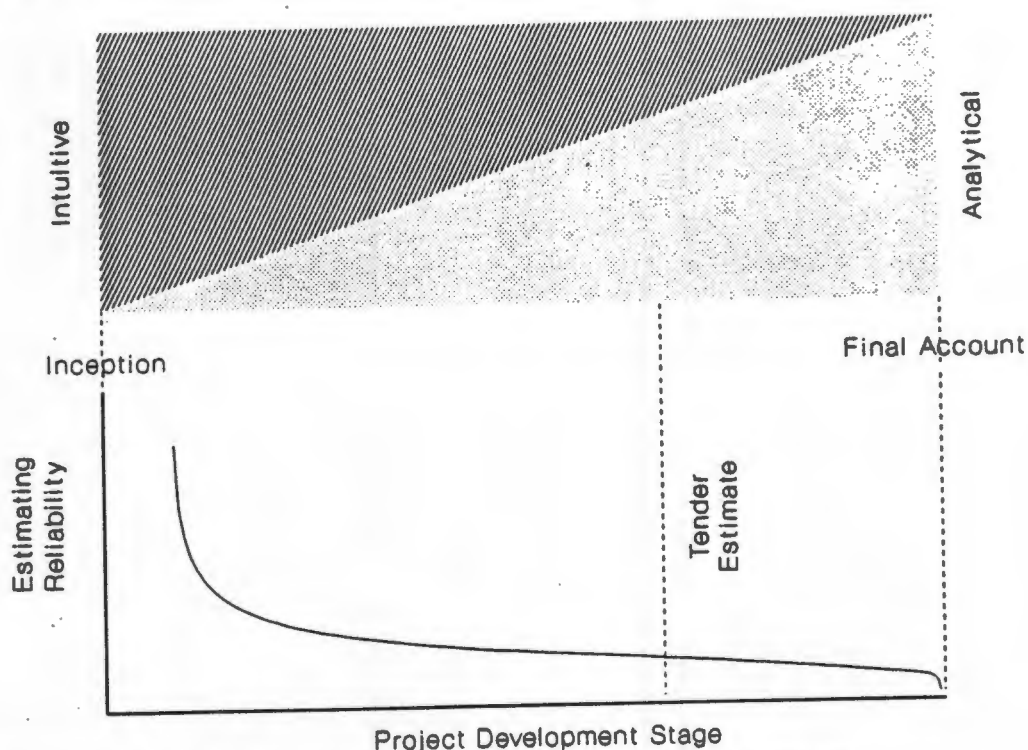


FIGURE 5.6 BUILDING PROJECTS TASK ENVIRONMENT.

(Adapted from: Ogunlana, 1991)

The issue concerning the improvement of estimating accuracy with an increasing source of information, revolves around two issues. The first issue concerns the inference that increased information about the project for which predictions are being made tend to reduce uncertainty due to better scope definition. Skitmore's (1985) experiment tests this proposition. This study involves a group of estimators being provided with increasing amounts of information about a contract to be estimated, in addition to information on similar past projects. The use of past contract information is found to have no significant effect on accuracy levels (Tan, 1988).

The second issue concerns the perception that the use of more price information is statistically expected to reduce the effect of possible error in historical cost data. Jupp and McMillan (1981), when testing this hypothesis using cost data from different numbers of bills of quantities, find that no advantage is gained by using more than 3 bills of quantities (Ogunlana and Thorpe, 1991).

A study by Bennett (1987) investigates the reliability of other data sources by conducting an experiment in employing eight subjects to price fifty items of building work four times, using a different standard price book on each occasion. The resultant totals for each book

show a marked variability, with one book significantly outperforming the others (Skitmore, 1988a).

The question of whether the level of information available to the estimator has any significant effect on improving accuracy of forecasts is a highly debatable issue, with many contradictory opinions being expressed. Tan (1988) states that most research shows that the level of information has little effect on estimating performance. Reference to the comprehensive review of estimating accuracy made by Ashworth and Skitmore (1982) indicates a coefficient of variation of 15% - 20% to be applicable in the early design stages, improving only to 13% - 18% at tender stage. Morrison's (1984) research also indicates that the accuracy of estimating does not improve appreciably during the development of a design when more detailed information is available.

One of the conclusions derived from the 1985 report on "*The influence of professional expertise in construction price forecasts*" produced by the Department of Civil Engineering at Salford University, is that the surveyors most accomplished at the estimating task show very little improvement in forecasting accuracy on receipt of increasingly comprehensive information 'chunks'.

It is concluded that the expected 'funnel' effect (Figure 4.2), does not apply to expert estimators. These estimators are capable of accuracy levels normally associated with detailed estimates when only a very minimal amount of information is provided, i.e., given only the building type and size, the experts are able to provide price forecasts with an accuracy level equivalent to an average practitioner pricing full estimates (Skitmore, 1988c).

The above view should be compared with the 'findings' of the later estimating experiments described by Skitmore *et al.* (1990), as recounted in Chapter 4 of this dissertation. The conclusions derived from the test of releasing increasing amounts of information in four stages to estimators include the statements that, (a) overall consistency improves in the first two of the four stages of design information release, and then remains constant through levels 3 and 4; (b) a much greater inconsistency exists within each information level than between levels; and (c) accuracy is a curved positive function, possibly asymptotic, of the amount of information received.

Chapter 5

This last aspect (item c) is emphasized by the statement, " *Accuracy therefore...shows a smooth increase through the information levels, with a suggestion of an asymptotic curve, exactly as predicted by the theoretical literature*" (Skitmore *et al.*, p.180, 1990). This statement is challenged on the grounds that the curve referred to is the so-called "funnel" effect commented upon in Chapter 4 of this dissertation (Figure 4.2), denoting the whole pre tender design process, whilst the limited release of 'chunks' of information in Skitmore *et al.*'s tests reflect a condition more comparable with the early design stages only.

Skitmore *et al.* (p. 14, 1990) summarise the difficulties experienced in assessing the importance of this factor by stating:

" The general lack of empirical research into the effect of information and different types of information available to the construction price forecaster is of major concern here, as a great deal of prescriptive and normative literature has been produced on the assumption of the importance of this factor. "

5.3.4 Market conditions

This factor is closely linked to other items likely to affect the estimating performance of quantity surveyors, particularly the number of bidders. Several authors (Stone, 1983; Hillebrandt, 1985) observe that tender prices rise as demand increases and fall when demand declines. This represents a normal market condition arising from the fact that the demand for buildings increases in the growth phase of the business cycle and recedes in the recession phase.

Hindle (1991) comments, as does Snyman (1985), that the degree of competition depends upon the amplitude of the cycle, noting that in severe recessions the competition becomes so fierce that contractors are even prepared to tender at their estimated cost (excluding any profit mark up) in order to maintain turnover.

Figure 5.7 indicates the general degree of competition for work in South Africa between 1975 and 1991, as presented by the Bureau of Economic Research, University of Stellenbosch. The graph, which is based on the opinions of contractors, is of a qualitative nature only.

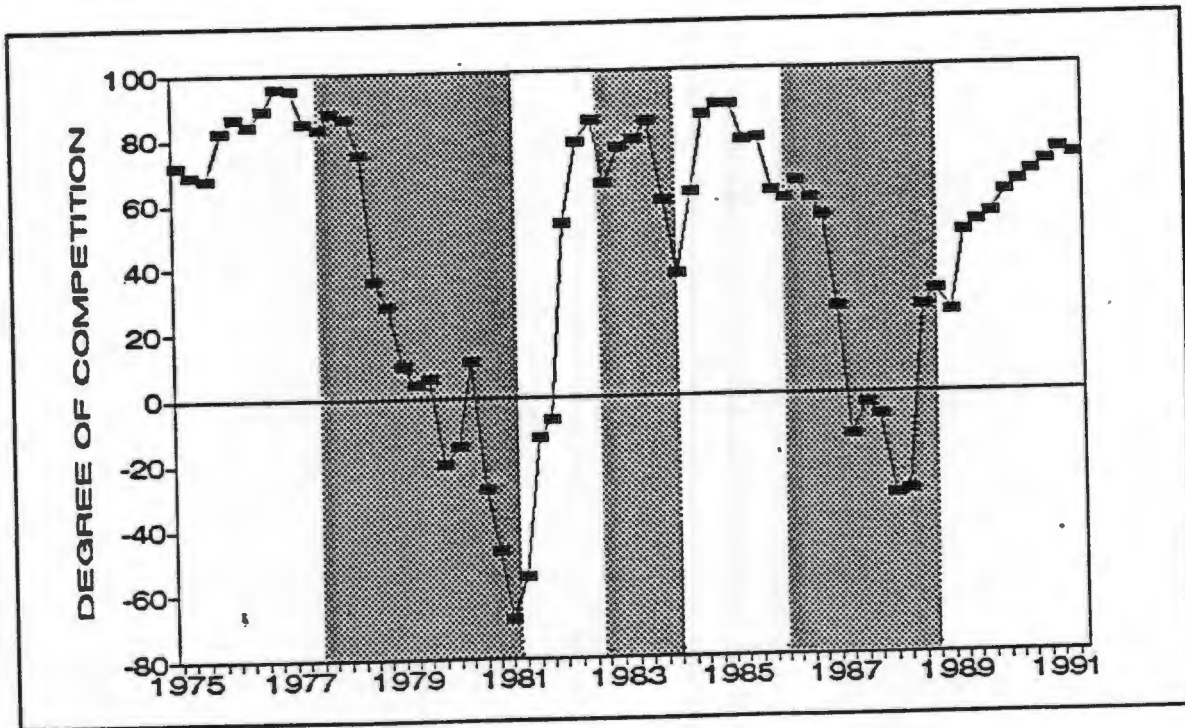


FIGURE 5.7 DEGREE OF COMPETITION IN TENDERING.

(Source: BER National Survey.)

The 'shading' on the above graph indicates the official economic growth cycle phases as recorded by the South African Reserve Bank. These growth phases are also applicable to Figure 5.8.

Snyman (1989) comments that the indices published in South Africa reflecting the measurement of change in tender prices display certain characteristics which should be noted by the estimator. These include:

- * Tender prices rise rapidly during the upswing phases,
- * Tender prices decelerate during the recessionary phase,
- * Tender prices rise faster and to a higher level in the long upswing phases than in the shorter ones.

Figure 5.8 demonstrates the degree of correlation between the BER Index representing relative changes in tender pricing, and the BER 'competition in tendering' data referred to previously.

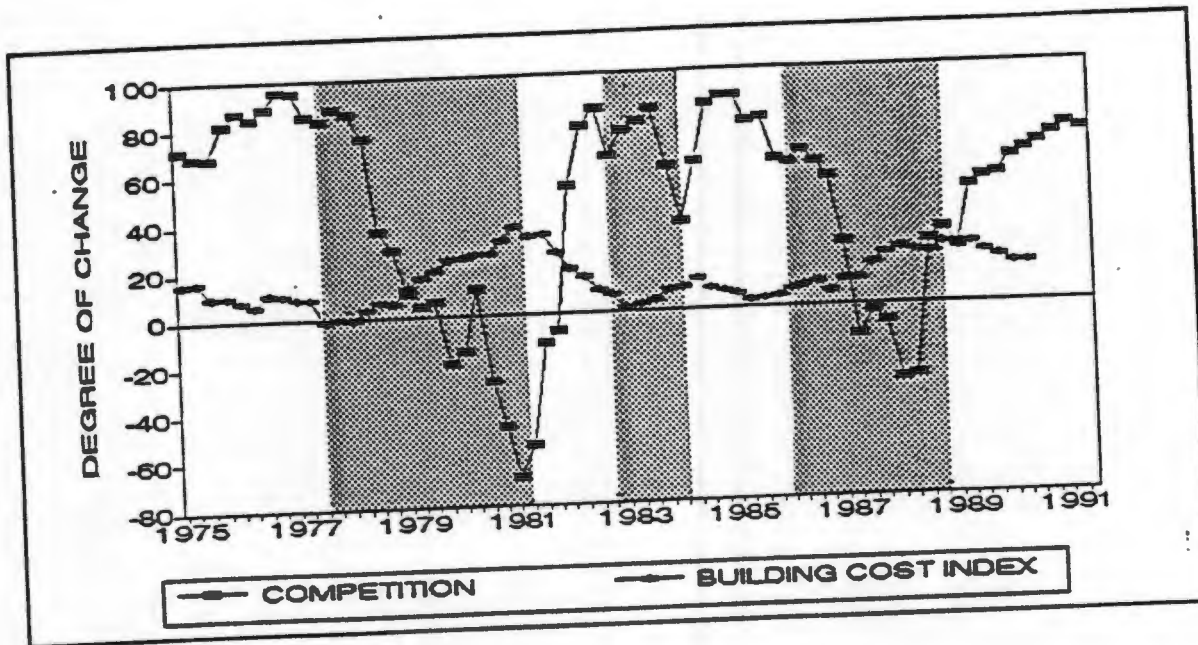


FIGURE 5.8 BER BUILDING COST INDEX / DEGREE OF COMPETITION.
(Source: BER Quarterly Reports.)

While the effect of market conditions on tendering levels can be easily established, the response of the estimator is not well documented, although market conditions have long been thought to have an effect on forecasting accuracy.

One of the more pertinent observations in this regard is articulated by Skitmore (1987c). In an analysis of the market effect on construction prices, he concludes that the changes in the state of the market, in terms of interrelated features such as changing price levels for diverse types and sizes of contracts in varying economic circumstances in different localities at various times, is the true source of changing accuracy levels (Tan, 1988).

Although it could be expected that the importance of the awareness of market factors would be universally recognised, Hayes *et al's* (1987) survey of North American companies' views on early stage conceptual estimating, surprisingly indicates that information about the market environment is not highly considered.

Equally surprisingly, the number of attempts to establish this relationship empirically are extremely limited. One of the earlier investigations uses data obtained from the Commonwealth of Massachusetts' Department of Public Works on 691 highway projects

Chapter 5

between 1966 and 1974 (De Neufville *et al.*, 1977). This report shows a distinct difference in estimating accuracy between 'good' and 'bad' years, which are defined as years with the greatest and least activity for contractors.

The study concludes that estimates made in 'good' years are generally lower than those made in bad years, independent of the number of bidders for a project. These differences are lagged as estimators only gradually appear to become aware of the changes in construction activity and the resulting price levels. These observations are supported by Harvey's (1979) analysis which shows that cyclical variations in different regions of Canada tend to match the state of the construction market in those regions.

In more recent studies, the Property Services Agency (1981) shows that differences in estimating error coincide with the level of uncertainty in the building industry. Skitmore (1988a) likewise reiterates that underestimates and overestimates are generally associated with the greatest and least activity for contractors. Flanagan and Norman's (1983) report also finds variable estimating performance which is ascribed to estimators not responding quickly enough to changed market conditions. This view is supported by Gunner and Betts (1990).

Tests conducted on 51 projects in the UK between 1983 and 1988 by Ogunlana and Thorpe (1991) are portrayed graphically as having quite substantial fluctuations in terms of mean accuracy and CV for different years. However, the authors disclose that analysis of variance tests indicate that there is no significant variation in accuracy according to the year of tender.

A study of cost planning performance on 199 government construction projects in Victoria, Australia (Mills, 1991), refers to instances of inaccurate cost planning (presumably based on price forecasting), as measured by a ratio of the tendered amount compared with the estimated cost plan. This, it is stated, is possibly caused by quantity surveyors basing their cost plans on information derived from previous years, which have been derived under vastly different economic conditions.

Figure 5.9 indicates the degree of accuracy of estimates as measured by the ratio of tendered price to the estimated cost plan.

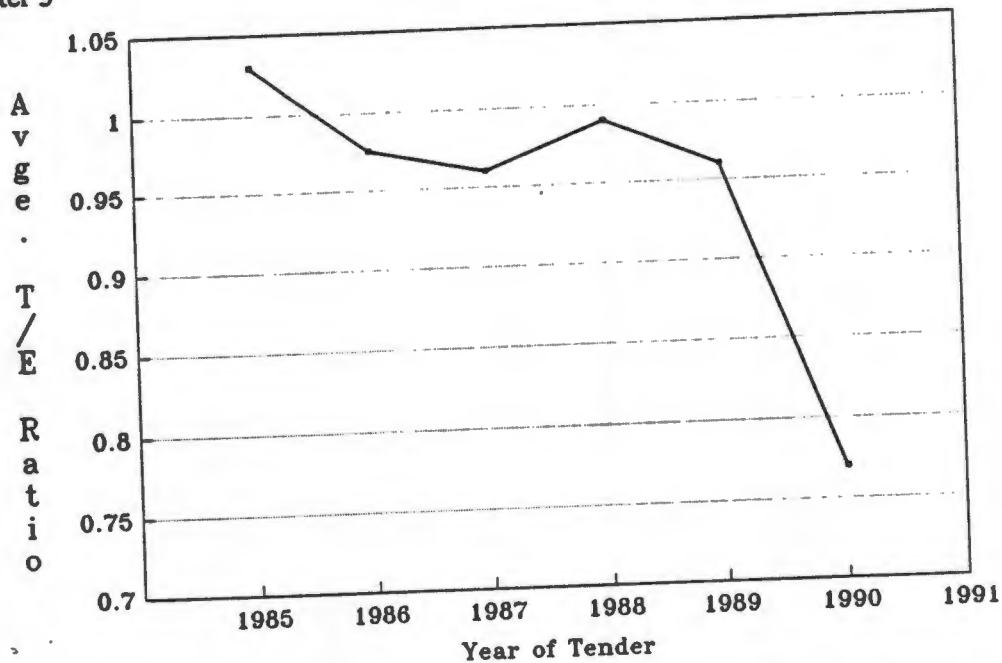


FIGURE 5.9 AVERAGE ANNUAL RATIO OF TENDER : ESTIMATED COST PLAN.
(Source: Mills, 1991)

It is noticeable that the marked performance drop in 1990 coincides with a time of diminished construction activity. From the above, it is apparent that quantity surveyors internationally react slowly to anticipated and actual economic market variations. It is not known if this is the case in South Africa. It would appear, however, as if the ability to respond expeditiously to these indicators, is a distinguishing feature between competent estimators and those who do not perform adequately. This is succinctly commented upon by Skitmore (1985), when stating that the estimators exhibiting the greatest expertise in tests conducted by him are found to be better in (amongst other characteristics) *"maintaining familiarity with the market and overall price levels than others"*.

5.3.5 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; and BER Building classification system), or to rely on a subjective classification of building types, based on use. In Chapter 7 of this dissertation, the CI/SfB Table 0 classification structure is used. The categories are: utilities and civil engineering facilities; industrial; administrative,

Chapter 5

commercial, protective service facilities; health and welfare; recreational; religious; educational, scientific and information facilities; and residential.

Further subdivision such as project value and floor area / volume are dealt with separately under the heading of 'project size'. Quality, structure type and plan shape are considered under the section of 'project complexity', whilst other issues related to certain building types are investigated independently (e.g. length of construction period).

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). In the latter case, the primary cause for any trend found is related to 'experience / expertise' and not to the inherent characteristics of the building itself.

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 estimators with the same background or ability.

The following text refers to the primary sources of data in this field. The evidence from these studies suggests that achieved estimating accuracy relates 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 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, Merrow *et al.* (1979) describes unusually high inaccuracy levels in nuclear power plant estimates, implying that the level of accuracy achievable on 'new'

Chapter 5

or unique types of construction is very low. This is consistent with the record of vast estimating errors occurring on 'one-off' structures such as those mentioned in Chapter 2 of this dissertation 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 revealed 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 mean accuracy levels recorded for the various building types observe a range of 32.28%.

The only analysis of this factor found to reflect a contrary opinion is that of Skitmore (1988b). A total of 33 UK local authority building contracts of different types of use are examined, and no significant differences in bias of percentage errors between the project types nor any difference in consistency is revealed. The small sample size is possibly the reason for these different findings.

In reviewing the above evidence it is concluded that subjective decisions, with regard to project type affecting price forecasting accuracy, is still necessary. This opinion is shared by Skitmore *et al.* (1990) when commenting that:

"....This suggests the conclusion that differences between the quality of forecasts, especially differences in consistency and accuracy, are more attributable to differences between subjects than contracts."

5.3.6 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, and (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 (1988b), 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 (1988b), 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, .

Skitmore *et al.* (1990) confirm that the estimators indicate that whenever uncertainty prevails, the experienced estimator normally seeks out more information, in order to avoid taking risky decisions.

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 is considered as a significant factor in assessing the expertise of an estimator.

5.3.7 Project size

Recognition of the effect that project size has on price forecasting performance, appears at first to be easier to establish than certain of the other factors studied. However, closer examination indicates a complex problem, 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.

Chapter 5

'Project size' can be construed to mean the physical parameters of the building (i.e. 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), subsequently commented upon by Skitmore (1988b). Tan notes, from the analysis of 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) 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 both the theoretical and empirical studies. In the paper referred to above, it is conceded that a contrary position does exist. The argument is presented that large projects have higher levels of inherent uncertainty than smaller projects. The supporting evidence is contained in Runeson's (1988) paper, suggesting that since large projects tend to attract more bids than small projects, they show higher variability. Ogunlana and Thorpe speculate that *"it may be that many of the contractors are not so keen to win the contract but wish to maintain close relations with the client."* The above scenario is considered unlikely to apply in South Africa. It is generally recognised that 'large' contracts attract fewer bidders than projects in the hypothetical

Chapter 5

'intermediate' value range, due mainly to the few contracting firms able to undertake projects of a substantial nature.

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 be better on large projects. The Property Services Agency's (1980) comprehensive research report 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 (1988b), in commenting on Tan's (1988) research, notes that there is a general trend of improving accuracy with increasing contract value for both the NASA and UK projects (referred to above in connection with building area analysis).

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. In this study, an arbitrary division of project values is made. An insufficient number of projects in the range of \$35 million and \$200 million could not justify analysis. However, a summary of the coefficients of variation on the other jobs provides the following figures:

1	< \$10 million	14.2%
2	> \$10 but < \$35 million	12.1%
3	> \$200 but < \$700 million	5.2%

The data within each of the categories is very small and conclusions drawn from the results should be regarded as indicative, and not proof, of a trend. 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. Mill's report specifically

Chapter 5

notes the effect of work value on various aspects of the procurement process. Overall, as the value of the project increases, the range of tenders received reduces. The results of Mill's survey, illustrated in Figure 5.10, show the range of tenders and the average CV of the tenders received.

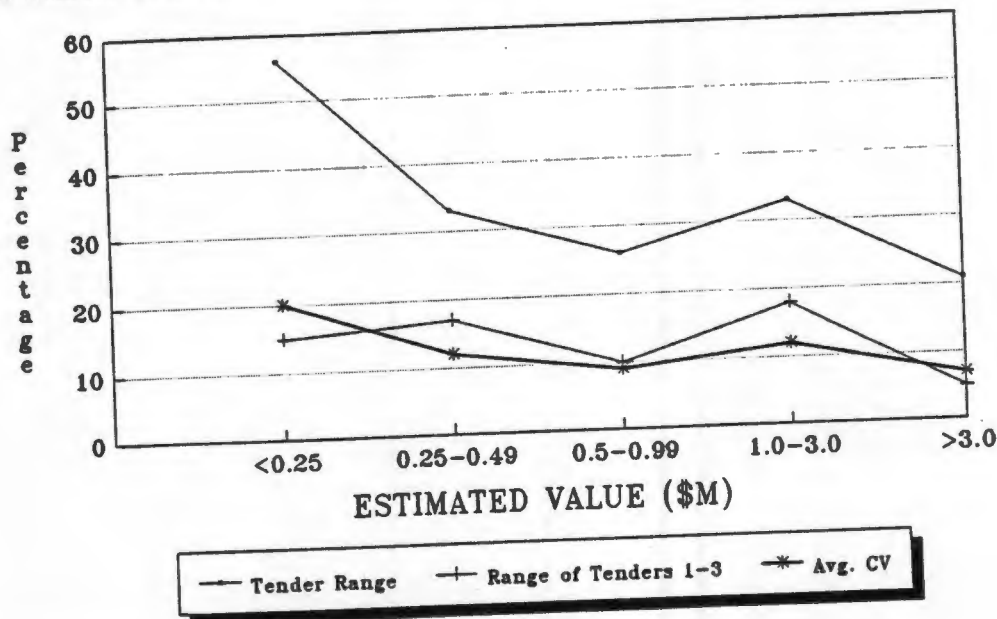


FIGURE 5.10 AFFECT ON TENDERS OF VALUE OF PROJECT.
(Source: Mills, 1991)

In contrast with the smaller projects, those valued over \$3 million have a smaller range of tenders and the bids are significantly more uniform. The reduction in the coefficient of variation amongst bids, which suggests keener competition, is also noted in the UK study. The significant improvement in the quantity surveyors estimating performance as proven by Ogunlana and Thorpe is illustrated in Figure 5.11.

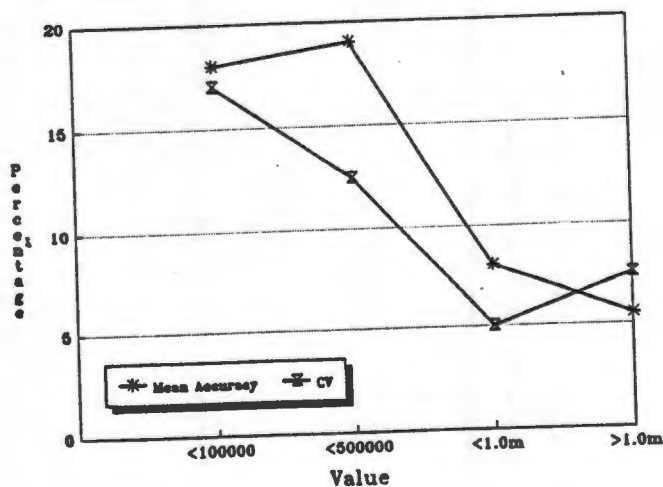


FIGURE 5.11 AFFECT ON PRICE FORECASTS OF VALUE OF PROJECT.
(Source: Ogunlana and Thorpe, 1991)

Further to the above, Skitmore *et al.* (1990) conclude that price forecasters tend to underestimate 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 jobs - 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' jobs.

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 circumstance 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.*, p. 9, 1990)

5.3.8 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. His findings are illustrated in Figure 5.12. The reduction in the number of tenderers bidding on projects during the 'upswing' cycle (shaded area) is in marked contrast to the increase during 'downswing' periods. It should be noted however, that on individual contracts, the number of bidders is not always an indication of intensity of competition.

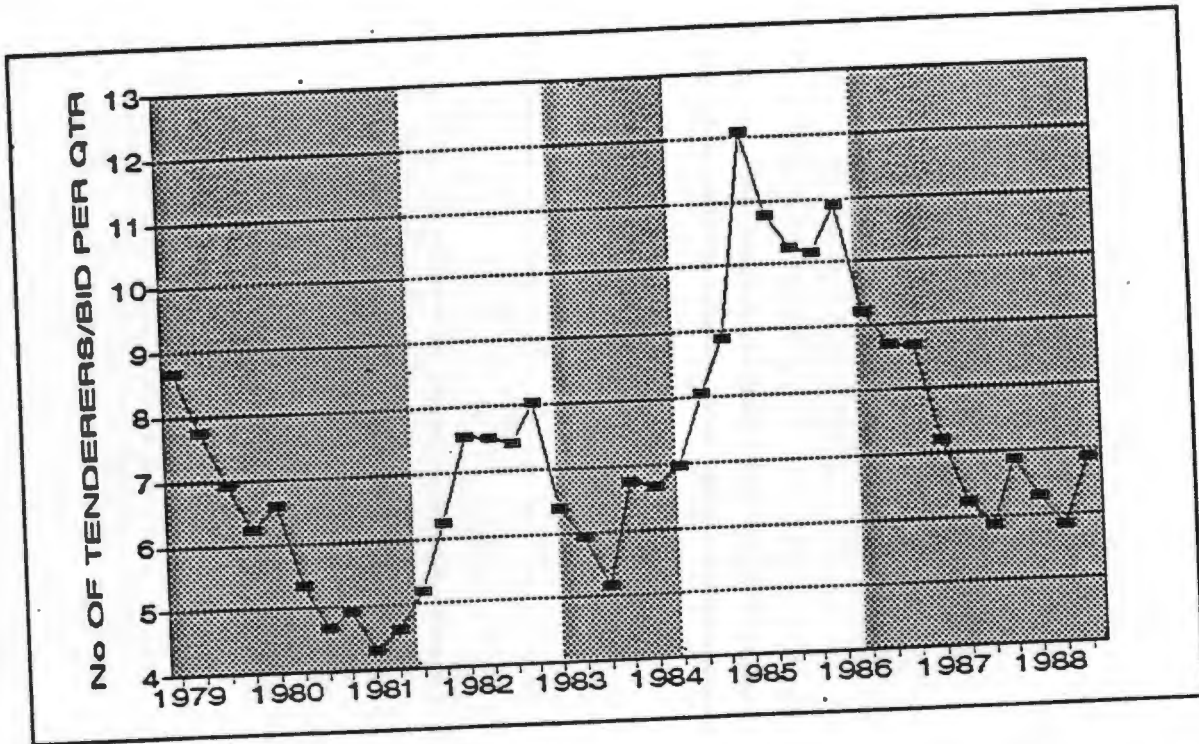


FIGURE 5.12 DEGREE OF COMPETITION IN TENDERING IN WESTERN CAPE.
(Source: Hindle, 1991)

There are mixed opinions with regard to the effect that the number of bidders have on tender prices. Wyskida (1986) is one of the few authors to suggest that the number of bidders has no effect on price. Most researchers, including McCaffer (1976), Wilson *et al.* (1987), Skitmore (1987c), and Mills (1991) contend that as the number of tenders increases, so the average value of the tender falls. This contention is clearly shown in Figures 5.4 and 5.5. The number of bidders involved would seem to affect the prices in the order of 20% to 25% (Skitmore, 1987c). Runeson and Bennett (1983) observe that as the competition increases, not only does the price level fall, but the accuracy of the contractor's 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.

Chapter 5

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. Skitmore (1988b), in commenting on the data in Tan's (1988) study confirms this trend when examining both the NASA and UK projects.

Figure 5.13, illustrating the results of an empirical study in Australia supports this reasoning.

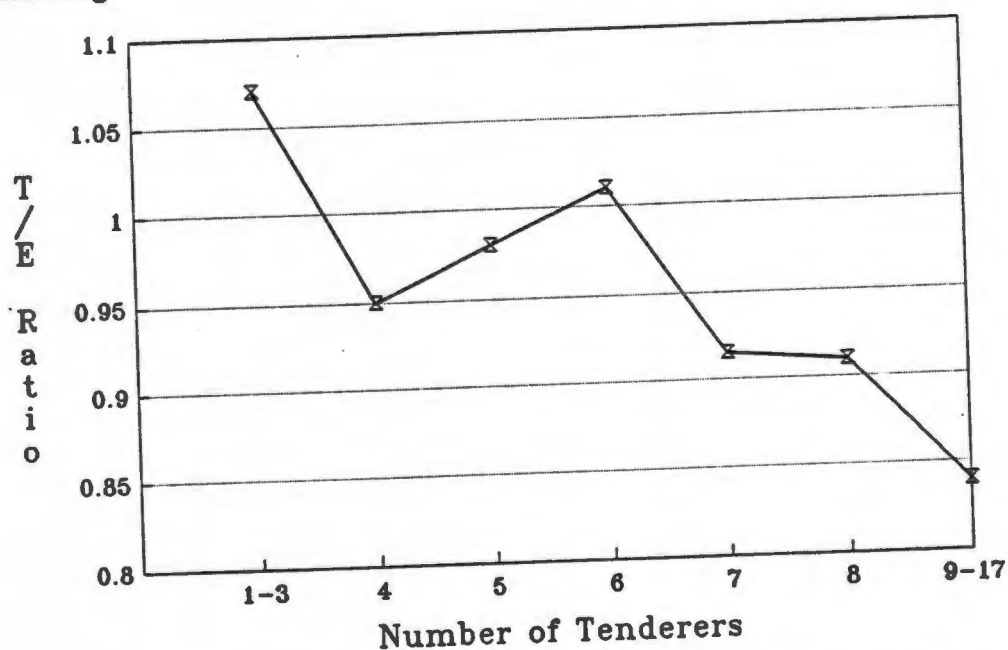


FIGURE 5.13 TENDER / ESTIMATE RATIO BY NUMBER OF TENDERERS.

(Source: Mills, 1991)

Other researchers indicate that as the number of bidders increases, the price forecasters' accuracy improves. Prominent amongst these authors are De Neufville *et al's* (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 / engineer's estimates ratios and the number of bids received. The findings are shown in Figure 5.14.

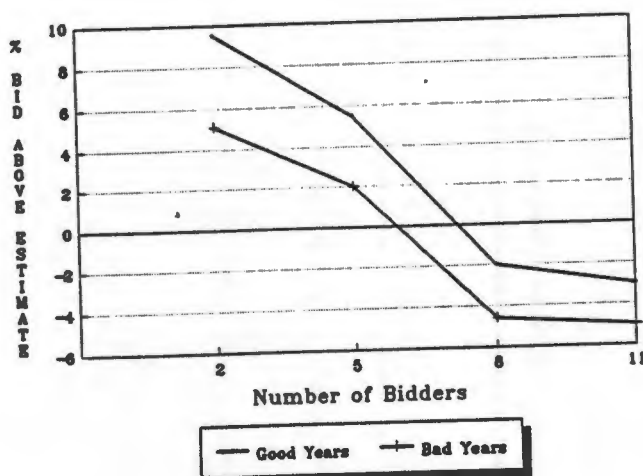


FIGURE 5.14 ESTIMATING ACCURACY / NUMBER OF TENDERERS.

(Source: De Neufville *et al.*, 1977)

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 majority of previous studies in the field, the results of Skitmore *et al.*'s (1990) experiments indicate that no correlation exists between competitive intensity. Recent empirical evidence in support of this theory is provided by an analysis of 51 projects undertaken by Ogunlana and Thorpe (1991). This study shows no apparent trend in the mean accuracy.

The linkage of this factor with others requires careful consideration. For instance, the assertion by Skitmore (1987c) in citing De Neufville *et al.* (1977), that the good / bad year effect is separate from the number of bidders, needs to be analysed under South African 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. Although the effect of large numbers of tenderers on price forecaster's 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.

Chapter 5

5.3.9 Duration of project

Ogunlana and Thorpe (1991) comment that a relationship between project duration and estimating accuracy derives from two sources and are more likely to affect a longer duration project than a shorter one. These sources are firstly, the need to allow for external changes in the project environment such as changes in material and labour prices, and secondly, the likelihood of design and scope changes increases with project duration.

Practically, in South Africa at least, the provision for price changes after tender submission is generally catered for by budgeting, either as part of the contract submission, or separately, by reference to commercially produced publications reflecting patterns of activity in the construction industry. If provision is made in the documentation, this is normally done by insertion of a clearly identifiable allowance which is used in a similar manner to the normal 'contingency' sum. Allowance for design, and limited scope changes, is normally considered to be a function of this contingency, and should be carefully assessed, prior to its inclusion. When establishing 'accuracy' of any estimate, these 'fixed sums' should be excluded from the calculations if 'true' accuracy is to be reflected.

Merrow *et al.* (1979) note that scope changes are more frequent on longer duration projects than on shorter ones and result in significant under-estimation of construction cost. This, however, can only be construed as affecting price forecasting accuracy if the target is determined by the actual completed cost. The validity of using this price as the basis for measurement of estimating accuracy is discounted in Chapter 7.

A link between project size, and project duration does exist (Kaka and Price, 1991). However, some projects are undertaken where an unusual balance is struck between these two aspects (e.g. 'fast-track' jobs). Only one reference in the literature to an analysis of the effect of project duration on estimating accuracy has been found. Skitmore (1988b), in commenting on Tan's (1988) data, observes a general trend of improving accuracy with increasing contract period. Whereas this trend is particularly noticeable when dividing the projects into less than, and greater than 12 month periods, it could be a reflection of project size, as the results are fully in line with those found for that factor.

5.3.10 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) states that locational

Chapter 5

influences can be considered in two groups. The first group contains factors 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 the second group are factors which influence design directly and are therefore of interest more specifically to those taking architectural decisions.

In South Africa, with its wide range of climatic and geographic conditions, virtually all of the above 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. Relative price information is freely published by both the Department of Statistics, and the Bureau of Economic Research, University of Stellenbosch, which can assist the quantity surveyor in this activity.

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.

There is clearly scope for further research to be conducted in this field in South Africa. Exploration of this factor must necessarily reflect it's interrelationship with aspects such as the availability of data, market conditions at the local level, type of project, and number of bidders.

5.3.11 Other factors

An aspect which is almost impossible to allow for is the keenness of some contractors to do work for certain clients, client types and consultants. The reasons for this attitude may be

Chapter 5

many, but financial reliability of client, prestige, and confidence in personalities or systems employed are suggested as contributory factors.

It is generally believed that public clients attract a higher price than private clients. Limited studies have also been conducted overseas to establish the effect on tender prices of alternative procurement systems, such as open competitive tenders, selective competitive tenders, and negotiated contracts. Whilst definitely not conclusive, it appears as if the lowest prices are given on open bidding with bills of quantities (Skitmore, 1987c).

Except for Wilson *et al.* (1987), no research appears to have been undertaken to test the relationship between estimating accuracy and general procurement method. Figure 5.15 illustrates the results of the study on 393 Australian Public sector projects between 1979 and 1982.

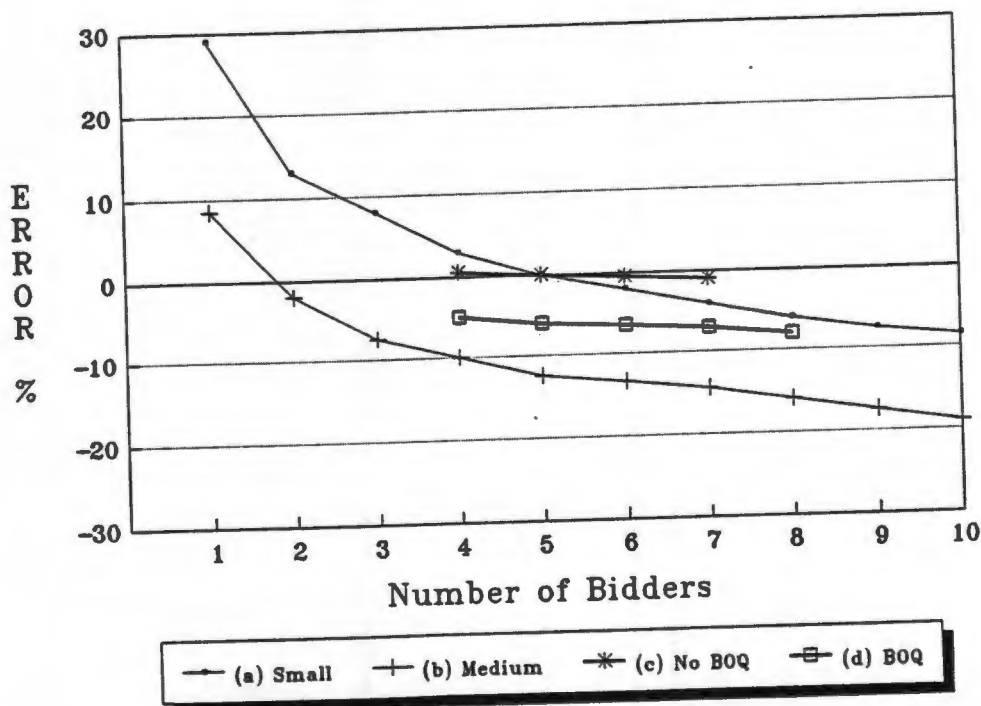


FIGURE 5.15 LOW BID / ESTIMATE FOR VARIOUS PROCUREMENT SYSTEMS.
(Source: Wilson *et al.*, 1987)

The illustration reflects four groups, namely (a) small projects estimated at less than \$A50,000 (b) medium sized projects over \$A250,000 (c) large projects over \$A250,000 without bills of quantities, and (d) large projects over \$A250,000 with bills of quantities. One of the major findings of the study is that those projects which have bills of quantities

Chapter 5

as part of the contract documents, indicate a significantly positive effect on the accuracy of estimates.

5.4 CONCLUSIONS

In this chapter, the factors affecting price forecasting accuracy are considered in the context of the competitive tendering process. No attempt has been made to link the estimating activity exercised by quantity surveyors with bidding theory, due to the two disciplines being underpinned by fundamentally different theoretic principles.

Inspection of the factors listed in the hypothesis presented in Chapter 1, reveals a high probability of those considered as 'project specifics' being interrelated with one or more of the other factors in the decision making process during tendering. As each tendering event is unique, there is thus an obvious need for the price forecaster to carefully consider all items when compiling an estimate.

The effect on estimating performance that each feature exhibits is summarised as follows:

- (a) *Type of project*. This aspect generally only has an effect when estimates are prepared on types of project for which the estimator has extensive personal experience.
- (b) *Project complexity*. Estimating accuracy displayed on buildings which are considered 'complex' is generally good. It is hypothesised that the necessity to consider the unique details of the project at an early stage of design development facilitates good performance.
- (c) *Project size / value*. The normal measure of project size used by researchers is the value of the development. The results of research carried out to date indicates that there is a distinct improvement in the relative accuracy of price forecasters' estimates on large projects as compared with smaller ones.
- (d) *Number of bidders*. Mixed opinions are expressed on the effect that the number of bidders has on the accuracy of price forecasts. There is some evidence that the optimum number of tenders is between 5 and 7, accuracy diminishing proportionally as the number of tenderers varies from this point.
- (e) *Duration of project*. There is a distinct relationship between this factor and project size. Research indicates that estimating accuracy increases for projects of a long duration.

(f) *Geographical location*. Results of overseas empirical research may not be applicable to South African conditions. Indications are that this feature needs to be approached by treating each job as a unique event, thereby ensuring timeous consideration of detail involved. This is the only factor categorised above as 'project specific', for which it appears to be impossible to establish an interrelationship with *all* the other sub-items under this heading.

It would appear as if the likelihood of price forecasters' predictions being affected by the historical price data factor is limited in South Africa, due to the small range of data sources available. However, even if these sources are expanded, on the evidence of studies conducted overseas, the main improvement potential would appear to be related to the use of more than one set of bills of quantities for pricing purposes.

With respect to the effect that the level of design information has on estimating accuracy, the ability of expert estimators to achieve a standard of accuracy normally associated with detailed estimates, with only a minimal amount of information is of prime importance. This would indicate that if expert price forecasters are employed, forecasting techniques play a relatively unimportant part in the provision of accurate reports.

If this is so, the suggested inaccuracy of early stage estimates is called into question if competent estimators, using common data and provided with adequate feedback on previous performance, are used at all stages of design. The cognizance of what Skitmore *et al.* (1990) refer to as the 'nature of the target', i.e. the factors discussed above, is then of vital importance in ensuring satisfactory estimating performance of quantity surveyors.

Whilst it is extremely important for the estimator to be aware of the impact of market conditions on contractors' tendering patterns, this is generally considered to be out of the control of the quantity surveyor, hence being termed an 'external' economic force. The ability to identify changing economic conditions in the industry, and to timeously respond to these signals, distinguishes 'expert' price forecasters from less proficient ones.

This chapter concludes the study of the purely theoretical aspects of price forecasting. The following sections deal with testing of the theory established, based on opinions of local quantity surveyors, and results of an empirical study of estimating performance under South African conditions.

6. OPINION SURVEY ON PRICE FORECASTING ACCURACY

"Of the general character of those outlaws an estimate may be formed from a few samples" : Macaulay

6.1 INTRODUCTION

In Chapter 3, it was suggested that there is a need for price forecasters to establish and maintain effective estimating data recording systems and to introduce feedback mechanisms as standard practice in subsequent appointments. However, this procedure can only be of real benefit if it forms part of a structured estimating policy, based on clear objectives and principles, understood by all involved parties and applied consistently.

Amongst the more important features of such a policy are components such as the "target" the price forecast attempts to simulate, the methods applied to enable an analysis of submitted tenders to be made, guidelines upon which estimate / tender comparisons are performed, and procedures for establishing the accuracy of price forecasts.

Few studies have been undertaken to examine either estimators' views on these matters, or to determine the extent of the procedural usage. The first objective of this chapter is to investigate the current utilization of the abovementioned features by estimators in South African quantity surveying firms and to present their views on the issues mentioned.

The second, and primary objective, is to examine the factors which the same estimators suggest can contribute towards improving the estimating activity. These opinions are compared with the established theories emanating from the research conducted overseas in order to focus on those primary factors influencing the provision of accurate forecasts.

As previously indicated, a vast number of items affect the price submitted by a building contractor when tendering for a project. These price elements in turn influence the accuracy of the quantity surveyor's price forecast when compared with the bid submitted. In view of the extent of the overlapping influence of the factors on each other, the list of primary factors must be carefully compiled if the magnitude of contiguity is to be minimised. The elements considered by Ogunlana (1989) are chosen as being representative of this

Chapter 6

specification and are consequently used as the control list upon which the South African study is based.

The method used to obtain the necessary information was a postal survey, distributed to all quantity surveying practices. In addition, informal interviews conducted with certain quantity surveyors in the Cape Peninsula are used to test the validity of the responses gained from the national survey. The interviews reveal no serious problems in terms of interpretation of the questions posed. A copy of the questionnaire distributed is incorporated in this dissertation as Appendix 'A'. Because the questionnaire reflects a number of similarities with that designed and used by Ogunlana (1989), it provides the opportunity to compare the results with those achieved in the UK.

6.2 PRICE FORECASTING ACCURACY - OVERSEAS OPINION SURVEY

6.2.1 General

Huxley (1991), reveals a wide diversity of opinion as to the most suitable reference point to use in the establishment of accuracy of cost engineers' estimates in the USA. His survey reflects the following:

* Project managers, when asked to indicate the tender against which they compare the cost engineers' estimate respond:

- low bid = 38% of replies
- average bid = 38% of replies
- median bid = 23% of replies

* Estimators on the other hand, display a significantly different set of opinions by responding as follows:

- low bid = 25% of replies
- average bid = 25% of replies
- median bid = 25% of replies
- other = 25% of replies

The divergence of opinion appears to indicate a general trend away from the low bid. More importantly, it is not stated what the client, for whom the pre-tender estimate is produced, interprets as the measuring datum. Should estimates be produced, aiming to reflect the bids

illustrated by the replies above, even perfectly accurate estimates will be viewed as inaccurate in approximately 75% of projects, if the client expects the price forecast to reflect the lowest bid.

In questionnaires sent to selected quantity surveying practitioners in the UK in 1989, Ogunlana (1989) addresses the obvious need for estimators to define such reference points. Although this survey sample is extremely limited in that it reflects the views of 8 firms only, the responses are summarised below. The format of the South African survey document discussed later is followed for comparative purposes.

6.2.2 Estimate comparisons

Respondents confirm that their estimates are regularly compared with the tender, but their comparisons are made to detect 'errors' in tenders, and not to aid future cost predictions.

6.2.3 Parameter used for comparison

Three-quarters of Ogunlana's respondents compare the estimate with the low bid. This practice is particularly relevant for the firms who regularly compare estimates, as listed in the item above. There is a limited response to the suggestion that the estimate be compared with the second lowest bid. However, almost half of the firms compare the estimate with the mean or the median of bids. Ogunlana states that the results of his survey shows differences between the practice in the industry and the measurements made by researchers, inasmuch as professionals in industry do not depend solely on making cost comparisons with the low bid, whereas researchers are often constrained to use the low bid as the basis for assessing accuracy.

6.2.4 Useful parameters for cost comparison

Ogunlana recognises that there could be differences between industry practice and the opinion of design offices regarding practices that may benefit estimating, and therefore asks offices to suggest parameters that are useful for comparing estimates with tender. Various suggestions, such as "the comparison is made with the average of the three lowest bids" are provided. The results show that what professionals do in industry is often constrained by available facilities. Although deemed beneficial, comparison of estimates with tenders are

Chapter 6

not done. Reasons given range from the office not having the time or the facility to make them to the statement that it "is not accepted standard practice".

6.2.5 Recording of estimate details

This aspect is not investigated in Ogunlana's (1989) survey.

6.2.6 Factors considered to affect estimating accuracy

In testing the effect of environmental conditions on accuracy, Ogunlana (1989) requires the firms to rate, on a seven point scale, factors considered to affect the accuracy of price forecasts. The overall ranking of the factors are as shown in Table 6.1.

Ranking	Factor	Strength of Feelings
1.	Historical cost data	1.46
2.	Estimators' expertise	1.24
3.	Design information	1.11
4.	Market condition	1.06
5.	Project type	0.79
6.	Project complexity	0.75
7.	Project size	0.51
8.	Number of bidders	0.46
9.	Project duration	0.46
10.	Project location	0.43
Mean = 0.83		Standard Deviation = 0.37
Median = 0.77		CV = 44.57%
		Range = 1.03

TABLE 6.1 OVERALL IMPORTANCE RANKS AND STRENGTH OF FEELINGS

(Source: Ogunlana, 1989)

Ogunlana records the individual responses of the offices, and extends the analysis by using these replies to reflect 'strength of feeling' tables, expressing the specific rating in terms of the total score of that office for all factors.

Chapter 6

The results of the opinion survey, although only carried out on a small sample, are generally consistent with previous studies referred to in Chapter 4 of this dissertation. The actual 'score' recorded for the first two factors in Table 6.1 (the total of rating figures) are identical, the ranking being established by the superior strength of feeling expressed for the significance of historical cost data.

Estimator's expertise is consistently rated highly, with comments submitted by the participating firms indicating that the contribution of this factor is distinguished by three major considerations, viz: (a) an ability to select suitable cost data for estimating purposes; (b) understanding of cost relationships and design parameters; and (c) the suitable development of intuitive abilities acquired through familiarity with projects.

The high ranking of 'design information' in Ogunlana's survey is partially explained by the fact that his questionnaire does not indicate a particular stage of design development for the factors to be applied. The response therefore reflects the opinions of estimators on the importance of the characteristics throughout the design sequence. In the traditional procurement systems being studied, design documentation is usually complete at tender documentation stage and the importance of this factor therefore diminishes in importance.

Market conditions, project type and project complexity are rated moderately in Ogunlana's survey. Of these, the firms' relatively strong feeling in support of market conditions would indicate that it should be considered a prominent factor affecting the estimating performance.

The factors of project size, number of bidders, project duration and location of project are given low ratings by the participating firms. There would appear to be a linkage between project size and duration of project, both being considered as of low importance in the estimating process. The low rating for number of bidders is noticeable when compared with the much higher ranking of market conditions, which is usually understood to influence tender list size. The nature of consulting quantity surveyors work in the UK, usually confined to a fairly limited geographical region, is thought to be a major reason for the low rating of the effect of location on estimating performance.

A study of the results of Ogunlana's (1989) survey discloses that none of the factors termed 'project specifics' in Chapter 1 of this dissertation, are considered to exert a great influence on estimating accuracy.

6.2.7 Desirable level of accuracy

Ogunlana's (1989) responses demonstrate that offices suggest that estimates within +/- 15% of the tender are acceptable in terms of accuracy. Of the offices that regularly compare costs with the low bid, virtually all suggest that a figure of +/- 10% can be expected. However, it is shown that overestimates are more likely to be deemed acceptable than underestimates. Ogunlana suggests that this fact supports the contention that some offices produce 'cost ceilings' for projects, rather than predicting the price.

6.2.8 Datum for assessing estimating accuracy

In view of the fact that design estimators may not always be predicting the low bid for projects, Ogunlana asks for an appropriate datum for assessing estimating accuracy. Almost half of the responses indicate that the low bid is appropriate. The results generally demonstrate a lack of agreement between practitioners. A good approach to assessing accuracy, Ogunlana asserts, is to allow comparisons of costs with as many parameters as possible.

6.2.9 Experience of estimators

This aspect is not covered by Ogunlana in his survey.

6.3 PRICE FORECASTING ACCURACY - SURVEY OF SOUTH AFRICAN ESTIMATORS

A description follows of the method used to establish the perceptions of estimators employed in quantity surveyors' offices, regarding the issues involved in the monitoring of estimating performance. This section includes the compilation of the questionnaires used for the postal survey, the selection of the sample surveyed, the response to the survey, and finally, the statistical method used to analyse the extensive amount of data.

6.3.1 Compilation of the questionnaire

Although a limited number of informal interviews were conducted with quantity surveyors in the Western Cape in order to test the efficiency of the questionnaire, it was decided that the gathering of information should not be limited to this region only. Since professional

activities may vary from district to district, a regional bias may be apparent in the survey results. This has been overcome by canvassing the opinions of estimators throughout the country by means of a postal questionnaire.

In the formulation of the questionnaire, reference has been made to Oppenheim (1966), so as to ensure that the way in which the questions are structured is beneficial in terms of how the respondents view the questionnaire. In addition, the questions are partially modelled on the discussion outline that Ogunlana (1989) utilises in conducting his research. Cognisance is taken of a disadvantage sometimes experienced in the postal survey method of acquiring information, by providing wide opportunity for respondents' comments, in order to gain a more complete view of the various perceptions.

6.3.2 Questionnaire distribution

Mailing lists obtained from the Association of South African Quantity Surveyors (ASAQS), listing all firms registered with the Council of South African Quantity Surveyors have been utilised. The sample, including private and public sector quantity surveying firms, amounts to 557. In each case, firms are encouraged to ask all estimators in their firms to submit returns.

6.3.3 Response to the survey

According to Oppenheim (1966), response to postal surveys can be expected to be approximately 10%, as respondents are often not sufficiently motivated to complete and return the questionnaire. For this reason, the document has been kept as short as possible. In addition, all Western Cape firms and personal acquaintances in other centres were contacted to elicit their support for the survey.

In an attempt to ensure an adequate response rate, a postage paid and self-addressed envelope was included with the questionnaire. To this end, a 'free-post' licence was purchased from the Post Office, assisting in simplifying postage procedures for the respondents.

As is usual in surveys of this nature, replies could not be expected from all parties due to reasons other than an unwillingness to respond. The original sample size was reduced by 59. This was due to 31 firms being found to exist in name only, or having diversified from providing traditional quantity surveying services, and the remaining 28 firms producing

'returned to sender' responses. This resulted in the sample reducing from 557 to 498 quantity surveying firms. Although a total of 258 responses were received, this includes 24 replies from estimators within firms from whom more than one reply has been received, resulting in a total of 234 comprising the legitimate sample of responding firms. This reflects a highly satisfactory response rate of 47%.

6.3.4 Analysis of data

Owing to the vast amount of data derived from the completed questionnaires, the utilization of a statistical package for data analysis is considered essential. After investigation, BMDP, a statistical software package run on the main-frame computer at the University of Cape Town was selected as being the most suitable due to its capacity to manipulate a large number of variables.

6.4 SURVEY ANALYSIS

6.4.1 Estimate / Tender comparisons

6.4.1.1 Question 1 : Estimate comparisons

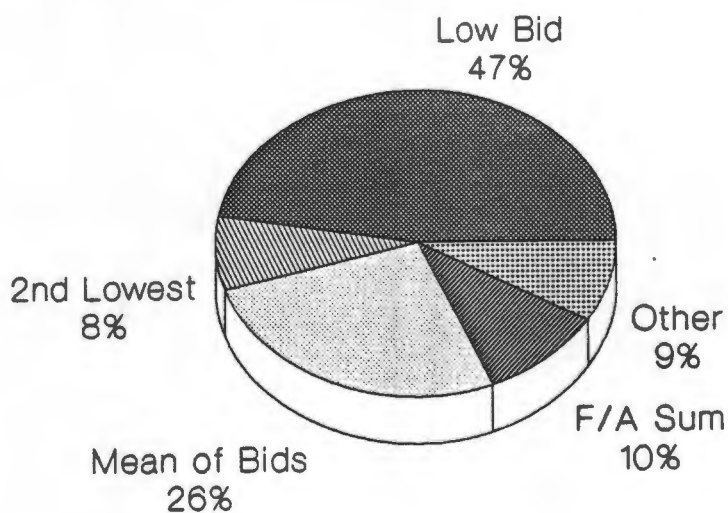
An examination of comments submitted on the questionnaire reveals that this is the only question which appears to have been misinterpreted by a small number of respondents. Some respondents confuse the required 'detailed comparison' of estimates and tenders, with a detailed analysis of the bills of quantities rates submitted by a chosen tenderer.

Of the 3 options provided, 51% of the estimators indicate that they compare their estimates with tenders submitted on all projects, whilst 49% do so only when their predictions differ significantly from tender figures. The other available option, being the comparison of estimates and tenders only when predictions are close to tender figures, receives a 'nil' response. The responses to this question are remarkably consistent when cross-tabulated with all other questions included in the survey. The above response is interpreted as indicating a propensity by a significant number of quantity surveyors to assume that their estimate is 'right', reflecting a similar scenario to that which Ogunlana (1989) indicates is displayed by their UK colleagues.

6.4.1.2 Question 2 : Parameter used for comparison

Respondents are entitled to indicate more than one option for this question, i.e. it being quite feasible to compare an estimate with a number of the bids submitted, or with any composite arrangement of bids. The results of the survey present a similar pattern to that provided in the UK study, although the strength of support for any choice is not as strongly indicated. 64% of the respondents state that they compare the estimate with the low bid, whilst the second most popular measure, the mean / median of bids, is used by 36% of estimators

The suggestion by Ogunlana (1989) that estimators do not rely entirely on making price comparisons with the lowest tender received is supported by the analysis of the total use of alternative measures indicated in Figure 6.1. This indicates that although 64% of respondents use the low bid as a measure, this reflects only 47% of total use, and of the 36% of respondents that use the mean / median of bids, this represents only 26% of total use.



Percentage use of alternatives

FIGURE 6.1 BIDS USED FOR TENDER ANALYSIS.
(National Survey, 1992)

The 'other' measures applied vary in nature, but several respondents indicate that they compare their estimate with a selection of bids such as the "lowest 3 / 4 / 5 bids", or "the average of the lowest half of the tender range".

6.4.1.3 Question 3 : Useful parameters for cost comparison

There is almost universal agreement (97%) that comparing the estimator's prediction with tenders received is a useful activity. Local quantity surveyors express similar opinions to their UK counterparts about reasons for not comparing estimates with tenders. The main reason provided being "a lack of sufficient time available for the exercise". Although drawn from a small sample indicating possible statistical insignificance, it is noticeable that none of the estimators with less than 5 years appropriate experience indicate that tender / estimate comparisons serve no useful purpose.

6.4.1.4 Question 4 : Recording of estimate details

Approximately 47% of the estimators' replies indicate that *formal* records of estimate / tender comparisons are kept with the specific purpose of using the data for future estimates. An analysis of the data however, discloses that of those signifying that such records are held, only 63% make a detailed comparison of estimates on all projects. Clearly, if all projects are not analysed, the records kept would be incomplete and the replies from those estimators falling in this group can be ignored. At best therefore, 30% of quantity surveyors keep full records which can be used to assist in the development of estimating control systems.

There is reason to believe that the position is worse than indicated above. Several instances of respondents to the questionnaire from the same firm giving contradictory answers are evident. In addition, comments submitted on the questionnaire indicate that many of the quantity surveyors interpret the provision by the successful tenderer of a priced contract document as a '*formal record*', and not the actual record of the estimate / tender sample comparisons as clearly described by the question.

Furthermore, when quantity surveyors in the Western Cape were personally contacted, even this level of data recording was brought into question. Severe problems arose whilst assembling data for use in the empirical survey of estimating performance discussed later in this dissertation. Although required by law to keep records of all projects for a period of 3 years after the settlement of final accounts, most firms struggled to find even the most basic records of recent projects, such as priced bills of quantities, client tender reports etc. None of the firms approached was able to produce a composite file of estimate / tender list analyses which could be construed as an easily accessible, formal, set of records. Whilst

the above comments are not verifiable in a scientific sense, the responses could be interpreted as suggesting that a high 'lie factor' is present in the answers to this question.

6.4.1.5 Question 5 : Factors considered to affect estimating accuracy

This question is dealt with separately in a later section of this chapter.

6.4.1.6 Question 6 : Desirable level of accuracy

The responses to this question shows great variance of opinion between the respondents to the local and Ogunlana's (1989) survey; the latter being open to criticism on the basis of the small sample size, particularly as it appears to contradict the views of researchers such as Jupp (1984), who indicate that quantity surveyors tend to be optimistic about their estimating abilities. There is a distinct similarity between the responses of quantity surveyors in Jupp's (1984), Bowen's (1992), and this survey, indicating a perceived ability to generally estimate within 5% of the tender at bills of quantities documentation stage in at least 75% of instances. A diagrammatic comparison of some of the surveys conducted is given in Figure 6.2.

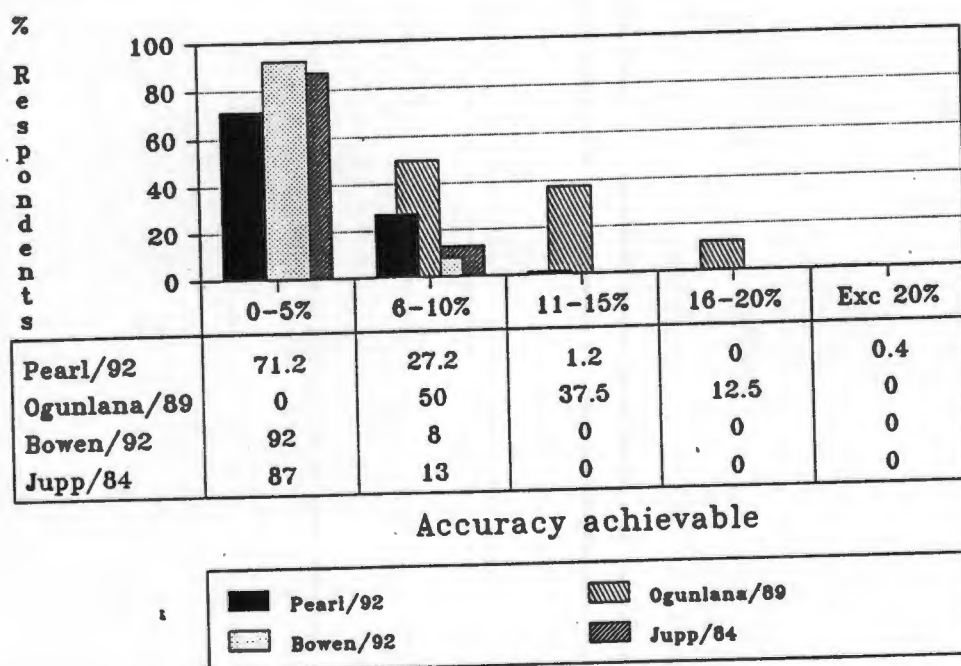
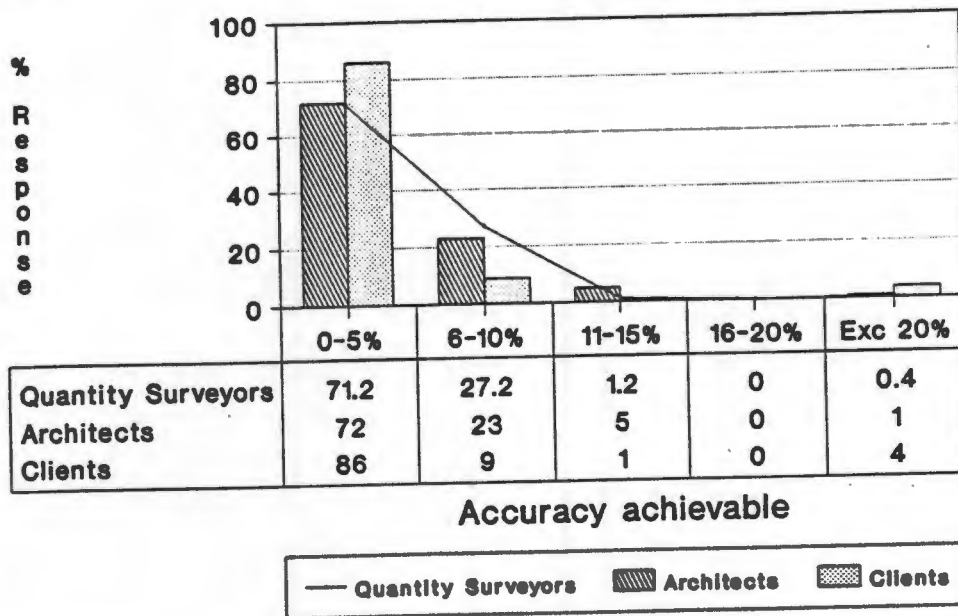


FIGURE 6.2 ACCEPTABLE LEVELS OF ACCURACY.
(National Survey, 1992)

If the accuracy levels reflected in Figure 6.2 can be achieved, the vast majority of clients and architects requirements in this regard would be met. This can be seen by superimposing

the results of the survey of estimators opinions on a bar chart reflecting the accuracy levels expected by the other parties, as stated in Bowen (1992), and incorporated in Table 4.2 of this dissertation.



QS Opinion versus Architect /
Client Expectations

FIGURE 6.3 OPINIONS OF ACCURACY ACHIEVABLE.
(National Survey, 1992)

The validity of the opinions expressed above are tested in Chapter 7 by analysing the estimating performance on a large sample of building projects undertaken in the Cape Peninsula. No correlation can be established from the survey between perceived accuracy attainable and other items not specifically mentioned.

6.4.1.7 Question 7 : Datum for assessing estimating accuracy

As for question 2, respondents are entitled to indicate more than one option being applicable. The response to this section is similar to that obtained in Ogunlana's (1989) survey; a general lack of agreement between practitioners on the most appropriate datum for measuring the accuracy of design stage price forecasts prevailing. The distribution of suggested datums against which the accuracy of the estimator's predictions should be measured are shown in Figure 6.4.

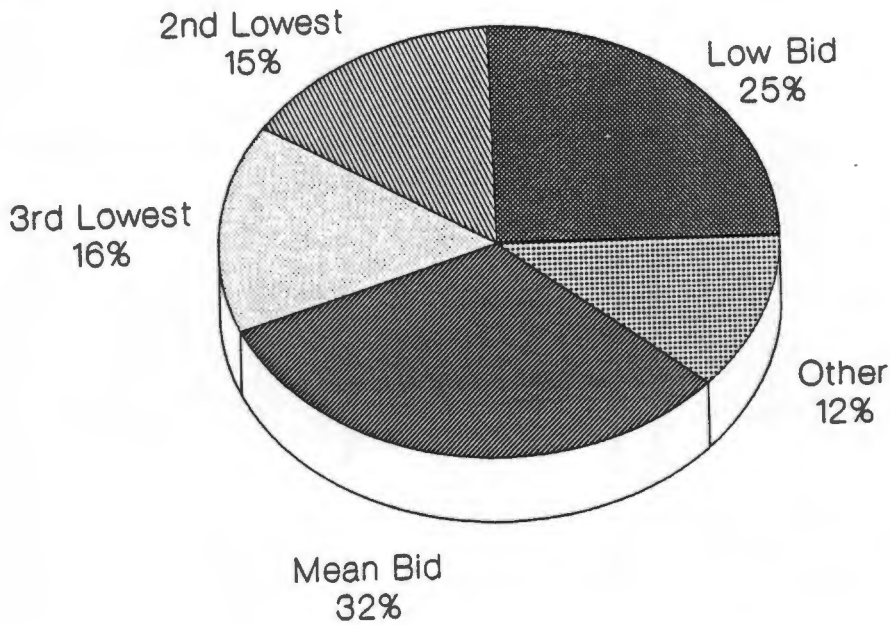


FIGURE 6.4 ACCEPTABLE DATUMS FOR MEASURING PERFORMANCE.
(National Survey, 1992)

A comparison of the above with the actual reference points used for measuring accuracy, as reflected in Figure 6.1, reveals a pronounced tendency amongst the quantity surveyors to accept the mean of the bid range as a more acceptable datum than the only other widely used point, namely the lowest tender. This is reflected in Figure 6.5.

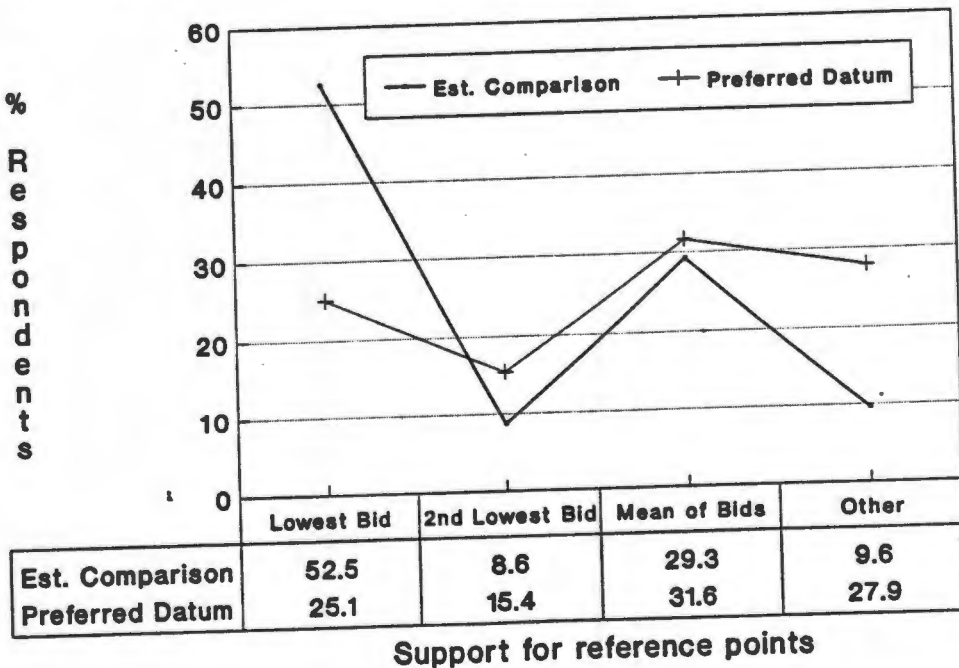


FIGURE 6.5 USE / PREFERENCE FOR ESTIMATING ACCURACY DATUM.
(National Survey, 1992)

Chapter 6

The relatively good support (28%) for 'other' datums is heavily influenced by the choice of the 3rd lowest tender as a suitable datum point, an option which is not separately indicated in question 2. Virtually no comments have been proffered which can shed light on why the estimators do not apply their 'preferred' reference points for tender analysis.

6.4.1.8 Question 8 : Experience of estimators

Billet (1990) discloses that the vast majority of quantity surveying practices in South Africa comprise a total staff of less than 13, inclusive of partners and associates. Furthermore, 95% of the firms contributing to his survey indicate that they have been in existence for more than 3 years. It is therefore not surprising that 75% of the respondents to question 8 indicate that they have at least 10 years of estimating experience. This is understandable in the light of this activity traditionally being reserved by principals for their, or senior personnel's attention only.

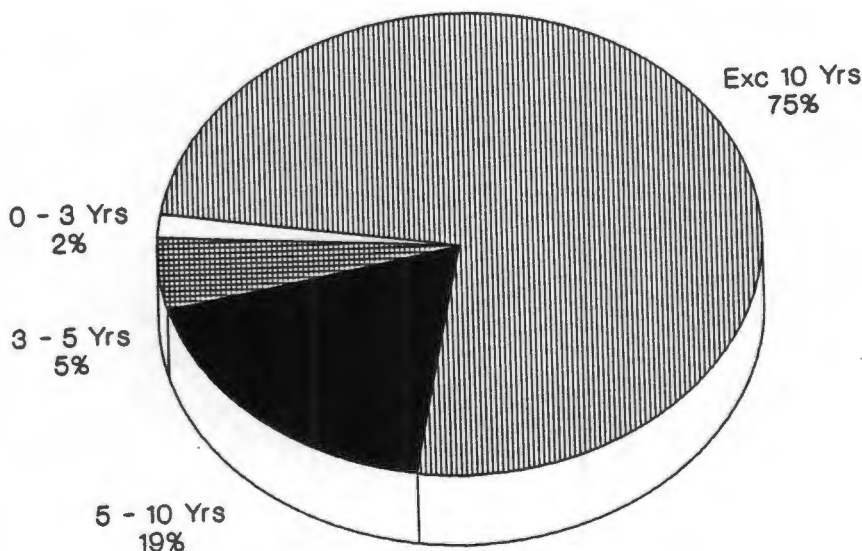


FIGURE 6.6 ESTIMATING EXPERIENCE OF RESPONDENTS TO SURVEY.
(National Survey, 1992)

A feature of the responses to questions 6 and 8 is the difference in the opinion distributions profiles of the least experienced group of estimators (with less than 3 years of price forecasting experience), and the other groupings of greater experience, as shown in Figure 6.7.

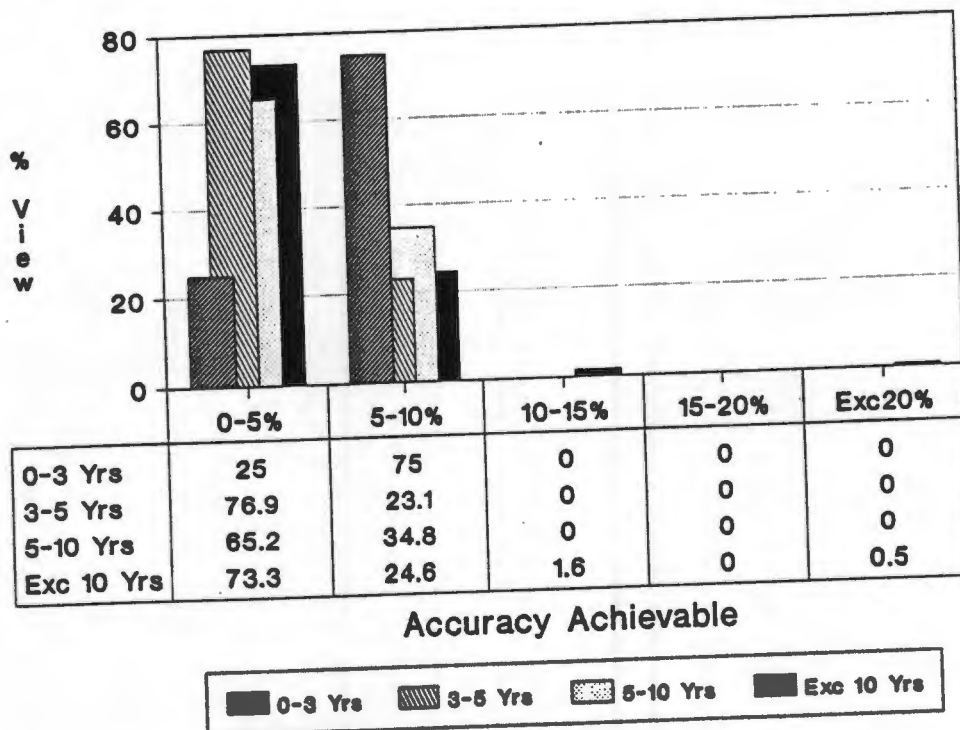


FIGURE 6.7 OPINIONS ON ACCURACY BY EXPERIENCED ESTIMATORS.
(National Survey, 1992)

Very few comments are made on survey returns in respect of this question. A possible reason for the less experienced estimators indicating greater conservatism than other sectors (but still within the 0 - 10% range), could be a lack of confidence in their own abilities, based on the perception that experience can be equated with expertise.

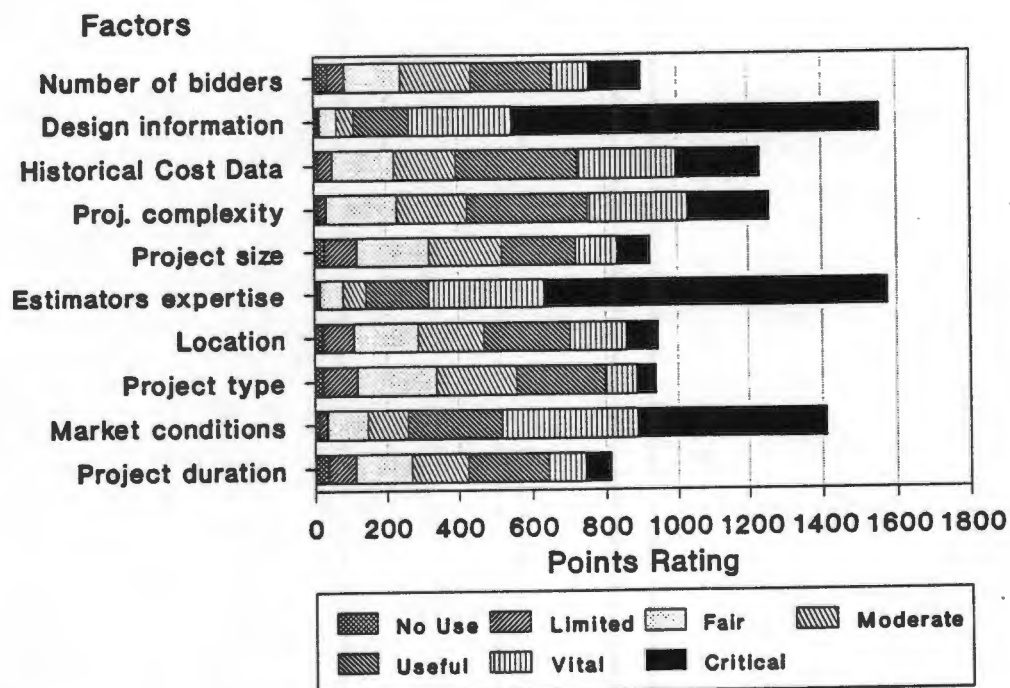
6.4.2 Factors considered to affect estimating accuracy

6.4.2.1 General

The views of estimators in South African quantity surveying practices on the relative affects on estimating accuracy of the factors previously identified, have been acquired by means of the inclusion of a specific question in the survey documentation referred to earlier in this chapter. It should be noted that the letter accompanying the questionnaire specifically requires those completing the forms to relate the answers to procedures applicable at the stage when the detailed design has been approved. The analysis of the data generated has been performed by utilising the BMDP statistical software package. This enables an in-

depth study to be made of the replies, in relation to the responses received in terms of features dealing with the monitoring of estimates and tenders.

In addition to the main analysis referred to above, a 'ranking exercise' based on the system used by Ogunlana (1989) is implemented in order to facilitate a direct comparison with the results of his survey. The overall cumulative results, emanating from the replies to question 5 of the questionnaire, are reflected in Figure 6.8.



Overall Ranking of Factors

FIGURE 6.8 IMPORTANCE OF FACTORS IN PRICE FORECASTING.

(National Survey, 1992)

The descriptions used for the legend of Figure 6.8 relate to the 7-point rating scale applied, indicating increasing importance of the factors listed. The rating points shown are calculated by multiplying individual ratings by the total number of responses for each category.

While the graphic presentation in Figure 6.8 does indicate the basic nature of the support for the various factors, the simple depiction of perceived importance requires further manipulation in order to clearly establish the true level of affirmative opinion. The method

Chapter 6

used by the writer follows that of Ogunlana (1989). The indicated 'strength of feeling' is calculated by using the equation:

$$\text{Feeling} = \frac{\text{Office score for all factors}}{\text{Total office score for all factors}}$$

The results of this test are almost identical to those indicated in Figure 6.8, the ranking being indicated in Table 6.2.

Ranking	Factor	Strength of Feelings
1.	Design information	36.37
2.	Estimators' expertise	36.07
3.	Market condition	31.57
4.	Project complexity	27.23
5.	Historical cost data	26.43
6.	Number of bidders	20.87
7.	Project location	20.47
8.	Project size	19.72
9.	Project type	19.59
10.	Project duration	18.39
Mean = 25.67		Standard Deviation = 6.65
Median = 23.65		CV = 25.90%
		Range = 17.98

TABLE 6.2 OVERALL IMPORTANCE RANKINGS OF S.A. ESTIMATORS
(National Survey, 1992)

The most notable difference between the South African survey and that of Ogunlana (1989), is the relatively low ranking by the local estimators of 'historical cost data'. This is particularly noticeable in the number of respondents signifying that this factor is of 'critical' (i.e. a rating of 7) importance. The reason for this is not clear, but a possible explanation could be that the limited availability of such data in South Africa is accepted as

Chapter 6

a fait accompli, and is therefore considered to be a static condition which cannot be improved upon. If so viewed other factors, which the estimators feel are capable of being improved, may have received a higher grading.

6.4.2.2 Detailed analysis of survey

A detailed analysis of the survey findings in respect of the individual factors follows. In each instance the independent survey response is recorded, together with an overview of interlinked features relating to the profile of the estimators that completed the questionnaire.

(a) Historical cost data

The views of South African estimators on the importance of this factor in aiding the provision of accurate price forecasts are indicated in Figure 6.9.

7-point rating

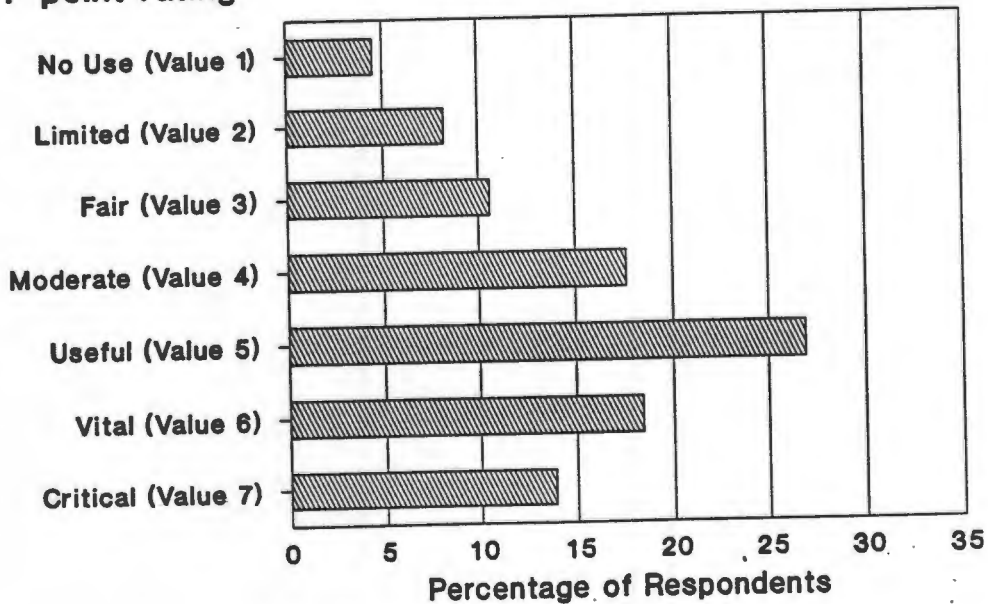


FIGURE 6.9 RATING PROFILE FOR HISTORICAL COST DATA.

(National Survey, 1992)

The respondents' choice of rating value is graphically expressed in terms of percentage of total returns. Whilst 59.2% of the replies indicate a rating of 5 or higher, an unexpectedly high number of replies (12.7%) rate the item at 2 or lower on the 7-point scale. Another noticeable aspect is the relatively wide spread of opinion at the higher support levels. If compared with the most favoured factors discussed later in this chapter, the 13.9% of

Chapter 6

returns signifying a top rating score of 7 is markedly inferior to the 56.7% and 53.1% recording the same score for 'design information' and 'estimators expertise' respectively.

Estimators who do not expect to produce price forecasts within 5% of tenders are more cautious than others at the highest support rating level; 6.3% of their returns giving this score compared with the average of 13.9% recorded. The returns of quantity surveyors with between 3 and 5 years price forecasting experience generally displayed neutral views with no ratings of level 1 being recorded, and a low percentage of 7.7% scoring the factor at importance level 7. This should be viewed, however, in the light of the relatively small sample size for this category of estimator.

(b) Estimators expertise

The rating profile for this factor, rated as the second most important as derived from the survey returns, is presented in Figure 6.10.

7-point rating

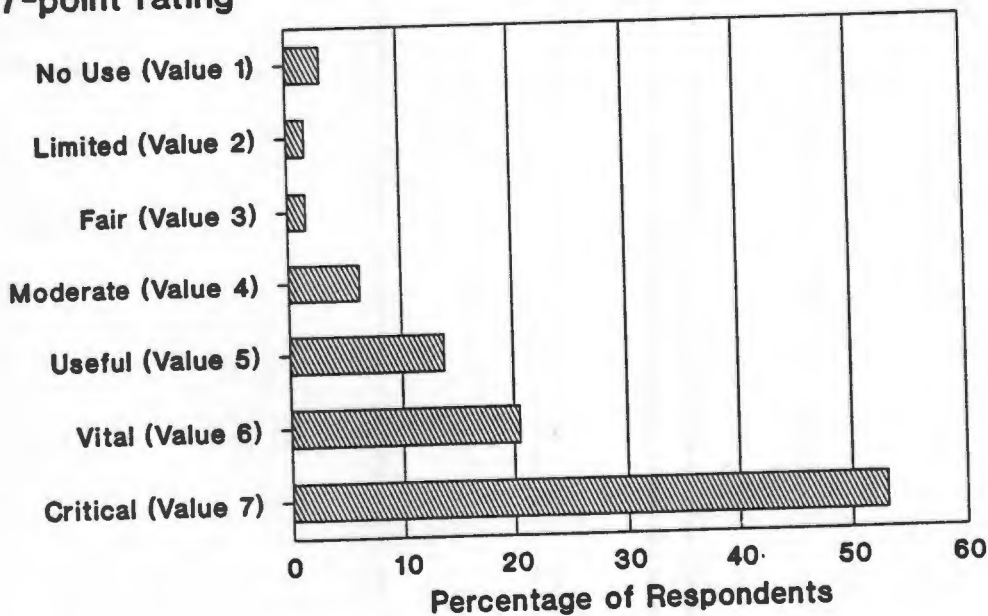


FIGURE 6.10 RATING PROFILE FOR ESTIMATORS EXPERTISE.

(National Survey, 1992)

The strong support for this factor is clearly indicated by the 87.4% of returns indicating an importance rating of greater than 5. As previously stated, 53.1% of the replies reflect the top score of 7 points.

Responses from the small sample of estimators indicating that there is no purpose achieved by comparing estimates and tenders, are generally irregular for most factors and are not comparable with the average condition. In the case of this factor, however, strong support which mirrors the average response is evident. Unfortunately the sample sizes of quantity surveyors with less than 5 years estimating experience are small, preventing a legitimate comparison being made with the views of sets of estimators with differing experience levels. Visual inspection of the results, indicate that those with more than 10 years experience hold nominally more forceful views on the importance of this item than their less experienced colleagues; a higher percentage than average selecting the extreme scores of 1 and 7.

(c) Level of design information

Figure 6.11 represents the response of estimators in terms of their perception of this factors' importance in the provision of accurate price forecasts at tender documentation stage.

7-point rating

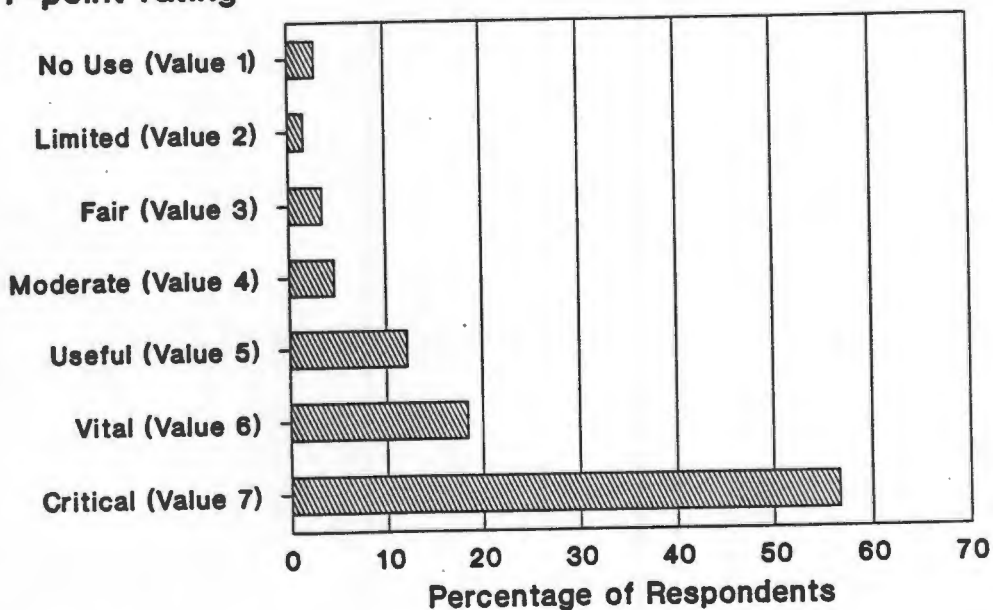


FIGURE 6.11 RATING PROFILE FOR AVAILABILITY OF DESIGN INFORMATION.

(National Survey, 1992)

Surprisingly, in view of the late stage of the design sequence being studied, this factor is clearly rated as the most important. The support indicated in terms of ratings of 5 or

Chapter 6

greater, is identical to that of 'estimators expertise' of 87.4%, but is greater for the top rating of 7, at 56.7%.

This factor is consistently rated across all groups of estimators for which reasonable sample sizes can be established. Whilst recognising the importance of this factor to the estimator during the development of the design process, it is contended that the exceptionally strong grading of the issue in this survey may not be a true reflection of its significance as respondents are required to indicate the importance of the factors "*once detailed design has been approved*". Therefore, it may be that the response reflects a profile of estimators views on the matter without paying due attention to the constraints of the design stage.

(d) Market conditions

This factor is rated highly in both Ogunlana's (1989) report, and in the survey conducted locally, as is indicated in Figure 6.12.

7-point rating

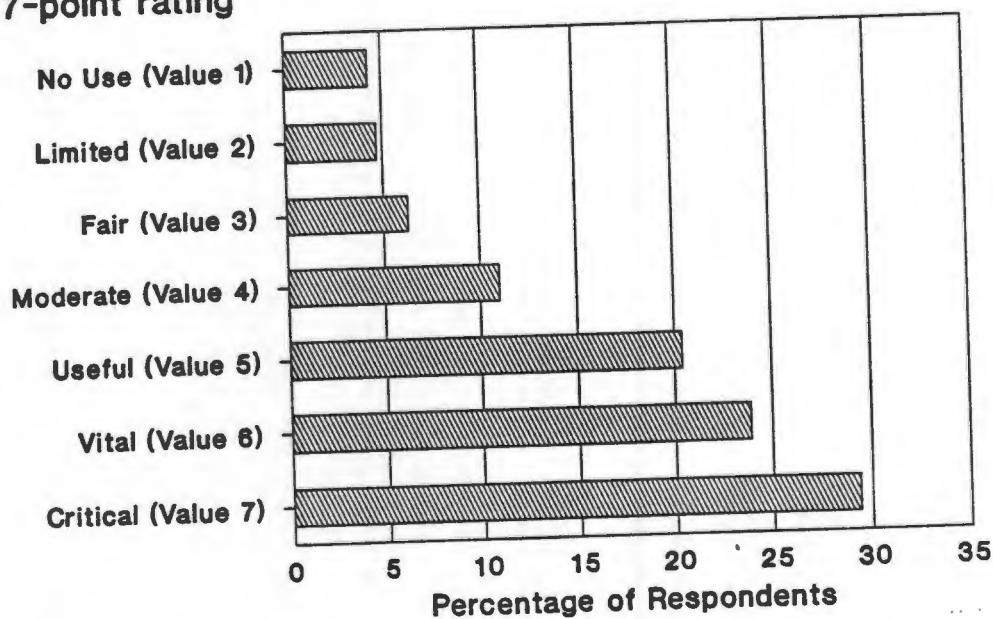


FIGURE 6.12 RATING PROFILE FOR MARKET CONDITIONS.
(National Survey, 1992)

A positive bias in respect of the higher ratings is clearly evident, denoting a factor which can be termed 'highly rated'. 73.7% of respondents score the item at 5 or higher on the rating table, with only 9.0% indicating low priority, with 2 or less points.

Chapter 6

In studying the views of different groups of estimators, it is noted that the small number that profess not to see any purpose in compiling estimate / tender comparisons nevertheless indicate an awareness of the importance of this factor. 87.5% of this group signify a rating for the item of 5 or greater. Other small sample sets, such as estimators indicating appropriate tender accuracy of more than 10%, similarly rate this item in a consistently high fashion.

Quantity surveyors with between 5 and 10 years price forecasting experience tend to rate the item in an inconsistent manner. In this group only 15.2% indicate the top rating of 7 points, as compared with the mean of 29.4% of respondents. 15.4% of those in the 3 to 5 years experience category indicate the lowest possible score of 1 for this item, compared with the mean of 4.3%, whilst 7.7% of the same group apply a rating of 6, compared with the mean of 23.9%.

(e) Type of project

Local quantity surveyors' impressions of the importance of this factor in the estimating activity are portrayed in Figure 6.13.

7-point rating

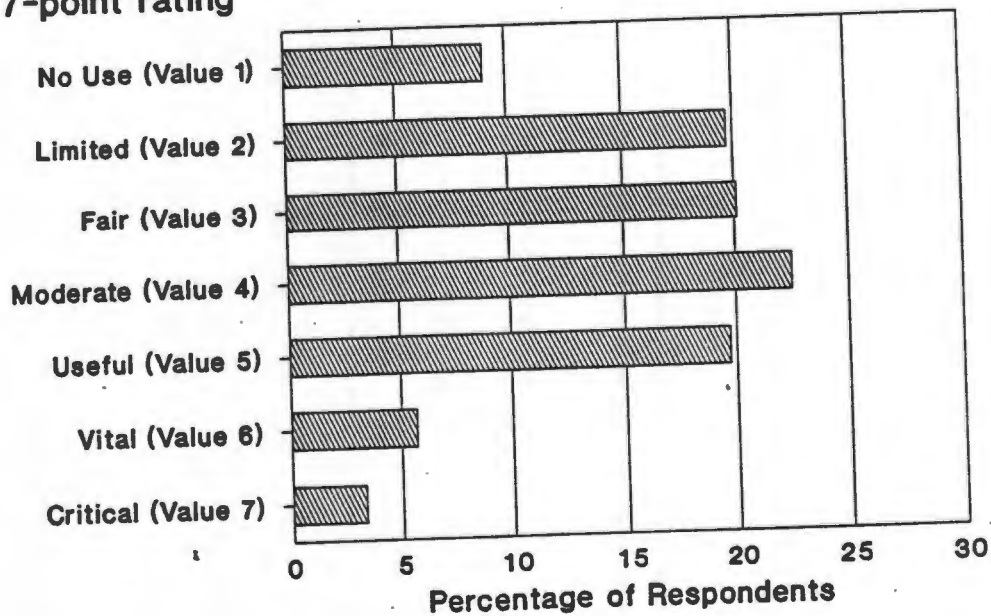


FIGURE 6.13 RATING PROFILE FOR TYPE OF PROJECT.

(National Survey, 1992)

This factor is ranked quite differently in the two surveys being compared. In Ogunlana's study, the type of project is identified as being of "moderate importance", but is considered

to be of no importance by local quantity surveyors, being ranked second last in the list of 10.

The profiles of factors ranked 4 to 10 in the local study are all similar in pattern, with the exclusion of the item ranked 6th - 'number of bidders'. The difference in gradings is attributed to fairly slight variations between categories of support. The typical profile of items in the group identified above consists of low support at the extremes (values 1, 2, 6 and 7), with the intermediate ratings each generally attracting the vote of between 15% and 25% of the respondents to the survey. This factor receives the lowest support of all for both the 'critical importance' rating of 7 (3.3%), and the 'vital importance' score of 6 (5.7%). Several of the other factors perform worse at the lowest score of 1. The middle group of scores (2 to 5) is selected by 82% of the estimators.

The frequency tables linking this factor to estimator characteristics investigated earlier in this chapter, disclose that the pattern described above is particularly pronounced amongst estimators with between 5 and 10 years estimating experience. Only 2.2% of this group mark the item at the 'no use' value of 1, but none of the 46 estimators in this group rates the factor at the top level of 7.

An abnormally high response (17.7%) at the lowest rating of 1, is received from price forecasters that suggest the low bid as being an appropriate datum for measuring estimating accuracy. Estimators who indicate they actually use the low bid for this purpose, respond in line (9.6%), with the mean distribution .

(f) Project complexity

South African quantity surveyors rank this factor at a higher level than their UK counterparts. However, it can still be categorised as of 'moderate importance', as was the case in Ogunlana's study. In the local survey, this factor is ranked highest of those items previously identified as 'project specifics'.

Figure 6.14 indicates, by means of a histogram, the South African estimators' views on the significance of this project characteristic, in the compilation of accurate estimates.

7-point rating

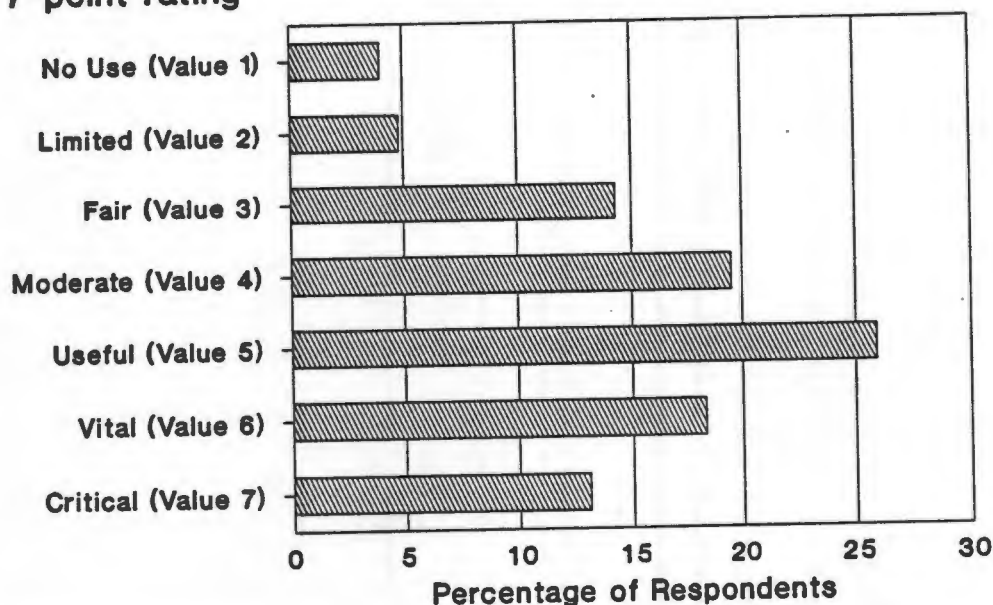


FIGURE 6.14 RATING PROFILE FOR PROJECT COMPLEXITY.

(National Survey, 1992)

The distribution of rating selections for this item are fairly evenly spread about the central values, displaying a slight leaning to the higher ratings. The highest percentage selection is that of value 5 (25.9%), with 91.2% of the estimators recording a score of 3 or greater.

Virtually all groups of estimators identified by means of the statistical analysis of the survey responses, display rating frequency distributions similar to that shown in Figure 6.14. The only notable deviation from this applies to estimators with between 5 and 10 years experience, none of whom rate the item at level 1.

(g) Project size

In both the UK and South African surveys this project characteristic is identified as one of the lowly rated factors. These factors are typically depicted as having a fairly strong central base (values 3, 4 and 5), with support at the higher levels of less than 10% per rating, and relatively high numbers of respondents indicating low item importance.

A total of 13.1% of respondents submit ratings for the high values 6 and 7 for this particular element, and 30.4% signify that they feel the factor is unimportant by marking the low values 1 and 2. A relatively neutral stance is adopted by the balance (56.5%) of respondents by marking the middle ratings. This is graphically shown in Figure 6.15.

7-point rating

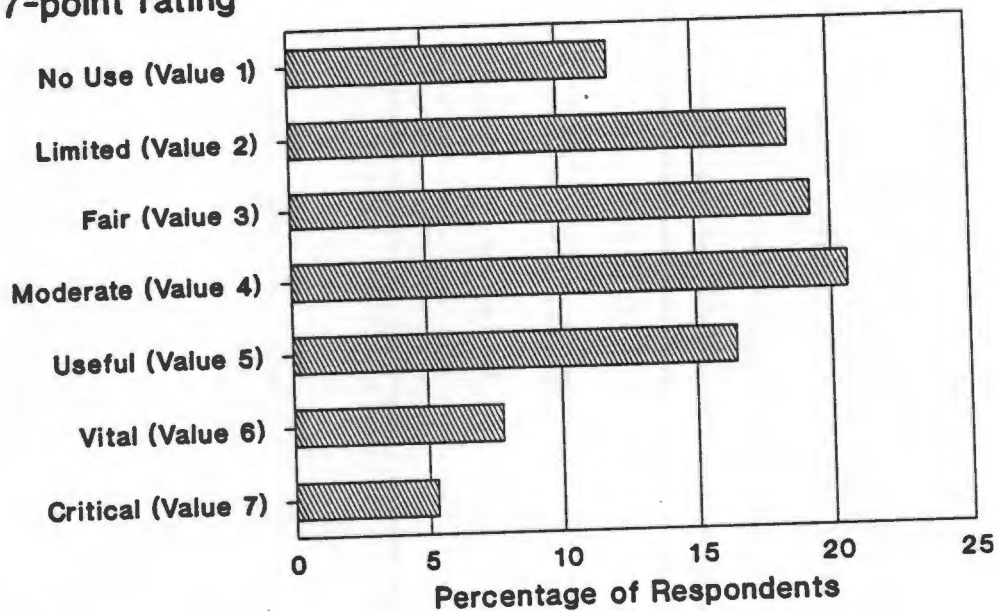


FIGURE 6.15 RATING PROFILE FOR PROJECT SIZE.

(National Survey, 1992)

Estimators automatically applying estimate / tender comparisons are slightly more negative when assessing the worth of this factor than those who do not apply this feedback mechanism on a regular basis. It is noted that estimators who actually use the mean of the bidding range as a datum for tender comparisons provide significantly higher ratings than those using other measures. In line with this observation, estimators indicating that the mean of bids is theoretically the most appropriate datum for this activity provide a similar frequency distribution. This is the only instance found of common deviation from the mean opinions of respondents to questions 2 and 7 of the questionnaire.

Minimal variation in opinion trends are found between the different groupings of estimators responding to the questionnaire. However, clearly different perceptions on the importance of this item are displayed by estimators having differing amounts of price forecasting experience. Those quantity surveyors with between 3 and 5 years estimating background provide far more negative responses than the mean for low level ratings, particularly value 1 (23.1%). Furthermore, a comparison of the two groups of practitioners having greater experience discloses that the factor is given greater recognition by the most experienced set.

(h) Number of bidders

The rating profile for this factor differs markedly from all others compiled from the local survey and is given in Figure 6.16.

7-point rating

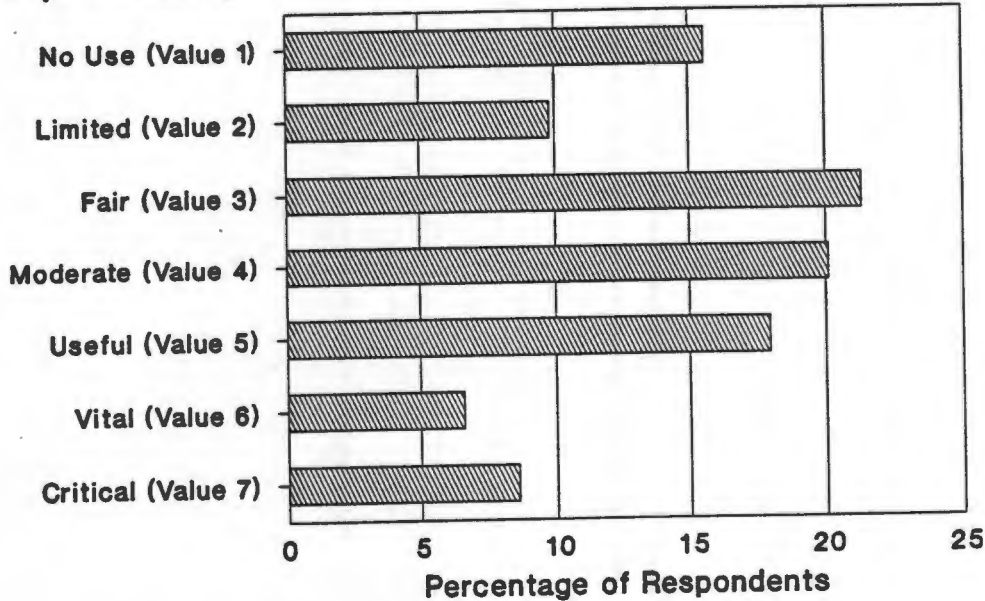


FIGURE 6.16 RATING PROFILE FOR NUMBER OF BIDDERS.
(National Survey, 1992)

The marked difference between the responses for this item and the other factors, is the uneven nature of the profile in respect of the low number of returns indicating applicability of either value 2 (9.8%), or value 6 (6.6%). In both these cases, the ratings on either side are significantly higher. In addition, the percentage response for the minimum value of 1 (15.6%), is the highest recorded for any of the factors studied.

In Chapter 5 it was suggested that there is a relationship between 'market condition' and 'number of bidders'. The profiles of these factors, created from the local survey returns, are totally dissimilar and would appear to indicate that South African quantity surveyors do not recognise any common ground for these items.

One of the few estimator 'sets' that do not reflect the sample profile illustrated in Figure 6.16, is the group using the mean tender as a basis for tender / estimate comparisons. The trend line established by this group is 'flat', but regular in pattern, in line with the other factor profiles. The group of estimators suggesting the mean as the best datum for tender

Chapter 6

analyses, reflect the 'dip' in the trend for value 2 ratings but indicate a conventional pattern in terms of value 6 scores.

A similar pattern occurs for estimators formally keeping records of tender analyses, except that the position is reversed. The 'dip' for value 6 ratings is maintained whilst the trend line for the lower ratings is standard in nature.

Estimators with between 5 and 10 years experience reflect a totally 'normal' profile in their responses, the abnormal condition being caused mainly as a result of the rating by the most experienced group with more than 10 years price forecasting background.

(i) Duration of project

The aggregated results of the two surveys undertaken shows that this factor is clearly considered the least important of those listed. The results of submissions for the South African investigation are given in Figure 6.17.

7-point rating

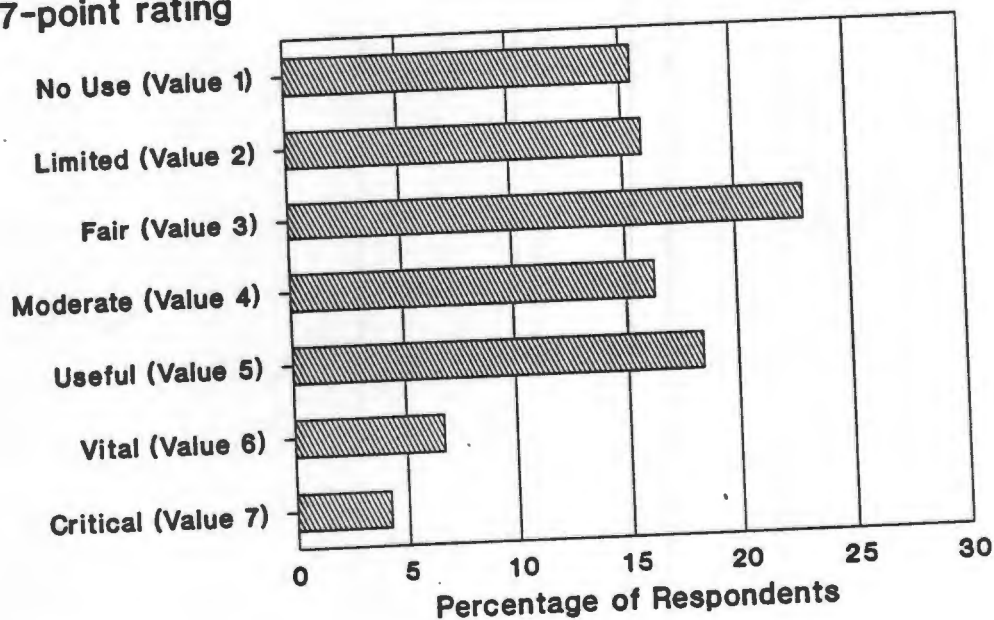


FIGURE 6.17 RATING PROFILE FOR PROJECT DURATION.
(National Survey, 1992)

The responses are biased towards the least favourable rating values, with value 3 having the highest percentage return (23.0%) of this sample. The sharp decline in support between value 5 and the two highest values are typical for the factors considered to be of low importance for estimating purposes.

Frequency distributions are generally regular for the various estimating sectors viewed independently, with moderate deviations from the norm occurring between groups expecting different accuracy levels, and also between estimators with disparate levels of estimating experience. In the case of estimators who suggest that accuracy of between 5% and 10% is to be expected at tender documentation stage, 13.1% rate the factor at value 6, with only 1.6% of the group suggesting that the item merits an importance rating of 7. Estimators with between 3 and 5 years experience similarly differ from the mean distribution shown in Figure 6.17, with only 2.2% of respondents indicating rating values of 6 and 7 respectively.

(j) Geographical location of project

Although this item is ranked as the least unimportant in the UK investigation, South African quantity surveyors grade it at a higher priority level, in the range of items considered to be of moderate import. Figure 6.18 indicates the mean rating form derived from the local survey results.

7-point rating

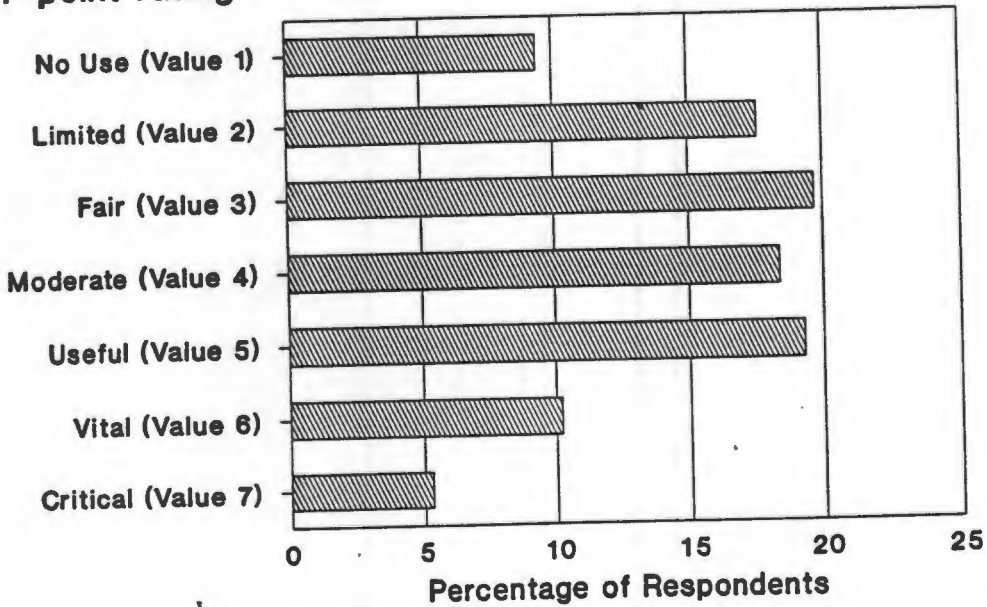


FIGURE 6.18 RATING PROFILE FOR PROJECT LOCATION.

(National Survey, 1992)

As can be seen from the figure, the response across rating divisions is widespread, no single class receiving more than 20% of the total available. This is interpreted as denoting a slightly neutral view of the item, being the only factor displaying this particular

characteristic. The slight bias towards the lower ratings is also clearly discernible in the histogram.

An unusually high number of the estimators who promote the low bid as the most suitable datum for tender / estimate comparisons grade this item at the lowest level (18.0%), as compared with the mean opinion of all estimators of 9.4%. The group of quantity surveyors who consider late stage estimating accuracy of 5% to 10% to be appropriate, differs from the mean profile at the higher gradings; value 6 being chosen by 7.9% of the group and the highest rating value only being indicated by 1.6% of the grouping. The group of price forecasters with between 5 and 10 years experience differs from the norm, with the extreme levels (values 1 and 7), being chosen by approximately half the average percentage of the sample in each case (4.5% for rating level 1, and 2.3% for value 7).

6.5 CONCLUSIONS

The responses to the survey of estimators in South African quantity surveying practices creates a clearly defined background, against which both the opinions of price forecasters on aspects of tender / estimate comparisons, and their perceptions of the importance of certain factors in the production of accurate estimates can be viewed.

Although quantity surveyors who submitted replies are overwhelmingly in favour of structured feedback mechanisms being implemented, only a relatively small proportion of these respondents, estimated to be no more than 30% of the sample, actually undertakes the basic operations considered necessary for this activity to be satisfactorily conducted.

No single 'estimating target' achieves universal, or even dominant support, although comparison of the estimators' price forecast with the lowest tender received is the most common. Responses to the questionnaire indicate dissatisfaction with the soundness of this choice amongst estimators, but there is widespread confusion as to a suitable alternative. Arising therefrom, scope for the study to be expanded is indicated. Further research is necessary to investigate the degree of awareness, and perceptions of clients receiving tender reports.

A possible reason for quantity surveyors not devoting more attention to the development of tender / estimate monitoring systems is the apparent impression that the estimates which they compile are accurate (within 5% of the lowest bid), and that architects and clients are

satisfied with the standards achieved. The estimators' perceived degree of accuracy attained is far superior to that noted in empirical studies conducted overseas. In Chapter 7 of this dissertation, the validity of the opinions expressed locally is investigated.

The views of the different groups of estimators regarding factors influencing estimating accuracy, as identified by the responses to the questionnaire, are generally consistent with the average response of all participants. A specific deviation of note is provided by price forecasters who express the view that comparing estimates and tenders does not perform any useful purpose. This group indicates abnormally strong support for the factors of "estimator's expertise" and "market conditions". This could be interpreted as reflecting an attitude of confidence in the ability of the experienced estimator to produce an estimate with a high degree of intuitive decision-making and to allow for the factors pertaining to individual projects.

Another sector of the respondents displaying distinctive characteristics are those estimators indicating that between 5% and 10% accuracy of tender stage estimates is appropriate. This group's opinion can be considered conservative, in terms of the total survey perception. In keeping with this profile, the views of the group are considerably more conservative than the average respondent for the factors of "cost data", "project location", and "project duration".

The groups that prove to have the most discriminating opinions are those determined by the experience categories of 3 to 5 years, 5 to 10 years, and exceeding 10 years estimating experience. As a large majority of the returns are submitted by quantity surveyors with more than 10 years experience, their views generally establish the pattern of opinions reflected in the 'factor profiles'.

It is suggested that this could be significant in assessing the relative importance of two factors; namely "number of bidders", and "market conditions". The abnormal profile established for the former factor could be construed as being a possible cause why the expected linkage between these two conditions is not reflected by a closer ranking. It is noticeable that the assumption that a relationship between "project size" and "duration of project" is strengthened by the consistent manner in which they are ranked in both the surveys inspected.

Chapter 6

The detailed study of the views of price forecasters on factors included in the questionnaires identifies three categories of importance in terms of contributing to estimating accuracy. The factors "estimator's expertise", "design information", and "market condition" are classified by firms as being highly rated. Included in the middle range of moderately rated factors are "historical cost data", "project complexity", and possibly "project type". Items which estimators suggest are of minor significance include "number of bidders", "project location", "project size", and "project duration".

In the following chapter, the actual accuracy of price forecasts produced by a large sample of quantity surveyors in South Africa is presented. In order to establish the potential for improvement in performance, the results are compared with the opinions previously stated. Furthermore, the theories relating to the importance of the various factors affecting accuracy are tested by examination of the sample data.

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7. EMPIRICAL STUDY OF ESTIMATING PERFORMANCE

"From principles is derived probability but truth or certainty is derived only from the facts" : Tyrone Edwards

7.1 INTRODUCTION

The first stage in the identification of the factors influencing the accuracy of building price forecasts, namely the evaluation of informed opinions relating to the subject, is comprehensively covered in the preceding chapters. This chapter describes the results of an empirical study of the estimating performance of South African quantity surveyors at the tender stage of building projects.

Limited published research is available on the subject of estimate "targets", (i.e. what segment of the tender distribution the estimate is meant to represent). Unless otherwise advised, it is understandable for clients to assume that the estimate indicates the approximate level of the anticipated lowest tender. This feature is examined in this chapter in order to establish the most effective "target" against which to compare price forecasts recorded.

The main objective of this inquiry is to identify clearly the primary factors to consider in the provision of accurate price forecasts by testing the validity of the opinions previously established. The basis upon which the study is conducted is a comparison of estimating performance in a large sample of project estimates with 'acceptable' standards as determined by the majority of price estimators in South Africa.

In the empirical study, factors found to be strongly linked with exceptionally good, or poor, estimating performance at the tender stage of project development are described as being influential in determining required accuracy levels for price forecasts.

7.2 TARGETING OF THE DESIGN ESTIMATE

Just as there are different views on percentage accuracy expected or achieved, so there are differing views on how this accuracy is assessed, i.e., which reference point to use for

measurement. Design price estimators have yet to agree on a target on which tender price efforts should focus, but each cost consultant should obviously determine the target, prior to producing the estimate.

Before examining the suitability of alternative "targets" for tender evaluations, it is pertinent to consider the relationship between the tenders received and the analysis of such bids as conducted in other countries.

7.2.1 Tender analysis procedures overseas

Cost consultants in many countries recognise the inadequacy of the "lowest bidder" criterion and consequently introduce qualifications to this standard in the process of evaluating tenders received. Although many of these procedures deviate markedly from the established system, they are based on the common objective of selecting a qualified contractor while promoting competitiveness.

The basis for the disqualification of a tenderer, as currently practised in some countries, is frequently based on the difference between the tender and the cost consultant's estimated cost, often reflecting the average of the bids received. For instance, the system used in Denmark disqualifies the two highest and the two lowest tenderers and the tender that is closest to the average of the remaining bids is selected. A similar procedure is used in South Korea, but only the highest and lowest are disqualified. Other examples include choosing the lowest bidder, provided that the tender is not less than: (a) a specified percentage of the design price forecast (e.g. 80% in Pakistan and 70% in Saudi Arabia), or (b) a specified percentage of the average of all bids received (e.g. 90% in certain construction sectors in the UK).

In Switzerland, the normal procedure for analysing tenders is to formulate a reference price from the middle range of tenders, and then consider only those tenders that are within a 10% variation of the reference. A procedure applied in Japan on large projects with repetitive tasks, and/or units is for the project to be divided into three phases. Contractors are required to tender on the entire project, but the work in two phases only is awarded to the two most qualified contractors. The third phase is awarded at a later stage to the contractor who out-performs the other. In Canada and the USA, the "lowest bidder" criterion is used, but contractors are required to submit substantial performance guarantees with their bid (Moselhi and Martinelli, 1990).

A reason for employing these different systems may be attributed to the use of procurement methods which are totally different from that of the traditional system using bills of quantities. However, even where this system is used, local variations in awarding projects to tenderers do occur. For example, in Singapore the contract sum is negotiated between the client and the contractor, using a figure based on the lowest tender received (Betts and Gunner, 1989).

As can be seen from the foregoing, the selection point in any tender evaluation system performs a critical function in the process of tender acceptance. This issue is also closely linked to the tendency for quantity surveyors to assume the correctness of their price forecasts. A distinct danger exists that tender awards may be negatively affected by comparing tender submissions with inaccurate estimated values.

7.2.2 Low bid

In the case of contracts adopting 'selected' tender lists the practice is to award the contract to the lowest bidder. Unless the client's consultants have reasonable doubt about the ability of a contractor to undertake the work, this system is also followed under conditions of 'open' tendering. This situation tends to influence the tender analysis process, resulting in comparison of the quantity surveyor's forecast with the low tender.

The estimator faces a difficult task in predicting the lowest tender. This is illustrated by the extensive range of prices commonly represented in tender submissions (commented upon in Chapters 3 and 7 of this dissertation). If it is recognised that all *bona-fide* tenderers (i.e. excluding 'mistakes' and 'cover prices') are submitted by contractors attempting to anticipate the level represented by the lowest bid, the ability of the quantity surveyor to consistently gauge this level, without access to much of the detailed information that contractors' estimators base their tenders on, is clearly a major problem. Ogunlana (1989) cites several examples of practical problems experienced in the tendering exercise. Amongst the examples are: (a) the tenderer having a pricing advantage over competitors (e.g. when old material held by a specific tenderer can be re-used), and (b) cases where a tenderer is party to 'privileged' information (e.g. sole knowledge of a particular site condition). In such instances the tender submitted can be dramatically affected, possibly leading to a price much lower than that expected by the quantity surveyor.

Exceptional instances such as those indicated above, or major errors by contractors in producing the tender are reasonably easy to detect if priced bills of quantities are called for,

Chapter 7

and discussion takes place with the contractor on the details in the document. In the light of the perceived interpretation by clients of their consultants' price forecasts, predictions of the low bid would appear to be appropriate.

7.2.3 The second, third or any other bid

Beeston (1975) notes that although the second and third, and particularly the average tenders, offer an easier target for the estimator to predict than the lowest tender, the usefulness of estimating them is questionable. The practical use of targetting the estimate at any but the lowest tender is dubious but is often suggested by practitioners. A cynical approach to this practice could be the suggestion that where estimates are much higher than the lowest tenders received, this attitude provides a convenient excuse to 'hide' the perceived poor performance.

Flanagan and Norman (1982b) suggest that when estimating the contract price, quantity surveyors should consider the bidding range, the relationship between the lowest, second and third lowest bids, and use detailed information on previous projects as a reference point. This suggestion is based on the observation that the tender distributions denote that the lowest tender is a poor indicator of the 'true' price for projects (Ogunlana, 1989). It is difficult to conceptualise how the knowledge that the second or third lowest tender may be a better representation of the true cost can be practically used by the forecaster. This concern is especially relevant in South Africa, where quantity surveying firms are generally small and do not have access to large data bases upon which to base their decisions.

7.2.4 Mean, mode and median of bids

The mean, mode and median are statistical terms used as descriptive measures of location (averages) for populations and samples. The most commonly used average is the arithmetical mean which is the total sum of all values in a sample divided by the number of items. The median for a collection of values is the value of the middle observation when the items have been arranged in either ascending or descending order. The mode is the value in the sample data that occurs most frequently.

The mode is considered unreliable for use in a small collection (i.e. less than 30), and since most building project tender lists are considerably smaller than this in South Africa, it is not anticipated to be a useful unit of measurement. In addition, no two tenders submitted for the same building contract are likely to be exactly the same, invalidating the use of the

mode as there can, by definition, be no mode in a series where no value occurs more than once.

Beeston (1983) considers the median to be the most stable measure of average for statistical description, as the mean is affected to a greater extent by extremely low or high values in the sample, which could be caused by non-serious tenderers or a low tender containing a major error. However, he observes that the distribution of tenders can generally be assumed to be 'normal', implying that the mean is a good representation of the sample. Morrison (1984) appears to support the use of the mean as a prediction target by expressing the viewpoint that lowest tenders are not capable of being predicted exactly. This is due to estimating accuracy being partly dependent upon the variability of the object which is to be estimated, i.e. the lowest tender.

Just as for the second, third or other tenders previously discussed, the practical use of the mean or median as the estimating target appears uncertain. A further practical consideration relates to generally observed tender practices. In South Africa, tenders on building projects are normally submitted without priced bills of quantities and the likely contractor is only approached for his detailed document after the tender opening. This is largely a result of conditions imposed by trade associations such as the local Master Builders' Associations. It is highly unlikely that tenderers whose submissions are almost certainly not going to be accepted, will submit priced bills of quantities to the quantity surveyor for comparative purposes.

7.3 RESEARCH METHODOLOGY

7.3.1 General

The small size and structure of the typical South African quantity surveying firm as illustrated by Billett (1990), results in a relatively low number of building contracts being handled by each practice. Therefore, in order to gain access to a significantly large amount of data on tenders and related estimates, it is necessary to establish contact with a large number of firms. No evidence of such a widespread source of estimating data being made available for research purposes elsewhere in the world can be found in the literature. These studies are generally undertaken on relatively small samples, or on data derived from either single or limited numbers of large establishments.

It was reasoned that the required support from practitioners in a sensitive matter dealing with confidential information, could only be realistically achieved by approaching firms individually; explaining the purpose of the research and responding to any problems raised by potential contributors. In order to adopt this personalized approach, it has been necessary to limit the scope of the survey source base to the Cape Peninsula geographic area.

In January 1992, at the time of the survey being carried out, 73 quantity surveyors' offices were listed in the directory of the Association of South African Quantity Surveyors for the Western Cape region (Peninsula and Surrounds). A number of these listings are, however, for offices where quantity surveying activities are not being conducted (e.g. University and Technikon Departments), and other listings are for firms with more than one branch within the same region. This results in a total of 55 registered practices comprising the potential data source.

The firms referred to above are considered to fairly represent price forecasting practice throughout South Africa, for the following reasons: (a) 21 of the firms are represented in other areas of the country, with certain of the Head Offices being located in this region, (b) all South African universities offering quantity surveying courses are represented by their graduates at partnership level within the local quantity surveying fraternity, and (c) movement of quantity surveyors around the country for career purposes is extensively practised.

An alternative data source used, and one which reflects a truly national character, is that containing details of tenders and estimates produced for the Department of Public Works and Land Affairs in 1990 and 1991. Whilst the size of the sample is relatively small (45 projects), the information does provide a basis for general comparison with that emanating from the main survey.

It is not the intention to criticise the estimating performance of either individual firms, or the quantity surveying profession as a whole - the information provided is used purely to establish possible ways of improving the price forecasting function.

7.3.2 Data acquisition

Full details of tenders on a large portion of the building work carried out in the Cape Peninsula are recorded by the Master Builders' and Allied Trades' Association (Cape Peninsula). This includes many projects for which quantity surveyors are employed to produce bills of quantities. This information was used in compiling a listing of contracts and associated professional consultants on contracts using this procurement method.

A total of 1086 such projects are identified as being tendered upon in the 10 year period 1982 - 1991. A number of these projects were dealt with by quantity surveying practices that were no longer active in January 1992. In addition, several of the practices listed in the ASAQS directory had not been involved in the administration of any contracts recorded by the MBA. This analysis resulted in 38 quantity surveying practices being approached to provide details of the estimates they had compiled on the projects listed.

It was found that virtually all the firms had difficulty in providing information on projects put out to tender more than 5 years prior to the investigation. In addition, most of the firms, although appearing to be supportive of the research, struggled to find the required details for comparatively recent contracts. The response indicates that a formal recording system for estimate / tender purposes is not widely implemented.

Of the 38 firms approached, 30 practices provided the details requested. Several of the firms providing data appeared to do so on a selective basis. A possible reason for this, confirmed by 3 responding firms, could be the practitioners' reluctance to divulge details of estimates not close to the tendered sum. *There would therefore appear to be grounds for suggesting that the estimating performance actually achieved is inferior to that reflected in this dissertation.*

The full schedule of 243 projects for which details were supplied by firms in the Cape Peninsula is incorporated in this dissertation as Appendix B. The schedule of projects reflecting 45 PWD projects throughout South Africa is presented as Appendix C.

7.3.3 Data analysis

Comparisons between the conditions generally prevailing within the local building industry (represented by the total data base of 1086 projects), and those indicated in the selected data samples used for examining estimating performance are necessary to indicate the validity of any conclusions derived therefrom. The four factors considered are; (a) the number of bids per project, (b) mean project values, (c) mean range of bids expressed as a percentage of the lowest tender, and (d) the nature of the tenderer's bidding expressed by the coefficient of variability. Graphical representations of the comparative conditions relating to these factors are provided in Appendices D, E, F and G respectively. A few differences are visible between the two samples, ostensibly caused by the small size of the data relating to estimates made available for the years 1982 - 1986. None of these are considered of great significance, however, as the sample of 243 projects manifests a fair reflection of the general situation.

In order to facilitate analysis of the schedules incorporated in Appendices B and C, the following aspects should be considered.

1. Project descriptions are non-specific in order to ensure confidentiality is maintained. For the same reason, the quantity surveying firms are referred to by means of a numeric code, based on the order of distribution of questionnaires.
2. Projects listed in Appendix C (PWD Sector contracts) are not described at all, as many of the projects refer to sensitive developments such as military installations.
3. Values shown as 'Amount Tendered' are the lowest bids submitted. However, certain quantity surveyor respondents advised that there are a number of instances where the contract was not awarded to these tenderers. In several of these cases the award was made to a tenderer not in the lowest 3, indicating a tendency to view the quantity surveyor's estimate as 'correct'. Only in instances where official records indicate that tenders were withdrawn as a result of a mistake becoming evident, has the next lowest tender been used in the analysis.
4. Amounts tendered have been adjusted to reflect mid-1992 values in the column headed 'Updated Value'. The index used (770.0), was provided by Medium Term Forecasting Associates in June 1992 as the forecast B.E.R. index (1975 base) for that month.

5. Although a few instances of 'cover prices' being submitted appear to be evident, no adjustment of tender ranges has been made to allow for this possibility. All bids submitted were considered as genuine tenders.
6. The mean CV for tenderer's bids of 5.44% (sample of 243 projects), and 6.07% (for the 1086 projects initially listed), falls within the 5% - 9% bracket suggested in Chapter 3 as being the international norm.
7. Gunner and Betts (1990) state that the value of 'fixed' sums in bills of quantities (i.e. contingencies, provisional sums and P.C. amounts) are considerable and should be allowed for in establishing accuracy of price forecasts. Although their research reflects conditions in Singapore, the situation in this respect is similar to that found in South Africa. Amounts reflected in the schedules therefore represent the 'true' accuracy, based on nett figures.
8. Whilst both relative and absolute percentage deviations from the low bid are given, the nett absolute accuracy is considered to be the most relevant.
9. Less information on tender details is provided on the schedule of PWD projects (Appendix C) as this information was not available from the respondent.

A comparison of the nett absolute accuracy values reflected in Appendix B, with the anticipated accuracy ranges identified by estimators responding to the writer's national survey, is provided in Figure 7.1.

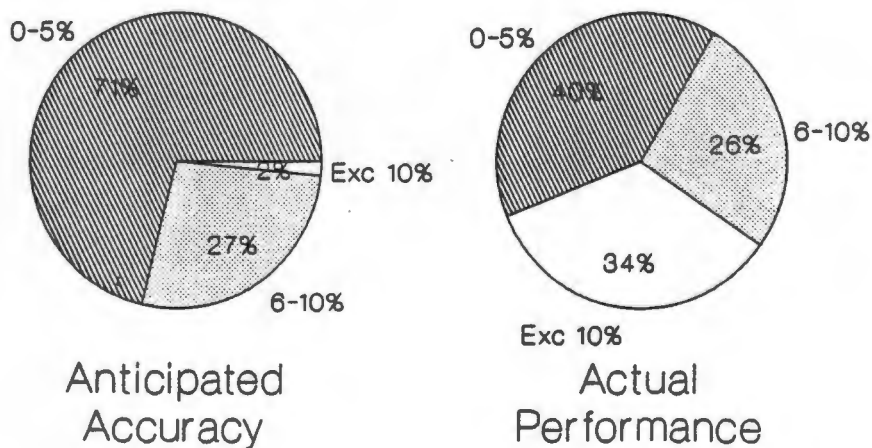


FIGURE 7.1 COMPARISON OF ACCURACY ACHIEVED / ANTICIPATED.

(Source: National Survey, 1992)

Whilst 98% of the survey respondents anticipate that their estimates are within 10% of the tender, the results of the empirical study indicate that only 76% of the estimates fall within this category. Additionally, the mean nett absolute accuracy actually achieved is outside the 0 - 10% range; being 11.84% of the lowest tender. These statistics indicate that there is a distinct disparity between what estimators perceive they achieve in terms of the accuracy of their forecasts, and actual performance.

A notable aspect of the empirical survey is that the average consistency achieved (CV value) is a very poor 49.85%, as compared with the international norm of 12% - 19% (indicated in Table 4.5). The results in the main survey are generally confirmed by the smaller investigation on PWD projects, with a mean nett absolute deviation from the low bid of 14.51%, and a CV of 33.51%.

Although it is likely that aspects relating to 'poor' results are easier to identify than those linked to adequate performance, all factors which are incorporated in the schedules in Appendices B and C are discussed below in order to identify the reasons for the results indicated above.

7.4 ANALYSIS OF SAMPLE OF MIXED TENDERS

Because of the relatively limited nature of the information supplied by contributing firms to the empirical survey, it is not possible to analyse the data according to project design information, historical cost data, project complexity or duration, and estimator's expertise. The data is, however, analysed in terms of market conditions, project type and size, number of bidders, and location of project. In addition, the general characteristics of the data sample are examined, with particular emphasis placed on possible linkage between features of the tenders received, and the factors affecting the quantity surveyor's price forecasts.

7.4.1 General characteristics

Subjects discussed in this section include : (a) the performance of individual firms and their influence on the results of the survey, (b) a comparison of price forecasting accuracy and consistency with tenderers' performance in terms of consistency in bidding, (c) the effect of

'fixed sums' on estimating performance, and (d) features of estimates within the specified accuracy categories.

7.4.1.1 Performance of individual firms

Of the 30 firms contributing to the study, only 6 submitted details on more than 14 projects. As previously noted, this is partly due to the lack of adequate records, but more significantly a reflection of the composition of quantity surveying practices - the available work being distributed amongst a large number of small firms.

Of the 6 larger samples, half portray a satisfactory level of performance in terms of both mean nett absolute deviation from the low bid and CV denoting consistency. Of the other 3 firms, two reflect acceptable mean nett accuracy figures (below 10%) but suffer from inconsistent performance. This is evident from their results displaying a CV greater than 20%.

The remaining firm (No. 21) submitted details on 25 projects, displaying an average nett accuracy of only 31.16%, whilst the CV level is an astonishing 99.96%. As could be expected from the above, only 6 of the jobs listed are estimated within 10% accuracy. This firm's estimates are generally high (16.9% mean relative deviation from the low bid), the highest deviation being 105.67% above the tender. Even if the effect of allowing for the deduction of 'fixed sums' is ignored, the performance displayed by this firm appears to be far below that previously described as an acceptable standard. There is no obvious reason for the above, the only noticeable feature of the sample being a higher than usual number of tenderers (11, compared with the norm of 8.)

As the projects submitted by firm 21 constitute approximately 10% of the sample, a study of the effect that the omission of this data has on the survey results, is conducted. The mean accuracy of the remaining projects improves to 9.67% (on the outer fringe of the expected range), but improvement in the coefficient of variation is less discernible at 43.93%.

The schedules indicating details of estimating performance for firms 1 (the most successful) and 21 (the least successful) are presented as Appendices H and I, together with the control charts developed therefrom. Although the mean results indicate general performance levels below that desired, it is noted that half of the participating firms achieve satisfactory results for both accuracy and consistency. Notwithstanding the fact that the mean CV of the total

sample is high, almost a quarter of the firms *consistently* produce estimates which are *inaccurate*.

However, only 4 of the 30 firms are considered to be producing work of a totally inadequate nature, being poorer than the established norm in terms of both accuracy and consistency. The distribution of individual firms' performance is shown in Figure 7.2.

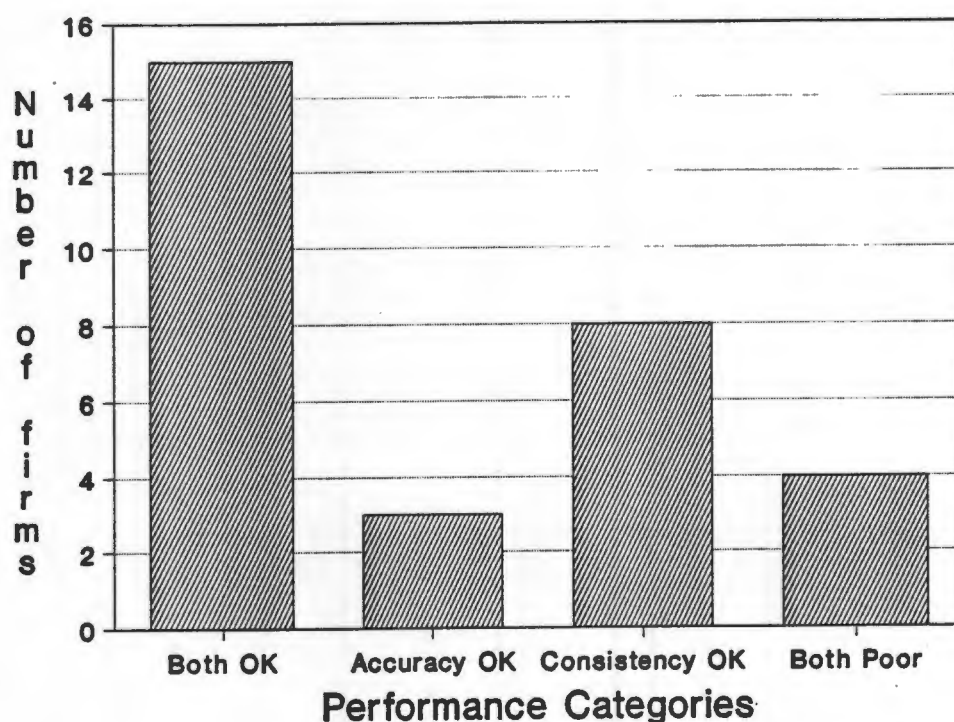


FIGURE 7.2 ESTIMATING PERFORMANCE OF INDIVIDUAL FIRMS.
(Source: National Survey, 1992)

The cause of the great differences between firms appear to be unrelated to any of the factors analysed below, the most likely consideration simply being differing levels of expertise between the estimators involved.

7.4.1.2 Comparison with bidding consistency

It is possible to examine the consistency of the bidding displayed by the tenderers on the various projects by reference to components such as the range of bids, and the coefficient of variation of the mean tender.

The range of tenders is unfortunately very sensitive to 'wild data' such as a single unrealistically low bid, or a 'cover price' submission, leading in both instances to an increase in the extent of the range. No clear definition of what constitutes an acceptable range exists. However, the average of 18.38% of the low bid for the sample is significantly lower than that shown by researchers such as Morrison (1984), and Betts and Gunner (1989). This average is achieved, notwithstanding the fact that the ranges listed for projects with more than 2 tenderers vary from a maximum of 129.02% to a minimum of 2.96%.

The sample is analysed in terms of three sets of data. The divisions are; those where the range is less than 15%, a group in the intermediate range of 16% to 30%, and those exceeding 30%. Certain trends within the bidding environment itself are apparent, but limited proof can be found of the bidding range exerting an influence on the quantity surveyor's estimate.

One of the apparent trends is that the range increases with an increasing number of bidders for any contract, the average number of tenderers for the groups being 7, 9, and 10 bidders respectively. A commensurate decrease in tendering consistency is indicated by the respective values of 3.34%, 6.05%, and 13.02%, compared with the mean CV for the total sample of 5.44%. Fixed sums constitute only 9.65% of the gross tendered amount for the group having a bidding range in excess of 30% compared with the average for the total sample of approximately 20%.

Quantity surveyors' estimating accuracy in all 3 sets is marginally above 11%. However, the intermediate group, representing the average condition, reflects a commendable level of consistency with a CV of 18.68%. In the case of the other two groups, the CV is approximately 50%. A study of the sample divided into 3 categories, denoting tenderers' CV of less than 5%, between 5% and 10% (the norm), and in excess of 10%, provides almost identical results to the exercise based on size of bidding range.

It is difficult to suggest the cause of the trends described above, but price forecasters should clearly be made aware of the circumstances which indicate that their estimates are highly sensitive to variations in bidding patterns. In cases where either the range of tenders, or the coefficient of variation deviates significantly from the norm, and particularly where low tender ranges occur, a distinct danger exists that the quantity surveyor's forecast could be inaccurate. In this situation the estimate should only be treated as 'correct' after a detailed examination of the total tender list is conducted.

7.4.1.3 Effect of 'fixed sums' on performance

The average value of items included in tender documentation which can be considered as 'fixed sums' comprises approximately 20% of the total gross tender. The effect that these items have on estimating performance is explored by studying the trends within the categories of fixed sums comprising less than 10% of the low bid, the 'normal' pattern with amounts between 10% and 25%, and projects where the sums exceed 25% of the tender.

A marked similarity is detected between the results emanating from this inquiry, and those linked to consistency in bidding. In both instances the quantity surveyors' estimates are normally both accurate and consistently forecast. However, performance deteriorates in both measures whenever an abnormal condition occurs, displaying great sensitivity to unusual conditions.

Unlike the quantity surveyors' estimates, the consistency of tenderers' bidding does not fluctuate wildly within the different divisions created. The CV of tenders actually improves with an increasing 'fixed' component, from 7.56% to 4.29%. The size of the fixed sum itself does not, however, appear to be the cause of the problem manifested in the highly variable price forecasts. When the calculation of the CV is based on the unadjusted values within the quantity surveyors' estimates, the category denoting a high fixed sum content still has a high CV of 46%, although mean absolute accuracy does improve to 8.85% of the tender sum.

It appears unlikely that price forecasters base their expectations of estimating accuracy on the 'nett' amounts (i.e. after adjustment for fixed sums). This is considered a major reason for the suggested propensity of estimators to be over-optimistic in the evaluation of their estimating skills.

7.4.1.4 Sundry features at differing performance levels

The actual estimating performance of quantity surveyors is presented in overview in Figure 7.1. However, this does not indicate the relationships between the nett absolute values used for the presentation and other features which could be applied in assessing relative accuracy. The results of applying alternative measures, used by researchers and

practitioners for measuring the accuracy or consistency of price forecasts, to the survey sample are indicated in Table 7.1.

MEASURE	NETT ACCURACY RANGES				
	0 - 5%	5 - 10%	10 - 15%	15 - 20%	EXC 20%
Nett Absolute Accuracy	2.13	6.97	12.54	17.27	41.49
Estimators' Nett CV	4.57	9.23	24.52	20.96	81.65
Gross Absolute Accuracy	1.68	5.46	9.73	13.32	28.15
Estimators' Gross CV	3.43	7.09	19.24	15.04	58.71
Bidders' CV	5.29	5.13	4.32	5.86	7.10
Fixed Sums Allowance	20.00	21.59	22.51	22.69	26.47

TABLE 7.1 MEASURES OF ACCURACY RECORDED.

(Source: National Survey, 1992)

The terms used in the table above are explained as follows:

"Nett Absolute Accuracy" - the mean absolute deviation of the estimate from the low bid, after allowing for the deduction of fixed sums.

"Estimators' Nett CV" - the coefficient of variation of the range of estimates, after allowing for the deduction of fixed sums.

"Gross Absolute Accuracy" - the mean absolute deviation of the estimate from the low bid, without allowing for the deduction of fixed sums.

"Estimators' Gross CV" - the coefficient of variation of the range of estimates, without allowing for the deduction of fixed sums.

"Bidders' CV" - the mean of the coefficients of variation for the tender lists applying to individual projects in the sample.

"Fixed Sums Allowance" - the mean of the fixed sums, expressed as a percentage of the tendered amounts for the individual projects in the sample.

It can be seen from above that the accuracy described by the gross figures are superior to those which allow for the omission of fixed sums. However, a further feature of the relationship between the two measures of accuracy is that the relative differences between them increase as the accuracy deteriorates. This is shown in Figure 7.3.

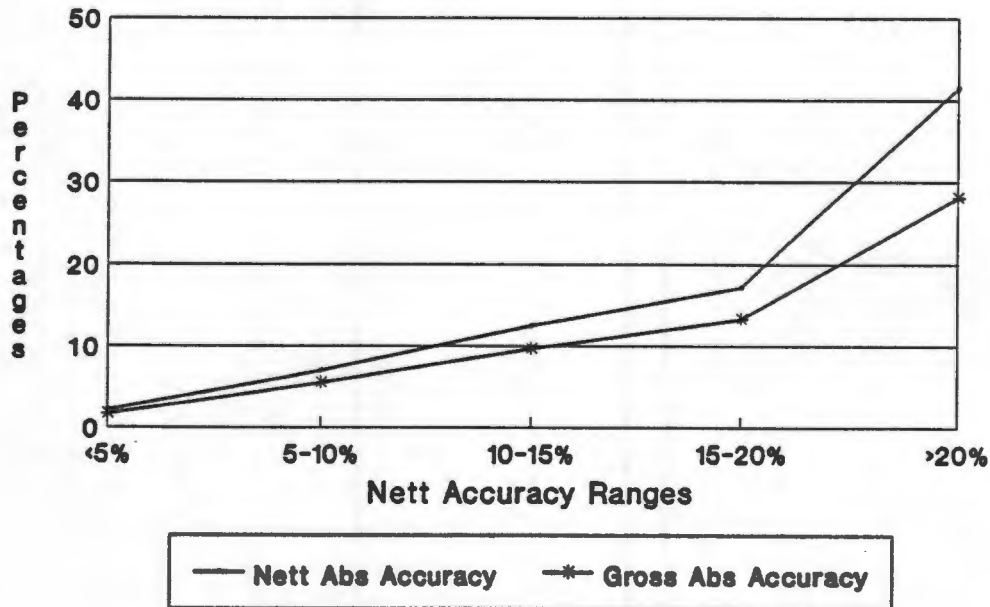


FIGURE 7.3 NETT / GROSS ABSOLUTE ACCURACY.

(Source: National Survey, 1992)

The details in Table 7.1 enable a comparison to be made between the estimating consistency achieved by price forecasters (estimators CV), and the variability of tenders about the mean bid on individual projects (bidders CV). It is recognised that, although the two measures are not directly comparable, the trends displayed by the analysis indicate that the consistency achieved by the professional consultants is far more variable than that of contractors compiling individual tenders.

All of the various measures of performance illustrated appear to be suitable for indicating relative performance levels, the sample indicating similar trends throughout. Of particular interest are the features associated with the range of projects exhibiting the poorest estimating accuracy. These are; (a) a high number of bidders, (b) higher than average project values, (c) greater variability than usual in terms of tenderers bidding range and CV of bids, (d) a large percentage of the tender amount comprising fixed sums.

7.4.2 Market conditions

This factor is investigated at two levels. Firstly, the data is separated into annual groupings, based on the tender date, to establish whether variable trends are discernible amongst the divisions. Secondly, the study is directed at possible differences in estimating achievements occurring during the different economic cycles experienced in the South African construction industry. In particular, the economic growth cycle phase from May 1986 to March 1989 (Hindle, 1991), is used as a basis for the investigation.

Table 7.2 provides a summary of the estimating performance achieved in each of the 10 years covered by the sample. Before analysing the data in detail, it should be stated that the sample sizes for the years 1982 to 1985 are comparatively small and could therefore be the cause of any anomalous results indicated for those periods.

YEAR	MEASURE OF ACCURACY				
	Nett Accuracy	Gross Accuracy	Bids CV	Nett CV	Gross CV
1982	39.20	26.36	6.18	22.42	18.81
1983	13.70	12.85	4.53	49.50	47.08
1984	16.88	12.98	4.73	26.96	20.74
1985	16.24	10.92	4.88	25.29	21.97
1986	8.55	6.93	4.37	17.66	13.60
1987	11.88	9.14	4.36	87.52	66.65
1988	8.43	6.61	5.79	17.81	12.50
1989	7.52	5.22	4.81	13.10	8.78
1990	9.50	6.86	5.23	73.14	51.19
1991	14.02	9.18	6.89	23.72	18.09

TABLE 7.2 ESTIMATE PERFORMANCE VIEWED ON AN ANNUAL BASIS.

(Source: National Survey, 1992)

It is notable that the bids CV indicating the consistency of contractor's pricing as shown in Table 7.2, is remarkably uniform in pattern. The higher values for 1982 and 1990 occur under contradictory economic conditions. Possible reasons for the same resultant effect occurring are a tendency for bidders to attempt to achieve higher profit margins in growth periods, whilst in times when work is scarce, excessively low bids are sometimes submitted in an attempt to procure work at any cost.

In both instances the result is a larger than normal spread of tenders (21.21% in 1982, and 22.85% in 1991, as compared with the sample average of 18.38%).

Throughout the period under review, price forecasters display a tendency to overestimate the price of projects. Of the 243 projects listed, 91 are underestimated, but the true nature of this practice is more appropriately portrayed by the nett relative accuracy levels. Only in two years, namely 1983 and 1988, are negative mean relative accuracy levels evident. The relative and absolute accuracy levels as portrayed in Figure 7.4 move in sympathy with one another, due in part to the predominantly positive nature of the estimates.

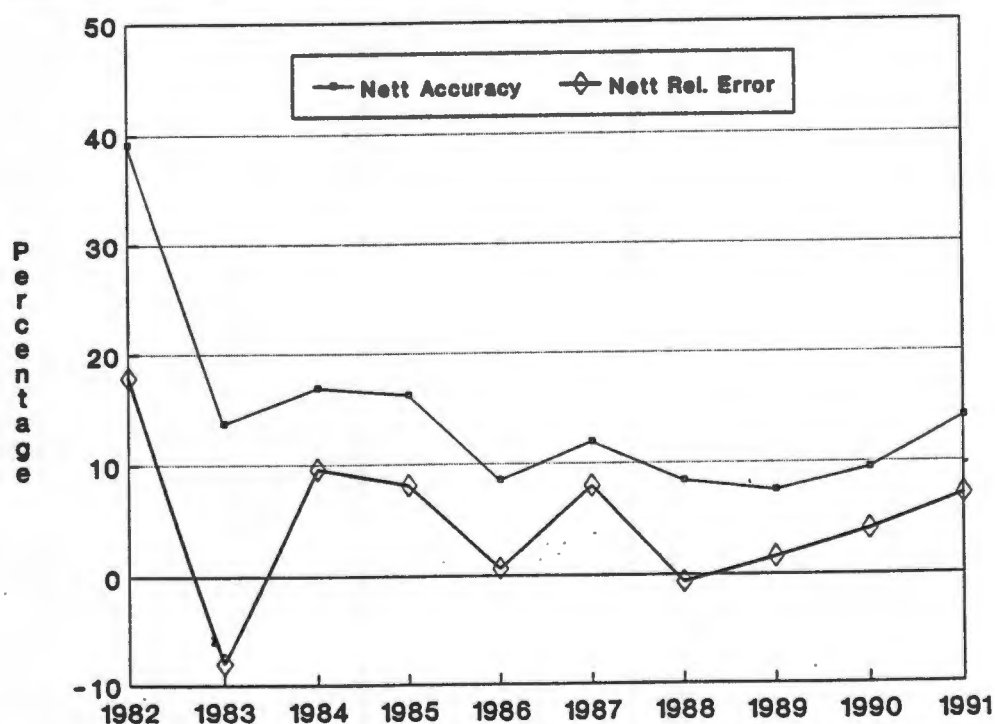


FIGURE 7.4 RELATIVE / ABSOLUTE ACCURACY: 1982 - 1991.
(Source: National Survey, 1992)

Inspection of the tender / estimate results around the economic growth cycle phase of mid 1986 to early 1989 reflect an interesting phenomenon, as indicated by the trend line for nett CV of estimator's price forecasts in Figure 7.5.

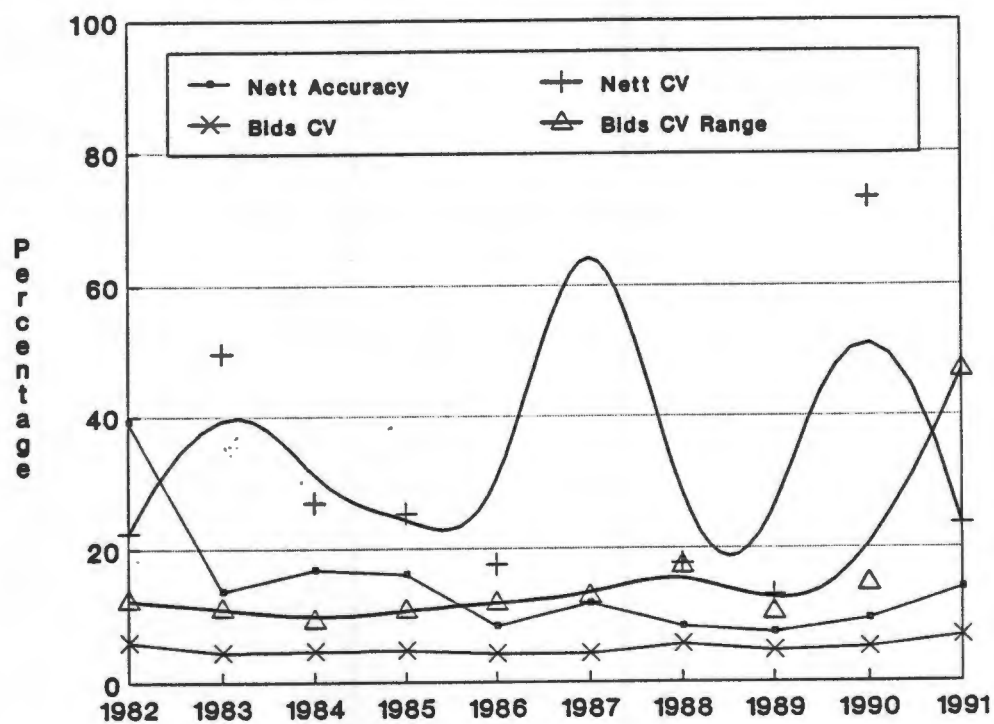


FIGURE 7.5 PRICE FORECASTING PATTERNS: 1982 - 1991.

(Source: National Survey, 1992)

Extreme variability in the accuracy of price forecasts produced in the period 1986 to 1990 is evident from the steep percentage rise in mean nett CV in both mid-1986 and mid-1989. It is postulated that a possible reason for the trend shown is a 'delayed reaction' by estimators to altering economic conditions in the first period; a period of stabilisation in the middle of the economic cycle; and a further 'delayed reaction' as conditions deteriorated in the second period.

On the basis of the postulation above, a period of relatively consistent performance in terms of price forecaster's estimates can be expected to prevail after the period studied, until shortly after the next swing in the economic cycle. An interesting feature of Figure 7.5 is the marked increase in the range of contractor's bidding CV's since 1990, notwithstanding the fact that the mean bidding CV displays a less pronounced increase. If this pattern continues after 1991, a possible result will be another steep increase in the variability of price forecasters estimates, even during a comparatively passive period in economic terms.

7.4.3 Type of project

A wide variety of project types are identified for the purposes of this investigation. Those studied include contracts undertaken for different client bodies (i.e. private sector, municipal authorities, and central government); the differentiation between new work and alterations / renovations; and for specific forms of accommodation as indicated in the CI/SfB classification system.

Client Sector

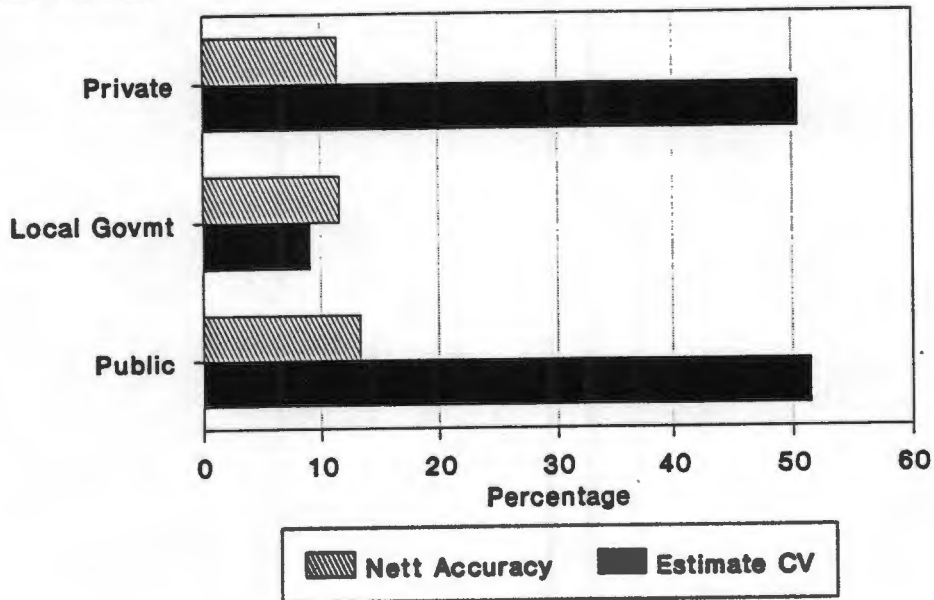


FIGURE 7.6 ESTIMATING PERFORMANCE BY CLIENT SECTOR.

(Source: National Survey, 1992)

Accuracy of estimates conducted for all three client sectors are similar, varying between 11.41% and 13.34%. Whilst the CV for work undertaken on local government projects is an acceptable 9.08%, the commensurate grade achieved for private sector work, and projects undertaken for central government, is 50.46% and 51.47% respectively. This is indicated graphically in Figure 7.6.

Analysis of the schedules fails to disclose reasons for the differing performance depicted, although it is noted that the bidding variability of tenderers on central government work is greater than the mean, but is not considered exceptional at 6.46%. A feature of the projects in this category is the low proportion of the tender amount constituted by the fixed sums (17.04%).

Little difference exists between the estimating performance of quantity surveyors on new work, as compared with alteration/renovation projects. The mean nett absolute deviation

from tenders are 11.51% and 12.47% respectively. The main distinction between the two types of work relates to the variability of the price forecasts, with new work registering a CV of 49.31% and alterations 24.01%. A feature of the alterations contracts is the high (28.34%) level of fixed sum content, but as in the case of client sectors, no obvious causes for the disparity in consistency are discernible.

The projects comprising the sample represent a wide spectrum of use as shown in Figure 7.7.

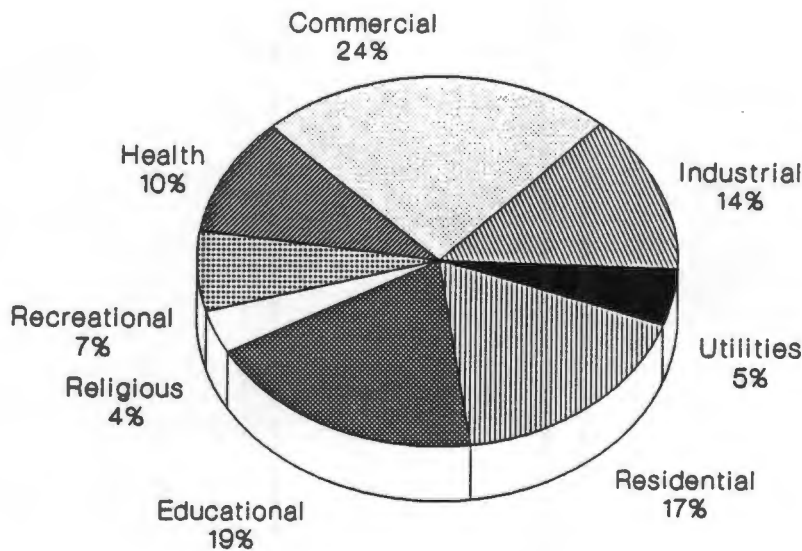


FIGURE 7.7 SAMPLE CATEGORIES BY CI/SFB GROUPING.

(Source: National Survey, 1992)

In most instances where it has been suggested that project type plays a significant role in determining estimating performance, the reason given is actually related to confidence and expertise gained by undertaking a number of estimates on projects of a similar nature, such as schools. Where this is the case, it is unlikely that the accuracy achieved can be ascribed to the project type.

In the sample tested, no evidence of estimates being produced on a major scale in this repetitive manner is visible, although one firm (No. 12) does produce a limited number of repetitive type estimates on service stations. Figure 7.8 provides an overview of the performance achieved by all firms in the various categories of use as represented by the CI/SfB groups.

CI/SfB Group

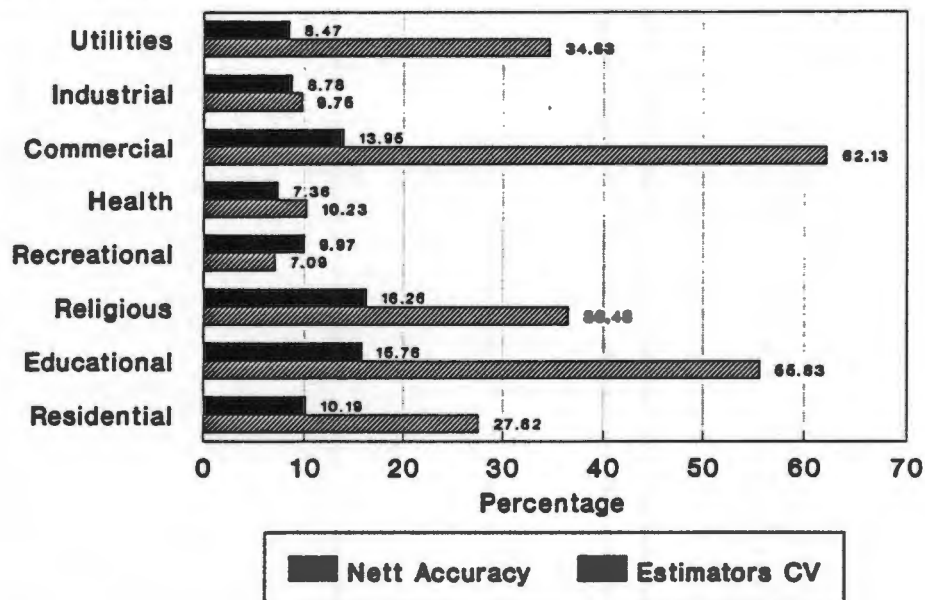


FIGURE 7.8 ESTIMATING PERFORMANCE BY CI/SFB GROUPING.

(Source: National Survey, 1992)

Whilst the overall performance for industrial, health and recreational facilities are far superior to the other types shown, an examination of the details relating to these groups fails to indicate any exceptional factors which could be construed to be a cause of the good results shown. However, the other groups do display some unusual characteristics which could be linked to the relatively high variability level of the associated estimates. A high level of fixed sums (30.89%) is included in contracts dealing with the group encompassing administrative, commercial and protective services, together with a low CV for tenderers bids of 4.47%. The variability of bids submitted for the remaining groups are noticeably higher than the average, in the range 6.13% to 6.62%. In this form, the analysis of the sample is regarded as inconclusive in determining whether the building use plays any part in influencing estimating accuracy or consistency.

The projects estimated by firm 12 are of specific interest in identifying whether or not estimates produced on a number of jobs of a similar nature produce better results than non-repetitive forecasts. Unfortunately, the sample size upon which the study is based is small (firm 12 having 6 service station projects plus 9 jobs of a varied nature). The results emanating from the study cannot therefore be considered as conclusive but should be viewed as indicative of possible solutions only.

As shown in Figure 7.9, the results achieved by estimates on service stations are clearly superior to those for the balance of the sample.

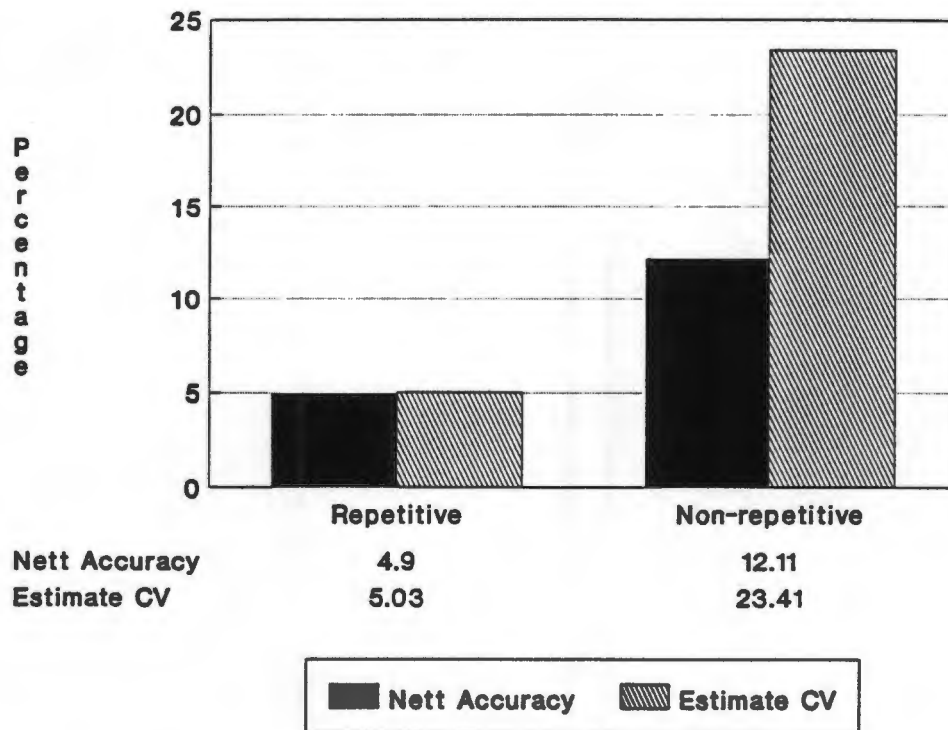


FIGURE 7.9 ESTIMATES CONDUCTED ON TYPICALLY REPETITIVE PROJECTS.
(Source: National Survey, 1992)

An important feature of the results shown above, is that several factors otherwise considered to be detrimental to the consistent provision of accurate forecasts are evident in the service station sample, whilst some normal indicators of likely good estimating performance apply to the remaining jobs.

In particular, the service station sample includes a higher than average number of bidders (9), a relatively high bids CV of 6.56%, and a large fixed sum content (25.47%). Conversely, the other projects are tendered upon most consistently (4.78%) by a small number of contractors (6).

These factors serve to confirm the opinion that forecasts presented by a specific estimator on typically similar projects are likely to be consistently more accurate than other estimates. As previously stated, the reasons for this would appear to be linked to factors not specifically contingent upon the project or type of building, but rather to influences such as effective data, and an 'expert' knowledge of all conditions relating to such contracts.

7.4.4 Project size

In order to establish a structured base for assessment of the affects of project size in South African contracts, value categories based on those listed in the Tariff of Professional Fees (ASAQS, 1992) are used. In those instances where sample sizes are small, categories have been combined to provide statistically meaningful results.

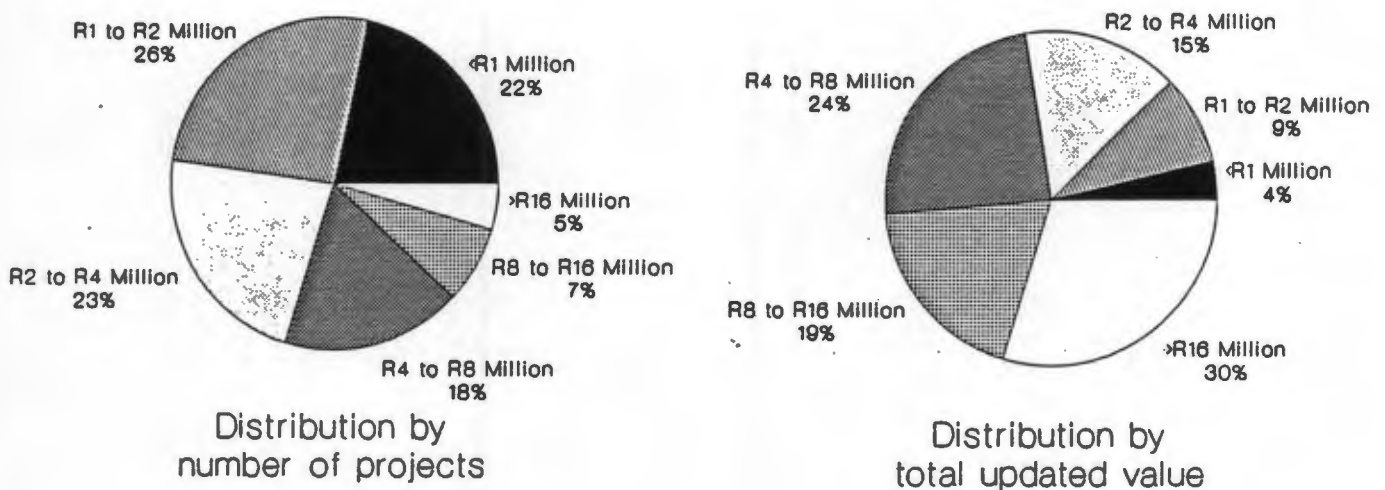


FIGURE 7.10 SAMPLE CATEGORIES BY VALUE OF PROJECT.

(Source: National Survey, 1992)

In Figure 7.10 it can be seen that although comparatively few large projects are included in the sample, in terms of the total value of estimates compiled by quantity surveyors these jobs comprise an extremely important sector of the market. The average value of projects in the total sample is R 4 348 110 at mid-1992 price levels.

An analysis of the sample based on the value categories stated is summarised in Table 7.3. From this abstract it can be seen that estimating performance within the divisions is generally close to the internationally accepted norms for both accuracy and consistency, but the values for projects of more than R16 Million indicate a sharp reduction in performance for large jobs.

CATEGORY	MEASURE OF ACCURACY			
	Bids CV	Fixed Sums	Nett Accuracy	Nett CV
Less than R1 Million	6.50	15.18	7.44	10.19
R1000000 - R2000000	6.33	19.28	12.64	21.81
R2000000 - R4000000	4.75	25.65	10.48	12.46
R4000000 - R8000000	4.28	27.75	15.58	17.13
R8000000 - R16000000	3.48	26.01	10.69	10.29
Exceeding R16 Million	6.39	21.40	21.22	34.54

TABLE 7.3 ESTIMATE PERFORMANCE BASED ON PROJECT VALUE.

(Source: National Survey, 1992)

The trend shown in respect of larger projects is unexpected as it is the total reverse of that discovered in empirical studies overseas. The schedules (Appendices B and C), confirm that tender lists on large contracts are comparatively small, the average number of tenderers being 7. This condition normally results in stable tendering conditions, but in this sample there is a slight increase in the variability of the bidding range for large contracts in comparison with the intermediate value ranges.

A possible reason for such variability is the possibility of collusion between the small groups of tenderers. This is dismissed as a consideration, however, as such action would result in estimates being generally below the tender values. In the sample however, the mean nett relative deviation for this group of projects is 17.17%, as compared with a mean figure of 3.99% for the study as a whole.

A tangible cause of the condition discovered above is not evident. It is possible, however, that the sample size (11 projects), for this category of work is a contributory consideration. A need for further research to be conducted into the matter is indicated.

7.4.5 Number of bidders

In the 10 year period covered by the study, the average number of tenderers per project is 8. As stated in an earlier section of this dissertation, the general view of researchers is that more than 3 to 5 tenderers for any project merely adds to the cost of obtaining bids and is therefore unnecessary. The data base has been segmented into categories of small tender lists not exceeding 5; average lists of between 5 and 10 tenderers; and large tender lists of more than 10 tenderers, and is summarised in Figure 7.4.

CATEGORY	MEASURE OF ACCURACY			
	Bids CV	Tender Range	Nett Accuracy	Nett CV
Less than 5 bids	5.76	15.53	13.44	59.56
Between 5 and 10 bids	5.17	17.98	10.18	38.97
More than 10 bids	5.76	23.32	14.08	20.38

TABLE 7.4 ESTIMATE PERFORMANCE BASED ON NUMBER OF BIDDERS.

(Source: National Survey, 1992)

Noticeable features of the summary are; the consistent nature of the tenderers' CV even though bidding ranges increase, and the reduced variability of estimators' price forecasts, with increasingly larger numbers of bidders.

Closer examination of the sample discloses that in addition to the range of bids increasing in the manner above, the mean relative deviation of forecasters' estimates from the tender amount increases significantly when more than 10 bids are submitted. This indicates a likelihood that the 'movement' within the range is at the lower pricing levels, resulting in the 'overestimation' by the consultant.

When the sample is further segmented to reflect projects upon which 3 or fewer contractors bid, significant deterioration in a number of the features relating to accuracy occurs. Tenderers' CV, range of bids, mean absolute accuracy of the estimate, and coefficient of variation of estimates are all affected by this situation.

7.4.6 Location of project

The initial data source (lists of projects tendered for by members of the Cape Peninsula MBA), automatically limits the extent of the investigation into the influence of this factor on quantity surveyors' price forecasts. A subjective division of the geographical areas covered by the projects is used for the study which is necessarily restricted to areas of the Cape Peninsula and surrounding regions. The analysis of the sample, divided into the areas considered to represent possible variable tendering conditions, is summarised in Table 7.5.

REGION	Projects	MEASURE OF ACCURACY		
		Bids CV	Nett Accuracy	Nett CV
(A) Cape Peninsula	86	5.96	9.28	23.66
(B) Boland	3	2.97	7.29	5.95
(C) Atlantis	5	4.85	3.70	7.99
(D) Metropolitan Area	34	5.82	20.10	83.98
(G) Northern Suburbs	49	4.97	13.89	15.82
(H) Cape Flats	66	5.07	10.00	70.47

TABLE 7.5 ESTIMATE PERFORMANCE BASED ON PROJECT LOCATION.

(Source: National Survey, 1992)

The conditions under which projects are undertaken in these areas vary considerably, and are undoubtedly allowed for by any contractor bidding for work there. These conditions include distance from major material suppliers such as experienced in the Boland regions (area codes B and C); difficulties of working in metropolitan areas (area D); challenging physical conditions such as experienced along the Cape Peninsula coastline (area A); and working in areas with extremely high crime and political disturbance records as found in parts of the Cape Flats (area H).

The most favourable results for areas B and C are not discussed in detail due to the extremely small sample sizes reflected. Apart from these results, the most prominent features of the summary are the very high levels of inconsistency for estimators' price

forecasts in areas D and H. Detailed inspection of the project details within these area samples fails to disclose the presence of any uncommon features which could indicate reasons for the results observed.

It could be argued that the total lack of any identifiable pattern within the regional data is an indication that the location itself is the prime reason for the variable performance displayed. However, the divisions created are relatively arbitrary and do not therefore conclusively support this contention. The need for further research into this factor is indicated, together with a broadening of the study of locations into larger, more widespread regions.

7.5 ANALYSIS OF PUBLIC SECTOR SAMPLE

Unless otherwise stated, the divisions used for the analysis of the foregoing main survey are applied to this section as well. The independent public sector sample discussed in this section (Appendix C), is derived from the data of the Department of Public Works and Land Affairs, consisting of 45 projects throughout South Africa, tendered for in 1990 and 1991.

Details relating to the tenders received, other than the value of the lowest bid, have not been made available. Comparison of factors derived therefrom, with similar data included in the main Western Cape sample is therefore not possible. In addition, the relatively small number of contracts, including projects of a diverse nature in many areas of the country, results in small sample sizes for certain features discussed in detail in the main study. The main objectives of including this limited sample in the dissertation are to broaden the scope of the study in terms of location, to reflect a particular public sector based overview, and to provide data for comparison with the main study.

The PWD allocates projects to consultants in a structured manner, attempting to distribute the work amongst as many firms as possible. In doing so they consider size of project / quantity surveying firm and the region in which the work is to be done. The result of this policy is that very few firms are shown to have worked on more than one of the projects in the sample. It is thus impossible to examine the performance of individual firms undertaking this work. In addition, as the data does not give details of the tender range, no comparison between tenderers' bidding consistency and price forecasters' accuracy is possible.

In some instances the PWD directs consultants not to include fixed sums in the contract documentation. The schedule consequently reflects a low mean fixed value content of 10.86%. If the projects without fixed sums are excluded from the sample, the mean content is shown to be 15.76%, still considerably lower than the average of 21.92% found in the main survey.

Extraction of a test sample comprising those jobs with fixed sums exceeding 25% of the low bid fails to provide any further indication of the affect that fixed sums have on estimating performance. Analysis of the 5 projects in this category reflects unacceptably high levels of inaccuracy in terms of both gross and nett figures, but lower than average figures denoting consistency in forecasting. Although this does indicate consistently inaccurate estimates being associated with high fixed sum allowances, the sample size dictates that these results cannot be viewed as being conclusive.

A notable feature of the PWD sample is that the accuracy profile for the main survey, portrayed in Figure 7.1 is confirmed. The uniform nature of the two samples in terms of division into accuracy categories is very significant, confirming in an even more emphatic manner that the accuracy levels indicated by estimators responding to the national survey are highly optimistic.

The division of the two samples into accuracy divisions is shown in Figure 7.11.

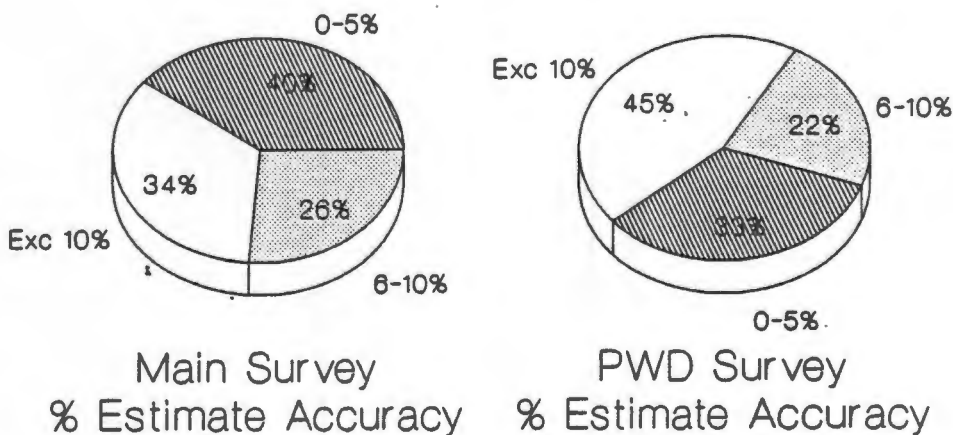


FIGURE 7.11 COMPARISON OF SURVEY SAMPLES: ACCURACY DIVISIONS.
 (Source: National Survey, 1992)

As the data provided is for 1990 and 1991 only, it is not possible to examine the 'market condition' factor in detail. However, it is seen that the decline in estimating performance levels over this period as shown in Table 7.2 is repeated in the PWD sample. The summarised details are given in Table 7.6.

YEAR	MEASURE OF ACCURACY			
	Nett Accuracy	Gross Accuracy	Nett CV	Gross CV
1990	11.40	10.56	30.46	25.41
1991	16.79	13.71	31.33	28.45

TABLE 7.6 PWD ESTIMATE PERFORMANCE VIEWED ON AN ANNUAL BASIS.

(Source: National Survey, 1992)

Evaluation of different project types is necessarily limited to a comparison of new work with alteration / renovation contracts, and a study of the predominant form of use for buildings included in the data base.

As in the main study, relationships between new and alteration work and estimating performance cannot be clearly established. The new work contracts reflect a reasonable mean absolute accuracy level of 12.15%, but poor consistency with a nett CV of 42.87%. Estimates on alteration work, however, display low variability (CV of 9.84%), but are generally inaccurate (21.01%).

Most of the projects included in the data base (76%), relate to buildings of an administrative / commercial nature as defined by CI/SfB categories. A comparison with the relevant details in the main study indicate an almost identical level of accuracy achieved for the PWD sample (13.61% as compared with 13.95%), but a vastly improved nett CV of 26.27%, as compared with the 62.13% recorded for the large sample. It was noted in the main study that this group was associated with a higher than normal value of fixed sum items. This is not the case in the smaller sample, and the inference that a particular relationship exists between these features can therefore be ignored.

The division of the PWD sample into value categories as determined by the main survey is given in Table 7.7.

CATEGORY	MEASURE OF ACCURACY		
	Projects	Nett Accuracy	Nett CV
Less than R1 Million	7	13.46	13.77
R1000000 - R2000000	11	16.51	23.75
R2000000 - R4000000	14	10.10	13.95
R4000000 - R8000000	6	13.74	11.42
R8000000 - R16000000	2	47.06	54.77
Exceeding R16 Million	5	11.87	5.96

TABLE 7.7 ESTIMATE PERFORMANCE BASED ON PWD PROJECT VALUE.

(Source: National Survey, 1992)

Analysis of Table 7.7 should recognise the fact that in several of the divisions few projects are represented. If the 3 largest value categories are combined in an effort to overcome this problem, the 13 projects represented display a nett accuracy of 18.15%, with a nett CV value of 22.15%. Although no meaningful conclusions can be drawn from these figures, it is noted that the few projects exceeding R16 million display a contrary pattern to the equivalent group in the main study. However, the trend indicated in the PWD sample is consistent with trends observed overseas for large projects.

Another factor tested which produces possibly spurious results due to small sample sizes is the number of bidders on any individual project. In both the PWD sample and main samples the average number of tenderers on any project is 8.

A summary of the national PWD sample, partitioned into the same categories used in the main Cape Peninsula survey is provided in Table 7.8.

CATEGORY	MEASURE OF ACCURACY		
	Projects	Nett Accuracy	Nett CV
Fewer than 5 bids	10	20.11	22.25
Between 5 and 10 bids	33	13.29	32.78
More than 10 bids	6	10.10	15.87

TABLE 7.8 ESTIMATES FOR PWD BASED ON NUMBER OF BIDDERS.

(Source: National Survey, 1992)

In the table above, the intermediate category is the only one that can be considered statistically reliable due to the sample sizes. The performance levels shown for this level are similar to those found in the comparative division for the main study. A further observation within the main study that can be confirmed by application of an analysis of the small sample, is the tendency for reduced variability of estimators' price forecasts with increasingly larger numbers of bidders. A test conducted in both studies indicates that when even smaller tender lists of 3 or less are encountered, estimating performance is seen to suffer.

7.6 CONCLUSIONS

It has been positively proven in this chapter that many price forecasters in South Africa perform at a level below that observed in similar studies overseas. In addition, the estimators' own perception of the accuracy and consistency of price forecasts produced has been shown to be extremely optimistic. This situation demonstrates that there is considerable potential for improving the design price forecasting service to clients.

The two data samples used for testing the validity of estimators opinions, previously established in respect of factors which influence estimating performance, provide sufficient information for determining the existence of such a relationship for several factors. The factors found to affect estimating accuracy and consistency are estimators' expertise, market conditions, type of project (particularly the client sector, and historical cost data when used for 'repetitive' project types), project size (value), and the number of tenderers

Chapter 7

for a contract. Whilst estimators' expertise and historical cost data are not specifically studied in the chapter, the results emanating from the study of the performance of individual firms provides reasonable indications as to the importance of these factors.

With regard to market conditions, the predominant trend is for price forecasters to overestimate the cost of projects. The tendency observed overseas for estimators to display a 'delayed reaction' to changing economic conditions in their forecasts is supported by the analysis of the main survey data covering a 10 year period.

While the reasons for contrasting performance are not identified, differences in performance between estimates compiled for various client sectors are apparent. This provides a possible area for further research, allowing for differences in contract documentation and price control mechanisms employed by various client bodies.

A similar situation in terms of a lack of clarity as to the causative nature of the factors is found when considering project value, number of bidders, and the nature of the tenders submitted. These factors are not seen to be highly influential in determining estimating performance, but the trends observed should be considered by the estimator both at the time of compiling the forecast, and in the assessment of the bids received.

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8. SUMMARY AND CONCLUSIONS

*"The great tragedy of science - the slaying of a beautiful hypothesis by an ugly fact" :
Thomas Henry Huxley*

8.1 CONCLUSIONS

The main objectives of this study are to establish the level of proficiency of price forecasting of South African quantity surveyors, and to ascertain the most significant factors influencing such performance. The first objective, namely establishing the proficiency level of local quantity surveyors' price forecasting, is closely linked to the main problem which is stated as:

Pre-tender price forecasts produced by quantity surveyors in South Africa are consistently inaccurate and do not meet the expectations of either architects or clients.

This statement is substantiated by means of an empirical study of the price forecasting performance of quantity surveyors on a number of local building projects. The results of this survey are compared with: (i) the accuracy standards expected by architects and clients as established in the literature review and (ii) the results of similar overseas studies.

The main findings to develop from the above analyses are as follows. In general, the pre-tender estimates produced by South African quantity surveyors are: (i) less accurate than that perceived by quantity surveyors themselves and fail to meet the expectations of architects and clients, and (ii) less accurate and more inconsistent than their overseas colleagues.

The potential for improving the design price forecasting service is therefore conclusively proven.

The second objective of the study is to identify the most significant factors affecting price forecasting performance. This objective is accomplished by: (i) examining established theory with respect to the subject matter in order to determine those factors considered by overseas researchers to be important, (ii) undertaking a national survey of South African quantity surveyors in order to establish their opinions on the importance of the factors, and

Chapter 8

(iii) analysing the empirical survey in order to determine the influence of certain of the factors on the accuracy of the estimates studied.

The findings emanating from these sources are summarised as follows:

(a) Estimator's Expertise. Overseas literature indicates that this is one of the most important features at all stages of design development. Feedback from estimate / tender results are considered necessary to improve the data base used. In both overseas and South African opinion surveys, estimators rate this factor highly. Although no direct test of the item is applied in the empirical study conducted in South Africa, differing performance standards applicable to individual price forecasters are evident. The universal support indicated by the research denotes it to be a most important factor in the consideration of achieving accuracy in estimates.

(b) Historical Cost Data. "Laboratory tests" described in the literature establish that there is a strong link between this factor and estimating expertise. The availability of data is extremely important to the inexperienced estimator in the early stages of design price forecasting. Recently priced bills of quantities are universally accepted as the most common data used. This factor was highly rated by respondents to Ogunlana's survey, but is only considered to be of moderate importance by South African estimators. The local survey reflects tender-stage views, whilst the relatively higher importance ranking of the overseas survey is linked to usage throughout the design sequence. This item is not directly tested in the empirical study but is seen to play an important role, particularly if the data is relevant to future projects of a similar design or use.

(c) Design Information. This factor is seen to be important in the early stages of design development. Studies conducted overseas indicate that its importance diminishes with the advancement of design development. UK estimators indicate that the item is important in the production of accurate estimates during the design stage as a whole. The local opinion survey indicates that South African price forecasters also rate the factor highly. However, the validity of the local opinion is questionable as the South African study reflects the tender stage when project information should be essentially complete. This item is not tested in the empirical study.

(d) Market Conditions. The literature review discloses that estimators are found to respond slowly to changed economic market conditions. Whereas the UK estimators in Ogunlana's opinion survey grade this factor in the moderately important range, the local survey indicates that the item is regarded as extremely important in achieving price

Chapter 8

forecasting accuracy. With regard to the delayed reaction of estimators to variable market conditions, the empirical study of South African building projects confirms the findings of the overseas studies. However, since this ability is a major distinguishing feature between expert and inexperienced estimators, it is considered to be a further aspect of the expert's skills acquisition.

(e) Project Type. The main finding in relation to this item is that estimating is better on types of projects on which the estimator has had extensive personal experience. This is, however, considered to be a function of experience / expertise, unrelated to type of project. Estimators in both the local and overseas opinion surveys view the factor as being of moderate importance for the attainment of accurate estimates. Although variable performances for different project types are apparent in the results of the empirical study, the underlying reasons are not identified.

(f) Number of Bidders. Studies conducted overseas reflect contradictory results of estimator accuracy in relation to different sizes of tender groups. Price forecasters in both the UK and South African opinion surveys rate this factor as unimportant for estimating purposes. In the empirical study it is shown that extremes in tender group numbers do result in poor accuracy being achieved by estimators. It is suggested that this circumstance is more related to market conditions than numbers of bidders. This factor warrants the consideration of being graded as moderately important for achieving accurate estimates at the tender stage.

(g) Job Complexity. The literature study reveals that this feature which primarily affects estimating accuracy in early stage forecasts, is particularly relevant for inexperienced estimators when historical cost data is limited. In both the local and UK opinion surveys respondents indicate that the factor is only of moderate importance. The item is not tested in the empirical study.

(h) Project Size. The empirical study conducted locally reveals contrary results to those emanating from similar studies undertaken in other countries. Research undertaken in the UK indicates that accuracy on large projects (in value terms) is generally considered to be better than on small jobs. In contrast, the main sample of the local study reveals that performance on large projects is clearly inferior to that of small jobs. The public sector sample in the empirical study, although based on a small sample size, presents a condition similar to that found overseas. This factor receives a low rating by estimators in both the local and UK opinion surveys.

Chapter 8

(i) **Contract Duration.** This factor is universally rejected by respondents to both the UK and South African opinion surveys as being significant in influencing estimating accuracy. A study of the literature shows that the role played by this item in the estimating function has received limited attention from researchers. The factor is not tested in the empirical study.

(j) **Geographical Location.** Virtually no research on this feature is described in the literature reviewed. Respondents to the opinion surveys indicate that the factor does not play an important role in price forecasting accuracy. In the empirical research, the factor is not fully tested since the study is restricted to a relatively small geographical area. The results achieved do not display a discernible pattern.

The foregoing findings support the principal hypothesis of this research, namely that *"the expertise of the price forecasters and the provision of adequate historical price data are the two most influential factors affecting the accuracy of pre-tender price forecasts produced by quantity surveyors in South Africa"*.

8.2 RECOMMENDATIONS

It is clear that a number of further research opportunities exist in this field. In addition to items listed in earlier chapters, further topics that offer potential for research are:

- * The interrelationship between the factors referred to as 'project specifics' requires specific attention, in order to establish the "true" extent of their influence on price forecasting performance.
- * The extension of this study to incorporate earlier design stage price forecasts.

Although certain further research into the role played by specific factors is indicated within the earlier sections of this work, the principal emphasis needs to be placed on the improvement of skills development for individual estimators. The recommendation of Feldman (1986) that *"a social environment that requires learning"* needs to be created for the training of expert estimators suggests that structured programmes should be considered for the development of South African quantity surveyors undertaking price forecasts.

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APPENDICES

APPENDIX 'A' - SOUTH AFRICAN SURVEY DOCUMENTATION

Appendix 'A' contains the survey documentation sent to all quantity surveying practices in South Africa in early 1992. This comprises a covering letter requesting assistance plus a two page questionnaire, loosely structured on that used by Ogunlana (1989) for his Phd Thesis.

Details of the survey are as follows:

a) Questionnaires distributed:	557
b) Firms no longer active	-31
c) Questionnaires not received	-28
d) 'Extra' responses from firms	-24
<i>Legitimate sample response</i>	234
 Response Rate	 47%



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10 February 1992

Dear Practitioner

QUESTIONNAIRE ON TENDER ESTIMATING CONSIDERATIONS

Enclosed herewith you will find a short questionnaire relating to certain factors considered to affect the accuracy of pre-tender price estimates, compiled once detailed design has been approved. I would be extremely grateful if you could answer by completing this form.

Whilst forming part of the ongoing research activities within the Department, the primary purpose of this survey is to gather information for use in my research thesis towards the requirements for the degree of Master of Science in Quantity Surveying. The thesis is entitled "Accuracy in design stage price forecasting".

The circulation of this questionnaire is funded by the Research Committee of the University of Cape Town and their assistance in this regard is gratefully acknowledged.

Should more than one member of your firm perform the estimating functions referred to, it would be appreciated if separate submissions for each such estimator could be submitted. The confidentiality of information provided will be strictly maintained, the aggregate results of the study being made available to the profession.

I trust that the results will prove beneficial to all quantity surveyors and thank you in anticipation for your support. Please return the questionnaire(s) in the 'Free-Post' envelope by Friday, 21st February 1992. A stamp is not required.

Yours sincerely

Signed

R.G. PEARL

TENDER PRICE ESTIMATING

This research is designed to find out the opinion of practising construction price estimators (Quantity Surveyors) and offices about certain issues that affect the accuracy (precision) of cost estimates. Response to the questions will be treated as confidential.

1. Do you normally make a detailed comparison of your estimates with tender figures/final account figures:

- a. On all tenders received?
- b. Only when predictions are close to tender figures?
- c. Only when predictions differ significantly from tender figures?

2. Which of the following do you compare estimates with?

- Lowest bid
- 2nd lowest bid?
- Mean/Median of bids
- Final Account figures
- Any other bid (Please Specify).....

Comments.....
.....
.....

3. Do you think comparing estimates with any of the above serves any useful purpose?

- Yes
- No

Comments.....
.....
.....

4. Do you formally record estimate/tender comparisons with the specific purpose of using the data for future estimates?

- Yes
- No

Comments.....
.....
.....

Appendix A

5. Please rate each of the following as they affect the accuracy of estimates (from your experience) on a 7 point scale. (e.g. 1-least effect on estimate accuracy, 7-most effect on estimate accuracy).

Number of bidders
Design information available
Historical cost data
Project complexity
Project size

Estimator's expertise
Project location
Project type
Market condition
Project duration

6. What level of accuracy is appropriate for tender price estimates once the detailed design has been completed. Use office or/and personal standards.

+/-5%

+/-10%

+/-15%

+/-20%

Over +/-20%

7. What should be the datum for measuring the accuracy/precision of design phase cost estimates?

Low bid
2nd lowest bid
3rd lowest bid
Mean/median of bids
Other (Please specify).....

.....
.....

8. Please indicate for how many years you have been active in producing tender price estimates.

0 - 3

3 - 5

5 - 10

10+

Comments.....
.....

Thank you for your help with this research.

APPENDIX 'B' - SAMPLE OF 243 PROJECTS USED IN EMPIRICAL STUDY

Appendix 'B' is a schedule reflecting the details of building projects tendered for in the Cape Peninsula in the period 1982 - 1991. In order to identify a potential sample of projects tendered upon on the basis of bills of quantities, the records of the Master Builders' and Allied Trades' Association (Cape Peninsula) were scrutinised. This reflected a total of 1086 projects tendered upon using this procurement method. Consultants were then approached for details of estimates provided for listed projects. Information was provided on a total of 243 projects.

SUBMITTED BY ARA MEMBERS IN 1982-1991

TENDERS ON ALL PROJECTS WITH OS ESTIMATES PROVIDED.

PAGE 11

DATE	AREA/CITY/SECTOR	INDX	CONTRACT	TENDER DETAILS		TENDER DETAILS		GROSS		ESTIMATE		TENDER		ESTIMATE		METT		WIRE		MANS		OS		
				AMOUNT TENDERED	UPDATED VALUE	RANGE BID %	MEAN	CV	ESTIMATE	DEVIATION R %	GRAVS	FILED	ALLOW	TENDER	DEVIATION	ESTIMATE	DEVIATION	METT	DEVIATION	REL	WIRE	REL	MANS	REL
82/03/02	B	A	M	PVT	250.90	WAREHOUSE AND OFFICES	813854	2878717	32.83	908100	10.29	1110000	296166	36.39	203440	25.00	610394	906560	296166	40.32	40.32	40.32	21	
82/03/03	B	3	M	PVT	256.90	RESIDENTIAL FLATS	3673376	11273414	15.47	3833880	4.42	4099000	425624	11.59	0	0.00	3673376	4099000	425624	11.59	11.59	11.59	21	
82/06/29	B	7	M	PUB/2	1232.40	LIBRARY	3446643	1181884	28.05	410029	0.42	3800000	213337	58.18	148770	44.94	201893	415220	213337	105.67	105.67	105.67	21	
82/07/28	A	1	M	PUB/1	1233.20	MILITARY RADAR SCHOOL	3019000	9183436	7.26	1319927	2.09	2150000	-869800	-28.80	950250	31.47	2065500	1199750	950250	-82.03	-82.03	-82.03	21	
82/08/03	B	7	M	PUB/2	1234.00	SCHOOL	5503637	18230742	22.71	3909293	6.08	5400000	245963	4.59	904300	16.89	4497337	4695700	245963	5.53	5.53	5.53	21	
82/11/10	B	6	M	PUB/1	1235.40	RETIREMENT COTTAGES	3127490	15458489	20.75	5483064	5.77	4165000	-942400	-18.77	789795	14.22	439825	3486025	-942400	-21.80	-21.80	-21.80	21	
83/02/04	C	3	M	PUB/2	1235.60	TRAFFIC CONTROL CENTRE	340720	1034321	40.47	368574	8.23	331200	-9520	-2.79	0	0.00	340720	331200	-9520	-13.99	-13.99	-13.99	10	
83/03/16	B	5	A	PVT	1237.80	OLD AGE HOME	211112	630552	31.40	241825	9.11	1900000	-11120	-0.00	55749	26.41	153563	134751	-11112	-13.99	-13.99	21		
83/06/16	B	2	A	PVT	1242.40	SHOPS	1739423	1106407	14.51	430556	3.88	4100000	112000	2.81	169600	43.38	2278000	2410000	112000	4.07	4.07	4.07	34	
83/07/06	H	1	M	PVT	1242.40	SERVICE STATION	1950000	5922118	6.21	202807	2.83	2150000	-1535423	-88.37	0	0.00	1737423	2020000	-1535423	-88.37	-88.37	-88.37	27	
83/08/02	A	5	A	PVT	1244.70	OLD AGE HOME	1249530	3634825	10.39	1370169	3.21	1225000	265000	1.76	278840	22.32	970670	946140	265000	10.26	10.26	10.26	27	
83/08/16	B	5	M	PVT	1244.70	POLICE FLATS	949494	2762034	9.37	1006065	2.59	1012928	63432	6.48	193100	20.34	754394	819828	63432	6.39	6.39	6.39	14	
83/08/31	B	7	M	PUB/1	1244.70	MUSEUM	2126146	6097327	12.32	1617231	1.74	12500000	-3236933	-20.37	0	0.00	15734833	12500000	-3236933	-20.37	-20.37	-20.37	10	
83/09/08	B	7	M	PUB/2	1246.50	PRIMARY SCHOOL	1252189	614449	15.44	232360	5.47	2250000	11787	0.53	80000	3.80	2045346	2189700	11787	7.03	7.03	7.03	34	
83/09/28	A	5	M	PVT	1248.50	TEENIS PAVILION	2208022	5919836	22.65	435206	4.51	3400000	-38451	-6.87	56000	7.74	518951	480500	-38451	-6.44	-6.44	-6.44	17	
83/11/15	A	7	M	PVT	1275.90	ALTS TO SCHOOL	523533	1461111	17.20	566586	6.39	5250000	1467	0.28	78300	14.76	597890	556000	1467	7.01	7.01	7.01	17	
83/12/02	B	2	A	PVT	1276.40	FACTORY	479890	1894650	11.97	705356	4.19	4380000	-41890	-6.16	82000	12.06	946200	884850	-41890	-6.48	-6.48	-6.48	17	
83/12/09	B	5	M	PUB/2	1276.40	SPORTS PAVILION	2352189	6229582	22.68	1344623	4.79	11890000	-61358	-4.91	304150	24.33	1587169	1485000	-61358	-6.48	-6.48	-6.48	17	
84/03/30	B	3	M	PUB/2	1291.00	MUNICIPAL OFFICES	374931	1345331	22.65	435206	4.51	3400000	-38451	-6.87	56000	7.74	518951	480500	-38451	-7.41	-7.41	-7.41	17	
84/07/20	C	6	M	PVT	1298.50	MODERN STYLE CHURCH	2208022	5919836	20.83	2429276	2.56	3085000	874978	39.72	39.72	39.72	39.72	2434850	3085000	874978	55.98	55.98	55.98	21
84/08/08	B	7	M	PVT	1297.20	BUSINESS SCHOOL	462131	1259000	21.07	516234	3.07	8250000	-67892	-7.40	85000	9.52	807892	740000	-67892	-6.40	-6.40	-6.40	17	
84/08/22	A	8	M	PVT	1297.20	RESIDENTIAL HATSOMMETTS	1424424	3818964	9.59	1087206	6.00	15100000	83576	6.01	270000	18.96	1154424	12400000	83576	7.41	7.41	7.41	17	
84/08/31	B	2	M	PVT	1297.20	WAREHOUSE	388386	1332670	27.40	644167	4.67	5550000	-35386	-5.67	102950	10.46	495336	432150	-35386	-6.08	-6.08	-6.08	21	
84/11/02	B	6	M	PVT	1295.40	DAY CARE CENTRE	972707	25412371	19.51	10853409	3.34	10950000	1227293	12.62	2192900	22.55	7530707	8758000	1227293	16.36	16.36	16.36	17	
84/12/07	B	6	M	PVT	1294.60	OLD AGE HOME	1128311	2908833	12.08	1178497	7.95	1128200	-111	-0.01	225000	19.94	903311	903200	-111	-0.01	-0.01	-0.01	17	
85/05/22	B	3	A	PVT	1295.30	ETT TO WAREHOUSE / OFFICES	442700	162118	22.33	282182	2.27	3400000	92100	37.15	20300	0.19	227600	413600	92100	40.47	40.47	40.47	21	
85/07/25	B	3	M	PUB/1	1296.00	SHOPPING CENTRE	4631000	162118	22.33	282182	2.27	5500000	-14900	-2.35	237000	37.32	398100	413600	-14900	3.74	3.74	3.74	6	
85/08/16	H	3	M	PUB/1	1296.00	MAJOR SHOPPING CENTRE	19849786	5168295	9.17	2008587	1.35	22870000	2950214	14.65	14.65	0	0.00	19849786	22870000	2950214	14.65	14.65	14.65	27
85/08/23	M	3	M	PVT	1296.00	REHABILITATION CENTRE	3162750	8277624	6.73	3274609	4.81	3530000	371250	11.74	11.74	57900	1.00	371250	371250	371250	11.95	11.95	11.95	6
85/08/30	C	4	M	PUB/2	1306.10	SCHOOL & HOSTELS	7879769	20218001	25.04	8584386	3.80	6350000	470231	5.97	1900000	24.11	5979769	6450000	470231	7.06	7.06	7.06	17	
85/09/25	A	2	A	PVT	1304.20	WHOLESALE WAREHOUSE	89735	3880375	10.45	1607000	4.05	1607000	74000	4.83	682000	44.49	74000	925000	74000	8.70	8.70	8.70	14	
85/12/11	B	4	A	PVT	1309.60	ALTS TO OLD AGE HOME	1815832	2237713	14.87	959429	2.61	10100000	110285	12.26	397000	44.12	502735	613000	110285	21.93	21.93	21.93	34	
86/01/17	B	3	A	PUB/1	1309.60	ALT CUSTOMS STORE BLDG	524300	4516120	9.01	1919493	9.36	16500000	-165832	-9.13	1343200	75.07	452632	2864000	-165832	-36.64	-36.64	-36.64	21	
86/01/24	B	8	M	PVT	1310.90	OLD AGE HOME	446888	1353760	31.54	635499	3.28	4800000	-68888	-12.55	66000	12.02	432910	456410	-68888	-14.27	-14.27	-14.27	11	
86/02/07	B	2	A	PVT	1312.20	FACTORY ALTS/ADDS	1417137	3495181	13.44	1524198	2.91	17170000	298843	21.16	1008750	26.11	2855110	2861250	298843	5.47	5.47	5.47	11	
86/02/26	H	7	M	PUB/1	1312.20	THEATRE	3863860	9529700	10.28	4100002	3.40	38700000	4140	0.16	1008750	26.11	2855110	3863860	4140	0.22	0.22	0.22	21	
86/03/10	A	0	M	PVT	1316.80	OLD AGE HOME	446888	1353760	31.54	635499	3.28	4800000	-68888	-12.55	66000	12.02	432910	456410	-68888	0.82	0.82	0.82	6	
86/04/22	A	4	M	PUB/1	1321.30	PSYCHIATRIC HOSPITAL	435400	1082714	46.18	482793	9.94	4500000	14600	3.35	25000	5.74	462720	4250000	14600	3.56	3.56	3.56	17	
86/05/07	B	1	M	PUB/1	1325.90	TELEPHONE EXCHANGE	377700	892387	17.02	398070	4.27	3750000	-2700	-0.71	22000	5.82	355760	3550000	-2700	-9.76	-9.76	-9.76	17	
86/05/07	B	6	M	PVT	1325.90	CHURCH HALL	1010101	2389486	15.47	1092404	3.67	11000000	89899	8.90	95650	9.47	114451	1001350	89899	9.03	9.03	9.03	34	
86/06/25	A	1	M	PUB/1	1325.50	ALTS TO RESIDENTIAL FLATS	826275	1954617	12.22	870113	4.27	7880000	-30925	-6.71	246700	29.83	500225	541300	-30925	-6.71	-6.71	-6.71	24	
86/06/26	A	0	A	PVT	1325.50	ALTS TO RESIDENTIAL FLATS	1596000	3775484	18.90	1687455	5.52	14900000	-104000	-6.84	254000	15.91	1342000	1234000	-104000	-7.90	-7.90	-7.90	17	
86/09/03	B	5	M	PUB/2	1325.50	COMMUNITY SWIMMING POOL	5232127	12370795	8.36	5411864	3.11	5764000	342723	6.58	1273000	70.33	3959127	4303400	342723	8.70	8.70	8.70	1	
86/10/03	A	0	M	PVT	1325.50	INDUSTRY RESIDENCE	1976887	4641840	6.40	2049881	2.04	1945022	-5865	-0.29	410000	20.40	1560687	1560687	-5865	-0.36	-0.36	-0.36	30	
86/11/19	C	2	M	PVT	1325.50	BEACH RESORT FACILITY	3295114	7787716	12.52	3454099														

CONTRACT DETAILS										TENDER DETAILS										ESTIMATE DETAILS									
DATE	AREA/CI/AL/SECTION	INDET	CONTRACT	BIDS	AMOUNT TENDERED	UPDATED VALUE	RANGE BID I	MEAN TENDER	CV	GROSS ESTIMATE	DEVIATION %	BOEY % REL	GRABS % DEV	FIXED SURS ETC	ALLOW %	TENDER NETT	ESTIMATE NETT	DEVIATION %	NETT	HDSV % REL	HTADS % DEV	OS							
87/01/30	B	M	PVT	338.80	OPPHANSE	3099727	33.71	1625602	7.64	1510000	146120	10.71	10.71	221630	16.23	1142230	1288330	16.120	146120	12.79	12.79	21							
87/02/03	B	M	PVT	345.30	SHOPS / RESTAURANT	1137272	9.30	337421	2.77	523000	15000	2.94	2.94	56374	11.03	453626	468226	15000	15000	3.31	3.31	9							
87/02/17	B	M	PVT	345.30	RESIDENTIAL UNITS	678427	84.20	376518	10.92	427000	118662	39.12	39.12	0	0.00	303330	427000	118662	118662	39.12	39.12	21							
87/02/17	B	M	PUB/1	345.30	UNIVERSITY SCIENCE BLDG	19990172	4.92	9146438	1.86	9100000	135576	1.51	1.51	2234894	24.93	7037530	6843104	135576	135576	2.01	2.01	9							
87/03/02	A	A	PVT	350.40	COLLEGE OF MEDICINE	1708330	13.76	814703	4.64	835000	37550	7.40	7.40	187400	21.10	590030	647600	37550	37550	9.75	9.75	9							
87/03/04	B	A	PVT	350.40	LADIES HOME	1948950	7.03	926761	2.52	864000	-30000	-3.35	3.35	196000	21.88	700000	670000	-30000	-30000	-4.29	-4.29	34							
87/03/13	B	M	PVT	350.40	OLD AGE HOME	493839	50.38	364081	11.09	310000	-2742	-1.02	1.02	47000	14.89	268742	261000	-2742	-2742	-1.04	-1.04	21							
87/03/25	B	M	PUB/1	350.40	UNIVERSITY RESIDENCE	17041375	10.84	801878	3.21	7800000	49777	0.58	0.58	1384779	17.86	6370244	6415221	49777	49777	0.71	0.71	9							
87/04/16	A	A	PVT	355.30	ALT. OFFICES	1051737	19.83	338230	6.59	481600	-3984	-0.82	0.82	52000	10.71	433584	429600	-3984	-3984	-0.92	-0.92	11							
87/04/22	B	A	PVT	355.30	CRECHE	884196	8.76	418840	2.56	424000	15777	3.56	3.56	42250	10.35	365973	381750	15777	15777	4.31	4.31	9							
87/04/25	M	M	PUB/1	355.30	COMMUNITY CENTRE	732414	41.56	368589	11.42	345000	6853	2.03	2.03	27470	10.12	310477	317530	6853	6853	2.21	2.21	9							
87/04/29	M	M	PUB/1	355.30	SCHOOL	3544465	9.87	1724046	3.53	1850290	213852	13.07	13.07	65000	3.97	1571438	1785290	213852	213852	13.61	13.61	25							
87/06/18	B	M	PUB/1	360.60	TECHNICAL LIBRARY	7168303	8.73	3327746	3.00	3360000	3000	0.09	0.09	667725	19.89	2689275	2629275	3000	3000	0.11	0.11	9							
87/07/24	B	A	PVT	373.00	ALTS FOR PARKING	308032	7.60	190311	2.52	1610000	-148668	-0.42	0.42	475405	26.94	1289763	1140595	-148668	-148668	-11.93	-11.93	21							
87/09/03	A	B	M	PVT	384.30	HOUSE	1568852	20.04	873513	5.37	800000	17000	2.17	2.17	384737	49.14	398243	415263	17000	17000	4.27	4.27	9						
87/09/25	A	M	PUB/2	384.30	LIBRARY	2492933	14.89	1312722	4.02	1306177	41977	4.98	4.98	317100	25.49	927100	989077	41977	41977	6.49	6.49	8							
87/10/20	M	M	PVT	389.30	UNIVERSITY TEACHING BLDG	3068691	4.79	2814930	1.57	3072000	509349	19.88	19.88	379467	30.42	1723184	2292333	509349	509349	28.36	28.36	21							
87/10/28	B	M	PUB/1	389.30	TECHNICAL ADMIN BLDG	7841285	8.98	4216745	2.67	3990000	13940	0.35	0.35	707000	17.78	3249060	3283000	13940	13940	0.43	0.43	9							
87/11/16	M	B	M	PVT	394.40	CHURCH	1253755	8.92	643648	2.94	655000	12817	2.00	2.00	91500	14.25	526838	583500	12817	12817	2.33	2.33	34						
87/11/18	M	B	M	PVT	394.40	2 BLOCKS FLATS	2466570	21.46	1453922	4.89	1500000	134162	9.02	9.02	241000	17.64	1124838	1259500	134162	134162	11.93	11.93	6						
87/11/20	M	A	M	PUB/1	394.40	TRAINING CENTRE	1472659	11.26	804555	3.00	785000	31000	4.11	4.11	134500	17.81	619700	650700	31000	31000	5.00	5.00	9						
87/12/04	A	M	PVT	404.50	RESEARCH CENTRE	6777827	7.07	3718075	2.09	2850000	-710560	-19.96	19.96	640000	17.97	2920560	2210000	-710560	-710560	-28.33	-28.33	17							
87/12/10	B	M	PUB/1	404.50	TECHNICAL TEACHING BLDG	24349885	4.27	13047403	1.58	20775219	7973117	62.28	62.28	4624269	36.12	1702212	16150950	7973117	7973117	97.30	97.30	21							
87/12/12	B	M	PVT	404.50	OFFICES	4037907	8.24	2186580	2.74	2030000	-91212	-4.30	4.30	419000	19.75	1611000	1611000	-91212	-91212	-5.36	-5.36	17							
88/02/03	B	M	PVT	424.90	CHURCH RECREATION HALL	674623	20.75	410267	11.90	387500	14127	3.78	3.78	44900	17.38	308473	322400	14127	14127	4.58	4.58	1							
88/02/10	M	B	M	PUB/1	424.90	TELEPHONE EXCHANGE	1443591	29.40	901120	3.35	894000	97400	12.23	12.23	0	0.00	796600	894000	97400	97400	12.23	12.23	1						
88/02/16	A	A	PVT	424.90	SERVICE STATION	1141227	24.43	730537	7.49	438000	8250	1.31	1.31	243200	38.42	366550	394800	8250	8250	2.13	2.13	12							
88/02/19	M	M	PVT	424.90	MUNICIPAL LIBRARY	5010281	7.78	2864328	8.51	1936000	-808784	-29.23	29.23	398400	14.41	2366364	1537600	-808784	-808784	-34.18	-34.18	12							
88/02/25	B	A	PVT	424.90	ALT/EXT HOSPITAL	3848352	11.16	3411431	6.48	3300000	72773	2.25	2.25	2000000	61.97	1227227	1300000	72773	72773	5.93	5.93	7							
88/03/01	A	A	PVT	424.90	HOUSE ALTERATIONS	1577644	23.01	965146	13.56	948000	70000	7.97	7.97	419500	47.78	459500	528500	70000	70000	15.27	15.27	11							
88/03/10	A	A	PVT	429.80	FACTORY EXTENSIONS	9917082	12.00	6018053	6.73	5435000	-100535	-1.82	1.82	74312	1.34	3461224	5364688	-100535	-100535	-1.84	-1.84	9							
88/03/17	A	A	PVT	429.80	ALTS/ADDS OFFICES	1496067	9.59	886809	4.20	790000	-44194	-5.52	5.52	201270	24.31	632924	586730	-44194	-44194	-7.30	-7.30	24							
88/03/30	M	B	M	PUB/1	429.80	TELEPHONE EXCHANGE	1065056	10.01	431291	3.49	630000	35905	5.77	5.77	6000	0.00	589495	620000	35905	35905	6.03	6.03	6						
88/04/20	A	M	PVT	434.70	THEATRE	2631294	27.06	1629479	7.04	1250000	-235485	-15.85	15.85	0	0.00	1485485	1250000	-235485	-235485	-15.85	-15.85	3							
88/05/04	B	M	PUB/2	439.60	LIBRARY	11467358	18.99	7136790	3.90	6740000	193687	2.95	2.95	2766000	42.25	3780933	3974000	193687	193687	5.11	5.11	17							
88/06/02	M	B	M	PVT	446.40	ALT/ADDS FACTORY	2230899	14.49	1382065	2.49	1086598	-211382	-16.29	16.29	198000	15.25	1099960	888598	-211382	-211382	-19.22	-19.22	14						
88/06/23	B	M	PVT	446.40	FACTORY OFFICE WAREHOUSE	6500032	7.30	3874881	1.64	3930000	161870	4.29	4.29	1689500	44.83	2078830	2240500	161870	161870	7.78	7.78	1							
88/06/30	M	B	M	PVT	446.40	WAREHOUSE	4619310	4.82	2757158	6.06	2800000	122000	4.56	4.56	1650000	61.61	1028000	1150000	122000	122000	11.87	11.87	6						
88/07/14	A	B	M	PVT	453.10	HOTEL	12860706	6.59	7795584	2.33	7464449	-103325	-1.37	1.37	2850000	37.66	4717774	4614449	-103325	-103325	-2.19	-2.19	8						
88/07/26	B	M	PVT	453.10	LABORATORY	1473156	5.62	890740	1.94	810000	1175837	21.54	21.54	1323107	24.24	4155036	373000	1175837	1175837	28.44	28.44	20							
88/08/19	A	M	PVT	459.90	PARKING GARAGE	9138477	22.18	6182829	6.40	6634000	-194	-0.01	0.01	347100	18.80	1499400	1499400	-194	-194	-0.01	-0.01	12							
88/09/03	B	M	PVT	470.20	ALT OFFICES WAREHOUSE	1946841	8.12	1237890	2.20	1306419	118112	9.41	9.41	128400	10.80	1060437	1172249	118112	118112	10.34	10.34	6							
88/09/16	M	B	M	PVT	470.20	TRAINING CENTRE	3986237	18.17	2366929	4.87	2456600	22407	0.92	0.92	522000	21.44	1912193	1936600	22407	22407	1.17	1.17	13						
88/10/14	M	B	M	PVT	470.20	RESEARCH CENTRE	7888871	9.70	4159350	10.26	890000	-78141	-7.69	7.69	0	0.00	964141	890000	-78141	-78141	-7.69	-7.69	17						
88/11/01	M	B	M	PVT	490.90	SERVICE STATION	1170136	56.43	844685	16.03	752750	6256	0.84	0.84	75800	10.16	670200	674500	6256	6256	0.93	0.93	13						
88/11/15	M	B	M	PVT	490.90	SCHOOL	2025387	9.91	1379893	3.13	1250000	-41250	-3.19	3.19	226300	17.53	1044950	1023700	-41250	-41250	-3.70	-3.70	9						
88/11/22	M	B	M	PUB/1	490.90	SERVICE STATION	1441367	19.92	1000739	5.99	896000	-22918	-2.49	2.49	68870	7.47	850248	827330	-22918	-22918	-2.76	-2.76	9						
88/11/23	M	B	M	PVT	490.90	HOSTEL	644672	30.24																					

DATE	AREA/CITY/ALT./SECTOR	INDEX	CONTRACT		TENDER DETAILS				ESTIMATE DETAILS				TENDER	ESTIMATE	METT	MIDREV	MIDABS	OS				
			NO	DESC	BIDS	AMOUNT	UPDATED	RANGE	MEAN	CV	GROSS	NEVIATION							GREY	REL	DEV	SUNS
89/01/19	H 2 M	PVT	530.60	FACTORY	4	456,184	1049866	16.31	758510	5.78	680000	-16184	-2.32	2.32	95500	13.72	600484	584500	-16184	-2.49	2.49	1
89/02/17	A 4 M	PVT	520.50	SCHOOL	10	3049019	4540413	9.55	3192761	3.50	3120000	50981	1.46	1.46	860636	28.04	2208183	2295344	50981	2.31	2.31	20
89/03/08	A 5 M	PVT	529.80	SPORTS PAVILION	8	629000	914175	11.03	666772	3.89	620000	-9000	-1.43	1.43	121700	19.38	507100	498100	-9000	-1.77	1.77	9
89/03/29	B 3 A	PVT	539.80	REFURBISH/T OFFICES	4	1489525	2458520	26.44	1824508	7.01	1700000	10475	0.62	0.62	800000	47.35	889525	900000	10475	1.18	1.18	7
89/04/21	A 4 A	PVT	539.20	ALT TO ORPHANAGE	8	67185	95460	17.33	737331	5.63	729000	31815	4.56	4.56	122000	17.50	53185	607000	31815	5.33	5.33	9
89/05/16	A 5 A	PVT	548.50	ALT TO GOLF CLUB	10	512215	719642	14.33	553250	6.36	508000	-4215	-0.82	0.82	141200	31.47	351815	348000	-4215	-1.20	1.20	1
89/05/28	A 7 M	PVT	548.50	PREPARATORY SCHOOL	7	729886	1024635	20.30	816400	6.22	831400	121514	16.45	16.45	92650	12.49	637236	730750	121514	19.07	19.07	12
89/06/07	H 1 M	PVT	548.90	SERVICE STATION	5	412960	579331	12.94	438980	6.72	418000	5020	1.22	1.22	120250	29.12	292750	297750	5020	1.71	1.71	12
89/06/08	H 1 M	PVT	548.90	SERVICE STATION	5	412960	579331	12.94	438980	6.72	418000	5020	1.22	1.22	120250	29.12	292750	297750	5020	1.71	1.71	12
89/06/08	A 3 M	PVT	548.90	OFFICES	14	945700	1326633	28.58	1056005	7.93	994300	48600	5.14	5.14	350880	37.10	594820	643420	48600	8.17	8.17	20
89/06/29	G 7 M	PVT	548.90	TECHNICAL BLDGS	7	5212536	7312175	11.59	5451328	3.66	4920000	-292536	-5.61	5.61	880000	16.88	4323536	4040000	-292536	-6.75	6.75	6
89/06/29	G 7 M	PUB/A	548.90	PRIMARY SCHOOL	4	2282922	3216524	6.48	2383042	3.40	2485000	192078	0.38	0.38	807941	35.24	1484984	1677659	192078	12.93	12.93	21
89/06/27	H 5 M	PVT	548.90	TURF CLUB PAVILION	4	9835000	1376593	2.96	10004931	1.89	9819801	-15199	-0.15	0.15	5202827	52.90	4832171	4618972	-15199	-0.33	0.33	8
89/07/21	A 2 A	PVT	549.30	EXIT TO FACTORY	6	1033000	1476079	6.69	1091940	2.49	1156000	97000	0.21	0.21	230000	21.84	823000	920000	97000	11.79	11.79	6
89/07/25	A 2 M	PVT	549.30	FACTORY	7	2829940	3964985	11.59	2975387	3.75	2780000	-89940	-1.76	1.76	104230	37.04	1781710	1731770	-89940	-2.80	2.80	22
89/07/28	H 8 M	PVT	549.30	SCHOOL FOR THE DEAF	4	1021000	1431222	10.68	1094421	3.92	980000	-61000	-4.02	4.02	589000	16.49	2940886	2811000	-61000	-4.42	4.42	17
89/08/01	A 7 M	PUB/A	549.80	TRAINING CENTRE	7	3529886	4943638	9.78	3707334	2.89	3400000	-129886	-3.48	3.48	589000	16.49	2940886	2811000	-129886	-4.42	4.42	52
89/08/22	M 7 M	PUB/A	549.80	UNIVERSITY LABORATORIES	6	7879767	10781074	3.88	7845298	1.48	8442967	715000	9.48	9.48	5103600	66.30	2593367	3339367	715000	28.72	28.72	20
89/08/25	A 3 M	PVT	549.80	RESTAURANT	6	1785433	2500515	14.75	1934643	5.37	1878527	93994	5.21	5.21	764000	42.70	1019433	1112527	93994	9.13	9.13	63
89/09/19	H 2 M	PVT	559.10	FACTORY / WAREHOUSE	13	3246309	4470840	30.12	3866325	6.76	3700000	45581	13.98	13.98	765000	24.18	2461309	2915000	45581	10.43	10.43	61
89/10/06	A 3 M	PVT	568.60	SHOPPING CENTRE	5	863886	1170289	14.13	939047	6.52	700000	-163886	-18.97	18.97	264000	30.56	599886	436000	-163886	-27.32	27.32	6
89/10/20	A 3 M	PVT	568.60	PRIMARY SCHOOL	7	110020	826382	8.85	632557	1.64	560100	-49920	-0.18	0.18	397000	20.61	279570	529650	-49920	-0.41	0.41	20
89/10/25	A 4 A	PUB/A	568.60	REHABILITATION TO OFFICES	7	2816177	3923392	25.64	3079442	7.01	2822000	-74177	-2.56	2.56	397000	20.61	279570	2225000	-74177	-3.23	3.23	6
89/10/30	A 7 A	PUB/A	568.60	EXIT TO SCHOOL	7	733990	994321	19.73	801146	5.02	777000	38010	5.18	5.18	36050	4.91	497960	735970	38010	5.45	5.45	20
89/11/01	G 7 M	PUB/2	577.70	WORKSHOPS AT TECH COLLEGE	9	498000	663720	28.92	571949	8.19	500000	2000	0.40	0.40	28000	5.82	470000	472000	2000	0.43	0.43	19
89/11/22	C 5 M	PVT	577.70	RESORT DEVELOPMENT	7	3803243	5045235	20.42	4215752	5.67	3800000	-3243	-0.09	0.09	50000	1.31	3753243	3750000	-3243	-0.09	0.09	7
89/12/12	A 4 M	PVT	585.00	MEDICAL RESEARCH CENTRE	10	1824600	2401610	7.91	1899285	2.68	1564000	-260400	-18.28	18.28	441500	35.16	1181310	922500	-260400	-22.63	22.63	52
89/12/15	A 4 M	PVT	585.00	DAY CARE CENTRE	9	948400	1248321	46.06	1043061	9.38	950000	1600	0.17	0.17	100500	10.40	847900	849500	1600	0.19	0.19	9
90/01/28	A 8 M	PVT	592.40	TOWNHOUSE SCHEME	5	1567200	2039642	23.92	1793544	7.00	1795000	-76676	-10.20	10.20	356885	22.73	1212515	1438315	-76676	-14.09	14.09	12
90/02/07	A 8 M	PVT	599.70	HOUSE	4	626276	889378	5.17	711963	1.82	622000	-76676	-10.20	10.20	191000	27.37	501676	431000	-76676	-14.09	14.09	12
90/02/09	H 5 M	PUB/A	599.70	COMMUNITY CENTRE	8	1350623	1736167	10.32	1425600	3.21	1360000	9377	0.69	0.69	250000	18.51	1100423	1110000	9377	0.85	0.85	12
90/02/14	H 5 M	PVT	599.70	MUSING	8	5319420	6630004	12.61	5701233	4.21	5373500	53880	1.01	1.01	817000	15.40	4500420	4554300	53880	1.20	1.20	52
90/02/19	H 7 M	PVT	599.70	OFFICES	9	2094934	2689844	17.82	2391177	5.78	2037475	-57459	-2.74	2.74	327500	25.18	1567434	1509973	-57459	-3.67	3.67	11
90/02/22	H 2 M	PVT	599.70	BREWERY DEPOT	3	5126400	6581657	14.29	5509084	5.29	5000000	-126000	-2.46	2.46	1311620	25.59	3814380	3689300	-126000	-3.30	3.30	502
90/03/27	H 3 M	PVT	607.80	SHOPPING CENTRE	2	40385134	51182476	6.74	40334971	6.37	41870000	11484866	28.44	28.44	13884658	34.38	26499078	37818942	11484866	43.34	43.34	20
90/04/09	H 8 M	PVT	615.00	OLD AGE HOME	7	4207000	5360490	36.35	5893896	7.23	4022844	-284156	-6.16	6.16	0	0.00	4207000	4022844	-284156	-6.16	6.16	10
90/04/09	B 3 A	PVT	615.00	ALT TO OFFICES	7	2209000	2762147	23.60	2522432	6.20	2250000	-49501	-1.08	1.08	847000	10.44	3701501	3622000	-49501	-1.33	1.33	502
90/04/27	A 3 M	PVT	615.00	FACTORY	12	2298717	2874329	15.58	2504940	5.65	2392000	93283	4.06	4.06	821000	35.72	1477172	1371000	93283	6.31	6.31	27
90/05/11	H 4 M	PVT	623.90	MUSERY AND GATEHOUSE	6	795295	981531	16.93	841121	3.90	797657	2362	0.30	0.30	0	0.00	795295	795295	2362	0.30	0.30	33
90/05/21	A 8 M	PVT	623.90	HOUSE	4	1670333	2071352	15.55	1809049	6.76	1650000	-28333	-1.89	1.89	485000	28.90	1133333	1165000	-28333	-2.37	2.37	13
90/05/30	A 8 M	PVT	623.90	COTTAGES FOR THE AGED	7	2282590	2817109	14.21	2449866	3.76	2400000	117410	5.14	5.14	122000	5.34	2160590	2278000	117410	5.43	5.43	19
90/06/04	A 3 M	PVT	630.60	SERVICE STATION	8	720000	879163	25.89	790253	6.20	760000	40000	5.36	5.36	37500	7.99	642500	702500	40000	6.04	6.04	12
90/06/06	G 7 M	PVT	630.60	UNIVERSITY TEACHING BLDG.	6	3032000	3702624	13.80	3307837	4.00	3032000	-305	-0.01	0.01	335000	11.05	2697505	2697000	-305	-0.01	0.01	6
90/06/15	B 3 A	PVT	630.60	ALT. TO OFFICES	8	1932000	2359087	11.06	2034251	3.64	2209490	277490	14.36	14.36	1382700	71.57	549300	626790	277490	50.32	50.32	33
90/06/21	G 4 M	PUB/A	630.60	SECURITY OFFICE AND WARD	12	2620000	3199175	26.83	2989589	4.42	3000000	380000	14.50	14.50	160700	6.13	2459300	2893500	380000	15.45	15.45	52
90/06/21	G 5 M	PVT	630.60	SPORTS CLUB BUILDING	3	1210600	168214	6.33	1266320	2.94	1150000	-60600	-5.01	5.01	356000	29.41	854000	794000	-60600	-7.09	7.09	17
90/07/17	H 4 M	PVT	637.20	TRAINING CENTRE	5	486000	587288	16.32	532037	6.52	490000	4000	0.82	0.82								

CONTRACT DETAILS			TENOR DETAILS			ESTIMATE DETAILS			TENDER			NETT												
DATE	AREA/CT/ALTY/SECTION	INDEX	AMOUNT TENDERED	UPDATED VALUE	RANGE	MEAN	CV	GROSS ESTIMATE	DEVIATION	R %	GRADES	FILED	ALLOW	TENDER	ESTIMATE	NETT	DEVIATION	NETT	DEVIATION	MEDEV	HEADS	OS		
					%	TENDER			R %	%	%	SURS ETC	%	NETT	NETT	NETT	%	NETT	%	%	%	%	%	
:90/08/16:	A	B	A	PVT	643.90	ALT TO HOUSE	370797	9.34	3248991	3.31	2860000	-240000	-7.74	1277000	41.26	1821000	1381000	-210000	-13.10	13.10	13.10	24		
:90/08/17:	A	B	A	PVT	643.90	ALT TO HOUSE	729349	18.77	67000	6.18	605828	-4078	-0.67	156000	25.58	653706	419828	-4078	-0.90	0.90	0.90	16		
:90/08/27:	B	2	A	PVT	643.90	ALT TO FACTORY	737584	15.46	648795	5.15	450000	33207	3.38	75000	12.16	341793	573600	33207	6.13	6.13	6.13	7		
:90/08/31:	B	3	A	PVT	643.90	OFFICES - ADDITIONAL FLOOR	409748	8.39	353409	2.49	415000	75700	22.31	0	0.00	339300	370000	75700	22.31	22.31	22.31	17		
:90/09/04:	B	3	M	PUB/2	647.90	BANQUETING HALL	135483	16.77	1208349	3.61	980000	-197300	-13.98	388000	34.06	751300	592000	-197300	-21.20	21.20	21.20	17		
:90/09/24:	A	B	M	PVT	647.50	HOUSING FOR AGED	406749	42.72	4100398	13.27	3200000	-219783	-6.43	6.43	0	0.00	3419783	3200000	-219783	-6.43	6.43	17		
:90/09/26:	A	B	M	PVT	647.50	ETI TO APARTMENT BLOCK	723744	3.45	728887	1.23	7325000	-440580	-5.67	5.67	0	0.00	716590	7325000	-440580	-5.67	5.67	17		
:90/10/05:	B	3	M	PVT	651.00	OFFICE BLOCK	709068	6.95	6728136	1.99	6399750	60750	10.09	10.09	0	0.00	716590	7325000	60750	10.09	10.09	10.09	3	
:90/10/05:	B	3	M	PVT	651.00	OFFICE BLOCK	432581	14.03	5961627	3.88	5800000	277000	5.02	5.02	0	0.00	241235	2448384	277000	11.97	11.97	11.97	13	
:90/10/08:	H	3	A	PUB/2	651.00	ETI TO MUNICIPAL OFFICES	2735935	52.47	3067405	12.90	2740084	7119	0.26	0.26	0	0.00	241235	2448384	7119	0.29	0.29	0.29	11	
:90/10/11:	B	3	M	PVT	651.00	CHURCH	132643	22.67	1272251	7.75	1735000	582730	50.40	50.40	0	0.00	836525	1419153	582730	49.48	49.48	49.48	21	
:90/10/23:	B	3	M	PVT	654.60	OFFICES AND WAREHOUSE	793976	9.93	714644	3.65	675000	0	0.00	0.00	0	0.00	316900	316900	0	0.00	0.00	0.00	22	
:90/11/07:	H	3	M	PUB/1	654.60	POLICE STATION	935151	26.49	924546	0.85	865000	70000	0.81	0.81	0	0.00	790423	860423	70000	8.05	8.05	8.05	12	
:90/11/23:	B	3	A	PVT	654.60	SECOND FLOOR TO BUILDING	1169232	15.31	1061913	4.13	707291	-86708	-7.72	7.72	0	0.00	482999	598251	-86708	-12.70	12.70	12.70	35	
:90/11/29:	A	1	M	PUB/2	654.60	MUNICIPAL STORAGE DEPOT	1815264	26.27	1462649	8.28	1379000	35790	2.32	2.32	0	0.00	1543210	1543210	35790	2.32	2.32	2.32	12	
:90/12/13:	B	3	A	PVT	664.40	REDEVELOPMENT OF GARAGE	433708	18.87	395881	5.67	577000	30200	5.32	5.32	0	0.00	459800	490000	30200	6.37	6.37	6.37	12	
:91/01/25:	A	B	M	PVT	674.10	FLATS AND GARAGES	1111111	10.34	1140976	3.56	1050000	-81111	-3.50	3.50	0	0.00	811111	820000	-81111	-6.94	6.94	6.94	17	
:91/01/28:	B	3	A	PVT	674.10	ADDITIONS TO WAREHOUSE	1266189	16.31	1192082	4.89	1170000	44000	3.91	3.91	0	0.00	1078000	1114000	44000	4.08	4.08	4.08	1	
:91/01/28:	B	3	A	PVT	674.10	ALT TO MOTOR SHOWROOM	1447500	17.23	1597106	4.53	1600000	52500	10.34	10.34	0	0.00	1184855	1269355	52500	13.63	13.63	13.63	33	
:91/01/30:	A	7	A	PVT	674.10	ALT TO OLD ASE HUNE	913011	67.45	1027782	18.46	810000	10700	1.34	1.34	0	0.00	799300	810000	10700	1.34	1.34	1.34	24	
:91/02/08:	G	2	M	PVT	683.90	FACTORY / WAREHOUSE	2303306	29.70	2628979	7.51	2850000	535000	24.18	24.18	0	0.00	2295000	2850000	535000	24.18	24.18	24.18	17	
:91/02/13:	H	2	M	PVT	683.90	MINI FACTORIES	4435345	10.11	4169000	2.57	4180000	240407	6.11	6.11	0	0.00	2082393	2323000	240407	11.55	11.55	11.55	39	
:91/02/20:	B	3	M	PVT	683.90	NEW APARTMENT BUILDING	2913651	6.23	2676845	2.05	2349236	-38414	-1.49	1.49	0	0.00	1886242	1847268	-38414	-2.29	2.29	2.29	22	
:91/02/22:	B	3	M	PVT	683.90	OFFICES	2176504	8.90	2012227	3.14	2099000	158649	6.58	6.58	0	0.00	1725831	1891500	158649	9.61	9.61	9.61	19	
:91/03/05:	H	2	M	PVT	694.40	WORKSHOP	906795	31.42	961558	10.01	950000	32000	16.14	16.14	0	0.00	783000	915000	32000	16.86	16.86	16.86	19	
:91/03/15:	H	4	M	PUB/1	694.40	HOSPITAL	1741294	21.46	1932603	5.15	2253000	511706	29.39	29.39	0	0.00	1659294	2176000	511706	30.84	30.84	30.84	1	
:91/04/09:	B	3	A	PVT	705.40	REFURD OF OFFICES	6741147	99.727	22.50	612438	6.58	375000	26000	4.74	4.74	0	0.00	1540447	5479800	26000	6.39	6.39	6.39	14
:91/04/19:	A	B	M	PVT	694.40	HOSPITAL	19362458	9.43	1513718	2.64	14962458	60000	4.18	4.18	0	0.00	14362458	1962458	60000	4.18	4.18	4.18	3	
:91/04/24:	A	3	A	PVT	705.40	REDEVELOPMENT FOR BANK	8683837	6.30	8232585	1.63	7991000	35703	0.45	0.45	0	0.00	3138297	3174000	35703	1.14	1.14	1.14	1	
:91/05/03:	A	7	M	PUB/2	716.10	MUNICIPAL LIBRARY	1160168	24.80	1191378	5.72	1052000	-26956	-2.50	2.50	0	0.00	1050456	1023700	-26956	-2.57	2.57	2.57	1	
:91/05/08:	B	7	A	PUB/1	716.10	ALT TO SCHOOL	458397	10.28	413068	3.94	410400	19110	3.23	3.23	0	0.00	4000	606400	19110	3.25	3.25	3.25	61	
:91/05/24:	A	6	A	PVT	716.10	ALT TO CHEMISTRIUM	814887	9.21	802854	2.84	784724	24879	3.55	3.55	0	0.00	569845	596724	24879	4.72	4.72	4.72	3	
:91/06/03:	B	3	A	PVT	718.90	SHOPS AND OFFICES	1427030	17.71	1439749	5.51	1400000	7262	3.49	3.49	0	0.00	1280138	1281000	7262	6.03	6.03	6.03	27	
:91/06/03:	B	3	A	PVT	718.90	REFURBISHMENT OF ARCADE	487426	12.72	468921	4.21	8641000	1640732	25.54	25.54	0	0.00	5303129	2757071	1640732	146.87	146.87	146.87	27	
:91/06/12:	B	7	A	PUB/1	718.90	RENOVATIONS TO ROOF	679131	14.79	683921	5.36	645031	16031	2.47	2.47	0	0.00	587350	606400	16031	6.15	6.15	6.15	33	
:91/06/12:	B	7	A	PUB/1	718.90	RENOVATIONS TO ROOF	1870107	119.02	2508904	11.99	2618220	-684780	-39.22	39.22	0	0.00	15474000	16117200	-684780	-39.22	39.22	39.22	14	
:91/06/14:	B	2	A	PVT	718.90	ALT TO FACTORY / WAREHOUSE	3329868	8.91	3241911	2.64	2658888	-450000	-14.47	14.47	0	0.00	464000	371000	-450000	-28.71	28.71	28.71	52	
:91/06/19:	A	3	A	PVT	718.90	ALT TO OFFICES	88434	24.00	908043	6.43	854833	28740	3.48	3.48	0	0.00	553413	584153	28740	5.17	5.17	5.17	33	
:91/06/20:	B	8	A	PVT	718.90	SHOPPING CENTRE OF HOTEL	3461733	9.14	5523119	2.84	4850000	-594000	-11.28	11.28	0	0.00	4294025	3698025	-594000	-13.08	13.08	13.08	32	
:91/07/10:	B	7	M	PUB/2	721.00	PRIMARY SCHOOL	3918274	21.52	3981343	6.34	4100000	427000	11.63	11.63	0	0.00	363633	326894	427000	11.64	11.64	11.64	19	
:91/07/19:	A	B	M	PVT	721.00	HOUSE	3461733	24.03	328311	8.61	324899	-9739	-2.89	2.89	0	0.00	363633	326894	-9739	-2.89	2.89	2.89	3	
:91/07/22:	A	2	M	PVT	721.00	FACTORY	2275578	21.88	2314664	5.38	2380000	246867	11.57	11.57	0	0.00	1703133	2050000	246867	13.84	13.84	13.84	52	
:91/08/02:	B	3	A	PVT	724.60	REFURD TO RESTAURANT	63871	15.17	645331	5.86	780000	181402	30.30	30.30	0	0.00	371740	553150	181402	48.80	48.80	48.80	24	
:91/08/02:	B	3	A	PVT	724.60	ADD. TO DISTRIBUTION CENTRE	3391996	6.56	3310420	1.99	3354776	162776	5.10	5.10	0	0.00	266495	2348971	162776	7.38	7.38	7.38	20	
:91/08/07:	H	7	M	PUB/1	724.60	UNIVERSITY TEACHING BLDG.	1673375	26.59	1750053	5.26	1874000	299289	19.01	19.01	0	0.00	171955	299289	299289	28.28	28.28	28.28	21	
:91/08/14:	A	B	M	PUB/1	724.60	PRISON HOUSING	1830462	115.38	1595938	45.10	2100000	-297000	-13.90	13.90	0	0.00	1639800	3773000	-297000	-23.01	23.01	23.01	9	
:91/08/16:	B	3	M	PVT	724.60	OFFICE DEVELOPMENT	6421493	8.84	6292607	2.95	5550000	-92877	-1.54	1.54	0	0.00	3982877	3890000	-92877					

APPENDIX 'C' - SAMPLE OF 45 PWD PROJECTS FOR EMPIRICAL STUDY

Appendix 'C' is a schedule providing the details of building projects tendered for the Department of Public Works and Land Affairs in 1990 and 1991. This schedule reflects public sector projects throughout South Africa. Due to the sensitive nature of certain projects (e.g. military installations) full project details are not provided.

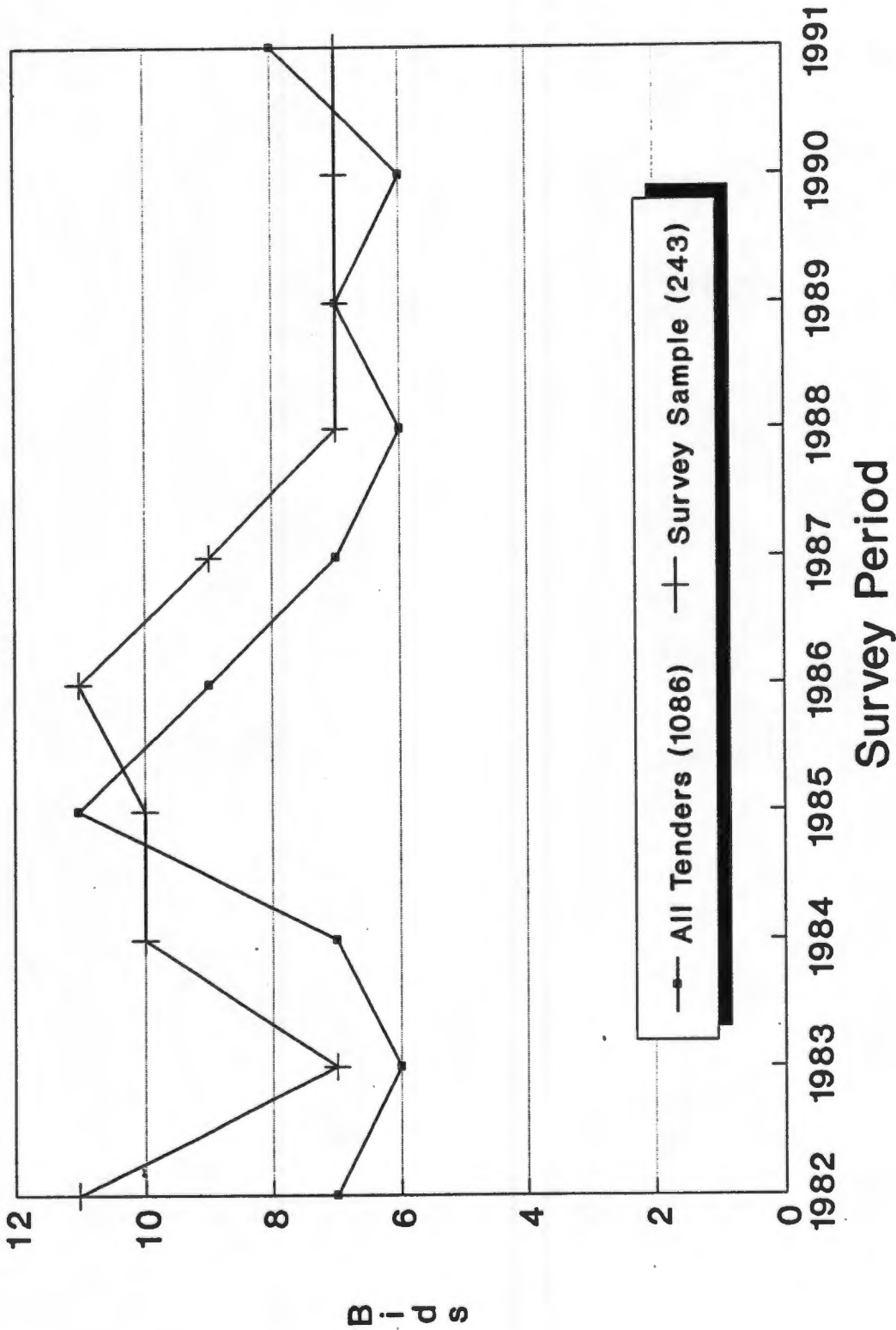
APPENDIX 'D' - SAMPLE VALIDATION : NUMBER OF BIDS / PROJECT

In order to validate the survey findings, a comparison of certain features in the sample comprising the total amount of tenders listed (1086 projects) and the sample reflecting estimate details (243 projects) was conducted. These features are:

- (a) The number of bids received for each project (Appendix D).
- (b) Mean project values indicated by lowest tenders (Appendix E).
- (c) Mean range of bids expressed as a percentage of the lowest tender (Appendix F).
- (d) The nature of the tenderers' bidding expressed by the coefficient of variation for tender distributions (Appendix G).

In Appendix 'D' it can be seen that the trends displayed by the *'sample'* and *'all projects'* over the survey period are similar. The validity of using this information (arising from the sample of 243 projects) is therefore supported.

TENDERS PER PROJECT



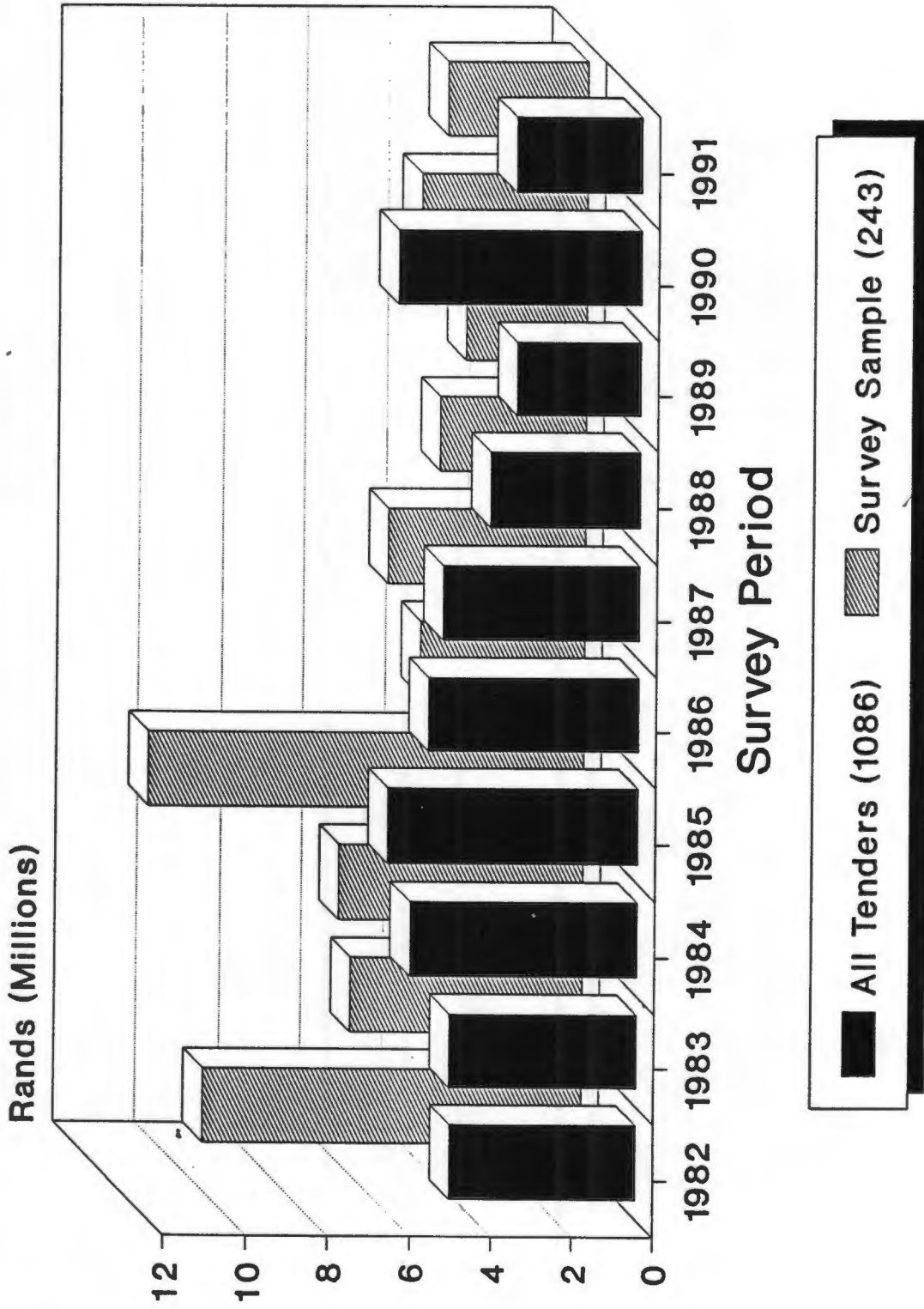
APPENDIX 'E' - SAMPLE VALIDATION : MEAN PROJECT VALUE

In order to validate the survey findings, a comparison of certain features in the sample comprising the total amount of tenders listed (1086 projects) and the sample reflecting estimate details (243 projects) was conducted. These features are:

- (a) The number of bids received for each project (Appendix D).
- (b) Mean project values indicated by lowest tenders (Appendix E).
- (c) Mean range of bids expressed as a percentage of the lowest tender (Appendix F).
- (d) The nature of the tenderers' bidding expressed by the coefficient of variation for tender distributions (Appendix G).

In Appendix 'E' it can be seen that the trends displayed by the '*sample*' and '*all projects*' over the survey period are similar. The validity of using this information (arising from the sample of 243 projects) is therefore supported.

MEAN PROJECT VALUE



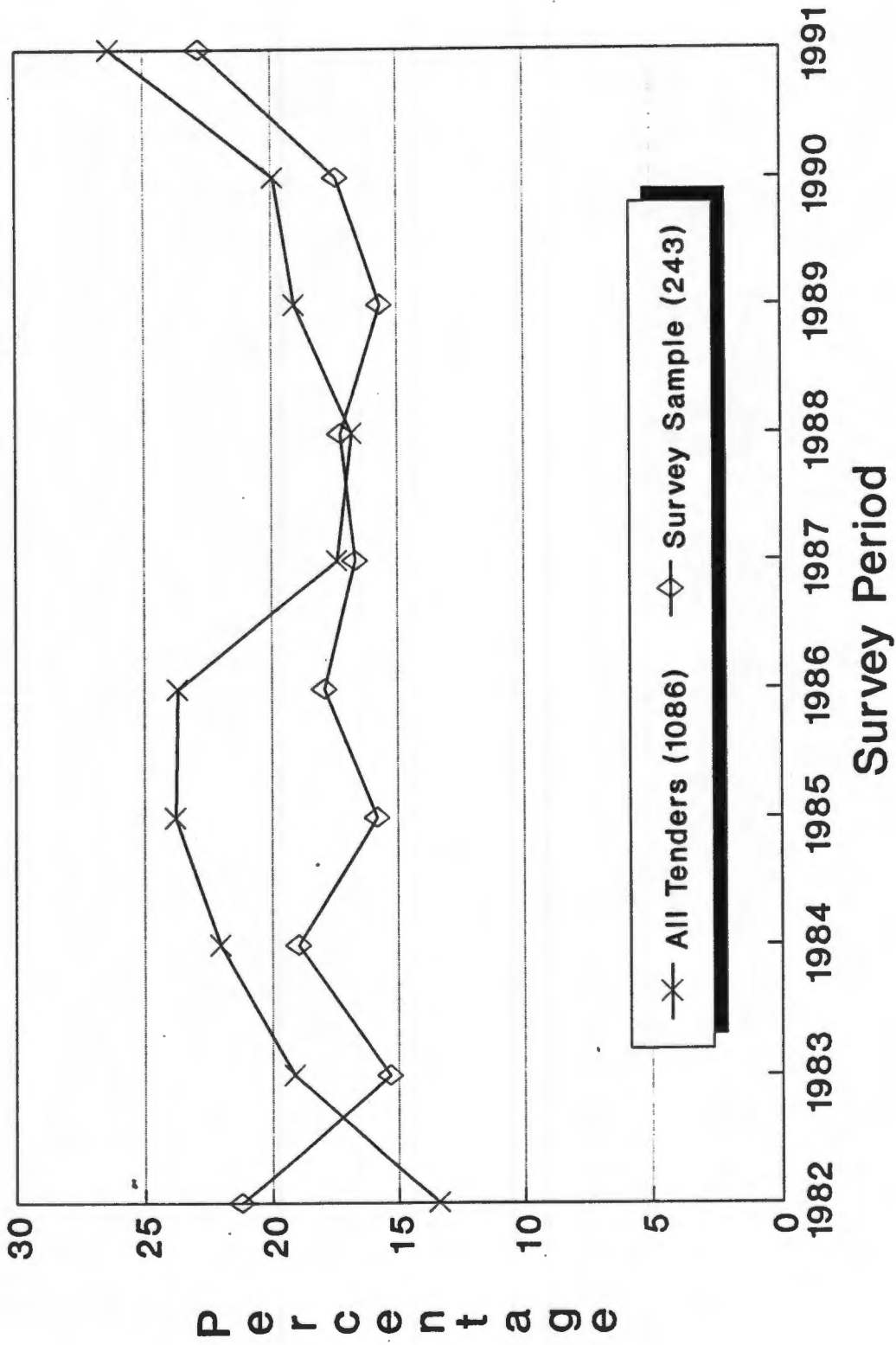
APPENDIX 'F' - SAMPLE VALIDATION : MEAN RANGE OF BIDS

In order to validate the survey findings, a comparison of certain features in the sample comprising the total amount of tenders listed (1086 projects) and the sample reflecting estimate details (243 projects) was conducted. These features are:

- (a) The number of bids received for each project (Appendix D).
- (b) Mean project values indicated by lowest tenders (Appendix E).
- (c) Mean range of bids expressed as a percentage of the lowest tender (Appendix F).
- (d) The nature of the tenderers' bidding expressed by the coefficient of variation for tender distributions (Appendix G).

In Appendix 'F' it can be seen that the trends displayed by the *'sample'* and *'all projects'* over the survey period are similar. The validity of using this information (arising from the sample of 243 projects) is therefore supported.

MEAN % RANGE OF BIDS



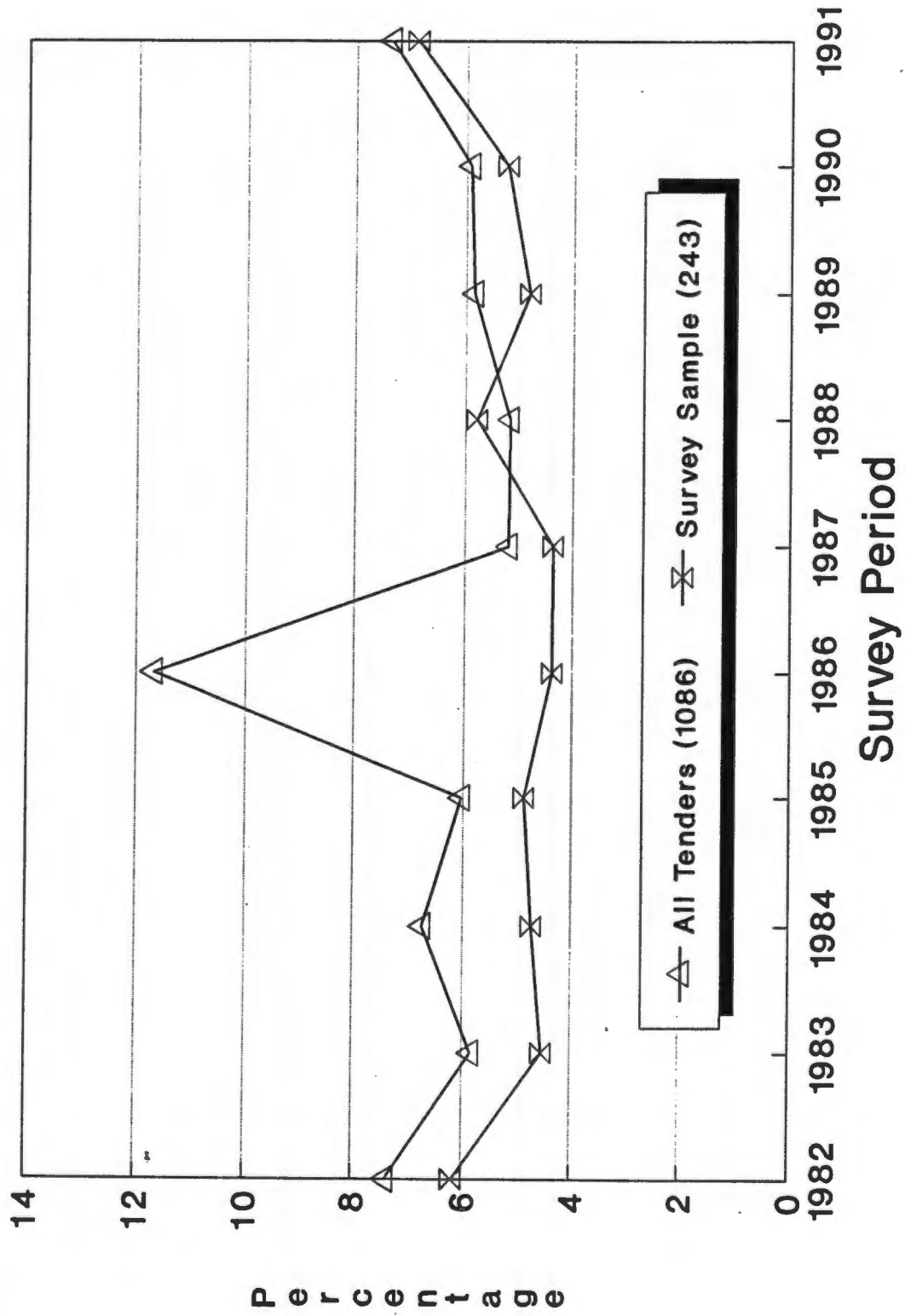
APPENDIX 'G' - SAMPLE VALIDATION : CV OF TENDERERS BIDDING

In order to validate the survey findings, a comparison of certain features in the sample comprising the total amount of tenders listed (1086 projects) and the sample reflecting estimate details (243 projects) was conducted. These features are:

- (a) The number of bids received for each project (Appendix D).
- (b) Mean project values indicated by lowest tenders (Appendix E).
- c) Mean range of bids expressed as a percentage of the lowest tender (Appendix F).
- (d) The nature of the tenderers' bidding expressed by the coefficient of variation for tender distributions (Appendix G).

In Appendix 'G' it can be seen that the trends displayed by the '*sample*' and '*all projects*' over the survey period (other than for the year 1986) are similar. The validity of using this information (arising from the sample of 243 projects) is therefore supported.

CV OF TENDERERS BIDDING



APPENDIX 'H' - DETAILS OF ESTIMATING PERFORMANCE (FIRM 1)

Details of selected individual firms' pre-tender price forecasting results are provided as an indication of the variable nature of performance. In Appendix 'H' details of Firm 1's recorded results (the best performance in the sample) are provided by means of:

(a) Schedule listing details of tenders and QS priced bills of quantities (Page 218).

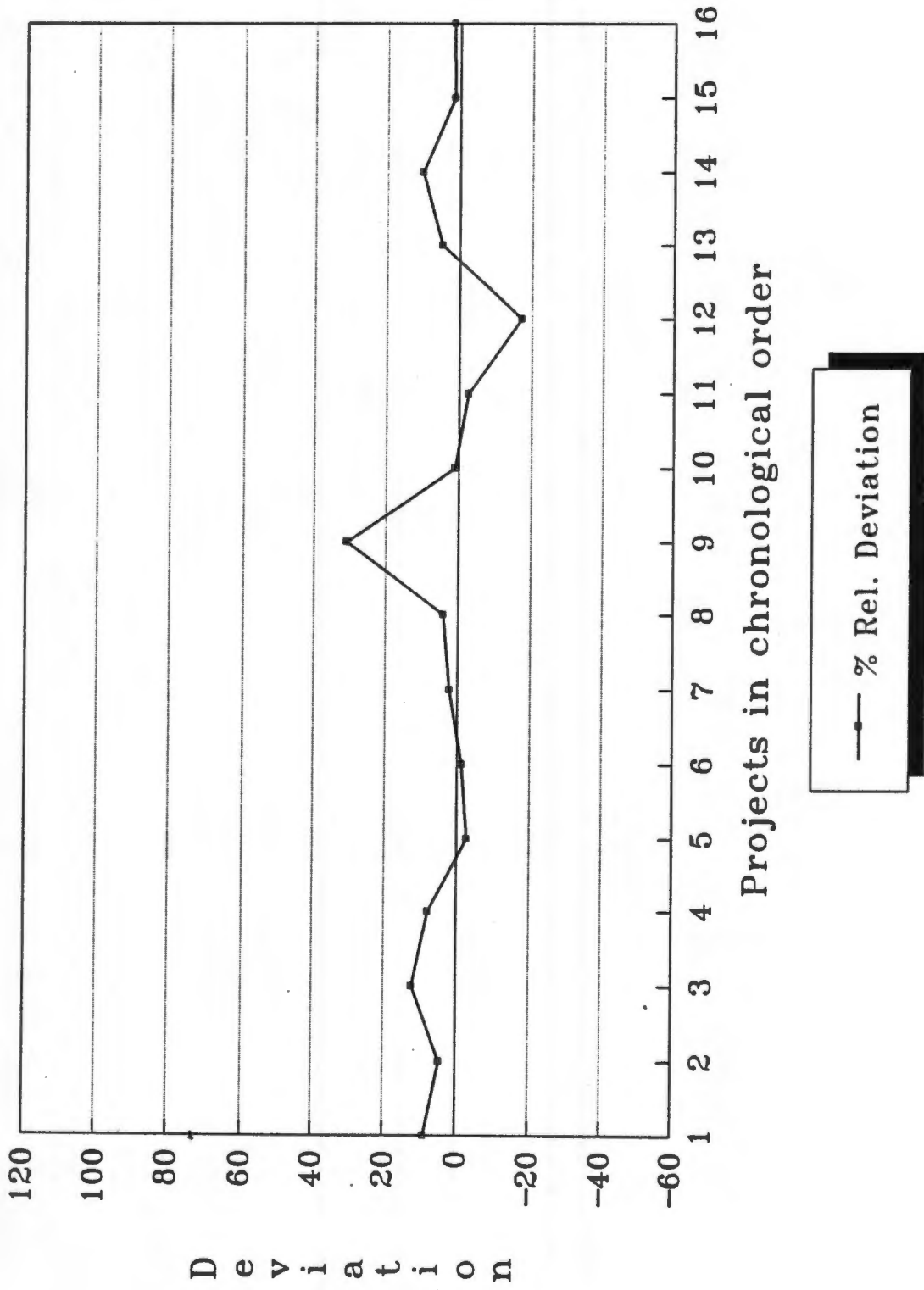
(b) Trend Control Charts in respect of the above information (Pages 219 & 220). Charts for both firm 1 and 21 are set to the same scale. The trend line indicated on the chart (page 220) identifies the trend of estimating performance. The nearer the trend line to horizontal, the closer the estimates are to the low bid. An upward trend line indicates a tendency towards overestimating whilst a downward trend line indicates a tendency towards underestimating. This form of plot enables one to identify a consistent trend within a time frame.

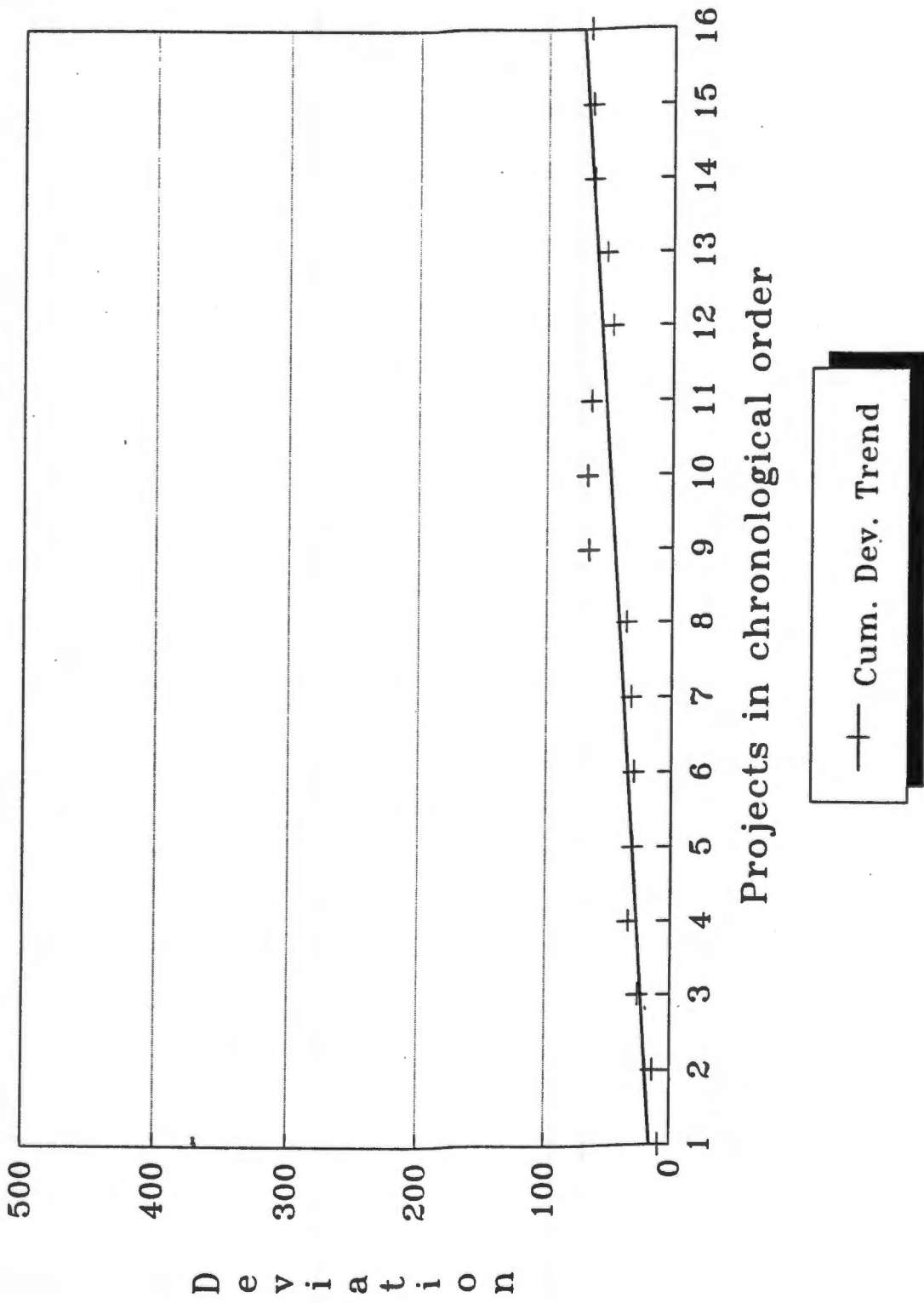
PROJECTS ESTIMATED BY FIRM NO. 1

DATE	AREA	CI/	ALT/	SECTOR	CONTRACT	BIDS	TENDERED	VALUE	DID 1	TENDER	BIDS	ESTIMATE	DEVIATION	% REL	GODEV	DEV 1	VALUES	%	METT	TENDER	METT	ESTIMATE	DEVIATION	% REL	MIBEV	BIABS	OS
86/10/03	A	8	N	PVT	UNIVERSITY RESIDENCE	6	5232127	12377075	0.36	5411864	3.11	5576400	344273	6.50	3.70	6.50	1273000	24.33	3959127	3959127	4303400	344273	0.70	0.70	1		
88/02/05	6	6	N	PVT	CHURCH RECREATION MALL	5	373373	676623	26.75	410267	11.90	387500	14127	3.70	3.70	3.70	61900	17.38	308473	308473	322600	14127	4.50	4.50	1		
88/02/10	N	2	N	PUB/1	TELEPHONE EXCHANGE	7	794600	1443591	29.60	901120	3.35	894000	97400	12.23	4.29	12.23	1689500	44.83	2078030	2078030	2740500	161670	7.70	7.70	1		
88/06/23	6	2	N	PVT	FACTORY OFFICE WAREHOUSE	6	3768330	6500032	7.30	3874081	1.64	3930000	161670	4.29	4.29	4.29	1689500	44.83	2078030	2078030	2740500	161670	7.70	7.70	1		
89/01/19	6	2	N	PVT	FACTORY	6	676184	1049866	16.31	750518	5.78	4800000	-16184	-2.32	2.32	2.32	95500	13.72	400084	400084	583500	-16184	-2.69	2.69	1		
89/05/16	A	5	A	PVT	ALT TO GOLF CLUB	10	512215	717062	14.53	552350	4.34	508000	-4215	-0.82	2.32	2.32	161200	31.47	351015	351015	348000	-4215	-1.20	1.20	1		
90/11/29	A	1	N	PUB/2	MUNICIPAL STORAGE DEPOT	6	1543210	1813244	26.27	1682689	0.28	1579000	35790	2.32	2.32	2.32	6	0.00	1543210	1543210	1579000	35790	2.32	2.32	1		
91/01/25	A	2	A	PVT	ADDITIONS TO WAREHOUSE	6	1126000	1286189	16.51	1220812	4.89	1176000	4000	3.91	3.91	3.91	48000	4.26	1078000	1078000	1127000	4000	4.00	4.00	1		
91/03/15	N	4	N	PUB/1	HOSPITAL	14	1741294	1930314	21.44	1932403	5.15	2253000	31706	29.39	29.39	29.39	4817000	40.55	3138297	3138297	3174000	31706	30.84	30.84	1		
91/04/24	A	3	A	PVT	REDEVELOPMENT FOR BANK	9	7955297	8683837	6.36	8232565	1.63	7991000	-26956	-2.30	2.50	2.50	28300	2.62	1050656	1050656	1023700	-26956	-2.57	2.57	1		
91/05/03	A	7	N	PUB/2	MUNICIPAL LIBRARY	12	1078956	1160168	24.80	1191378	5.72	1052000	-26956	-2.30	2.50	2.50	28300	2.62	1050656	1050656	1023700	-26956	-2.57	2.57	1		
91/05/16	B	3	A	PVT	ALT TO OFFICES	7	2841339	3076709	0.27	2991226	2.85	2717000	-144339	-5.04	5.04	5.04	2020000	76.60	841339	841339	677000	-144339	-17.16	17.16	1		
91/08/22	6	3	N	PVT	OFFICES	9	31795000	12534019	12.89	12516844	3.71	12234000	479000	3.72	3.72	3.72	2851000	28.17	8944000	8944000	9383000	439000	4.91	4.91	1		
91/10/08	H	3	N	PVT	SHOPPING CENTRE	8	4705109	4863825	10.10	4979859	3.22	5050000	344091	7.31	7.31	7.31	1355000	28.79	3350909	3350909	3495000	344091	10.27	10.27	1		
91/10/31	A	6	N	PVT	RELIGIOUS MEETING HOUSE	9	736868	761595	33.23	820300	10.29	746000	9132	1.24	1.24	1.24	123800	16.80	413068	413068	422200	9132	1.49	1.49	1		
91/11/26	B	2	A	PVT	EST TO OFFICES	5	1946659	1998560	5.21	2010751	2.22	1877700	34081	1.60	1.60	1.60	1979000	0.19	1787149	1787149	1818200	34081	1.74	1.74	1		
TOTAL					16 TENDERS ANALYSED	127	4064934	60974727		67448702	48245600	1876249					16780700		32160451	32160451	33076000	1876249					
MEAN						0	2929334	3804774	18.50	3693274	4.89	3046600	117266				628044	22.63	2006371	2006371	2123006	117266					

MEASURES OF ACCURACY

RANGE (MAXIMUM)	11.98	20.20	30.80
RANGE (MINIMUM)	1.63	-2.04	-17.16
RANGE (AVERAGE TO MAXIMUM)	13.44	30.43	47.97
MEAN RANGE	4.53	3.47	6.18
MEAN DEVIATION			7.11
STANDARD DEVIATION			
Coefficient of Variation	6.24	9.11	





APPENDIX 'I' - DETAILS OF ESTIMATING PERFORMANCE (FIRM 21)

Details of selected individual firms' pre-tender price forecasting results are provided as an indication of the variable nature of performance. In Appendix 'I' details of Firm 21's recorded results (the worst performance in the sample) are provided by means of:

(a) Schedule listing details of tenders and QS priced bills of quantities (Page 222).

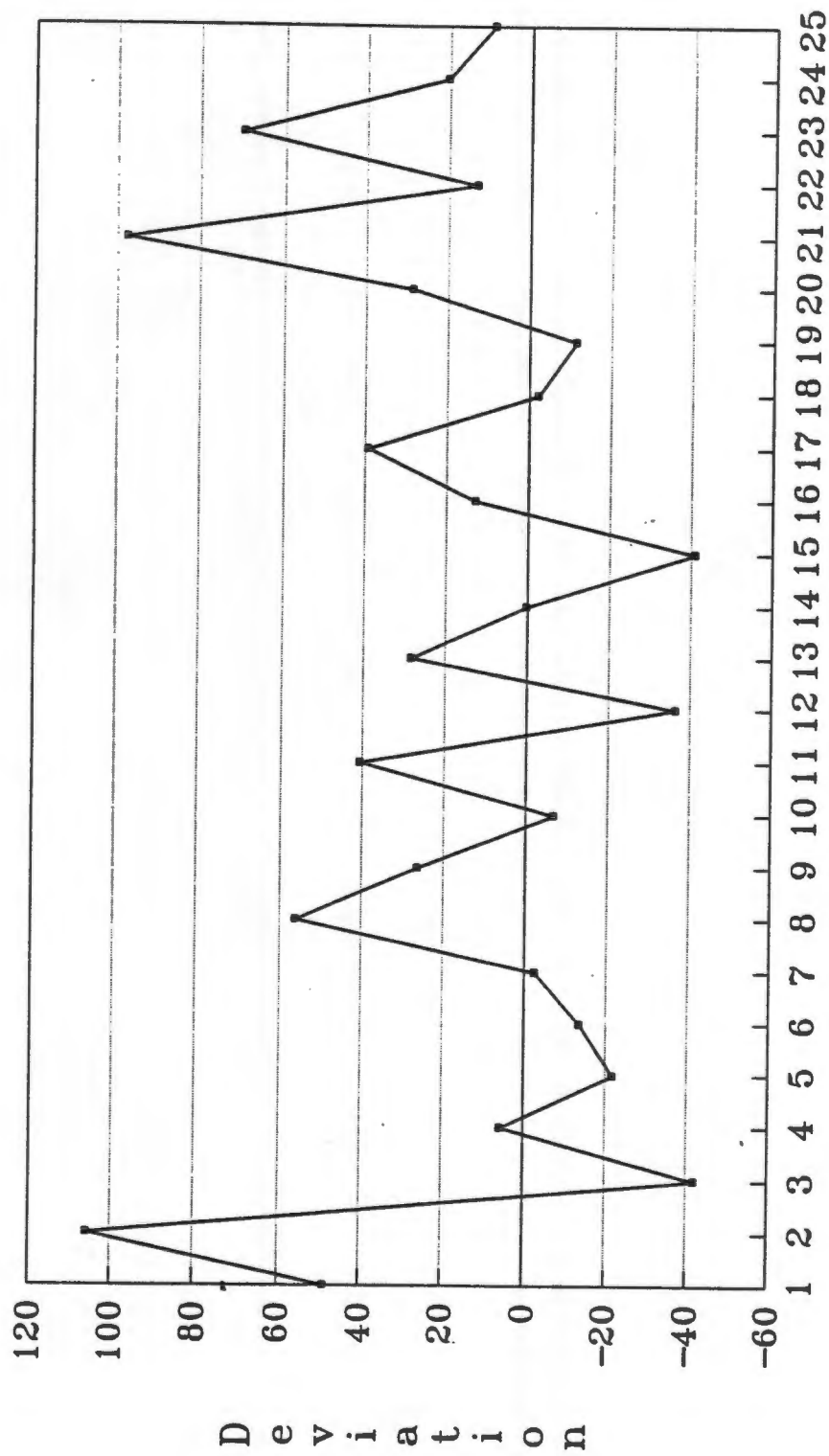
(b) Trend Control Charts in respect of the above information (Pages 223 & 224). Charts for both firm 1 and 21 are set to the same scale. The trend line indicated on the chart (page 224) identifies the trend of estimating performance. The nearer the trend line to horizontal, the closer the estimates are to the low bid. An upward trend line indicates a tendency towards overestimating whilst a downward trend line indicates a tendency towards underestimating. This form of plot enables one to identify a consistent trend within a time frame.

PROJECTS ESTIMATED BY FIRM NO. 21

DATE	AREA	CI/	ALT/	SECTOR	CONTRACT	BIDS	TENDERED	VALUE	BID 2	MEAN	BIDS	ESTIMATE	DEVIATION	% REL	GBARS	VALUES	%	NETT	ESTIMATE	NETT	DEVIATION	% REL	NETT	ESTIMATE	NETT	DEVIATION	% REL
92/03/02	0	-6	N	PVT	WAREHOUSE AND OFFICES	11	113934	2497417	32.83	908100	10.29	1110000	276166	36.39	36.39	203440	25.00	706360	706360	0	0.00	0.00	0	0	0	0	0.00
82/06/29	6	7	M	PUB/2	LIBRARY	12	346643	1110584	28.95	410029	8.42	580000	213337	58.18	58.18	144770	44.94	201893	213337	115444	53.64	48.52	213337	213337	0	0.00	
82/07/28	4	1	M	PUB/1	MILITARY RADAR SCHOOL	7	3019000	9183356	7.26	3119927	2.91	2150000	849600	-28.80	28.80	906250	31.47	2069350	1899750	-169600	-8.93	105.67	1899750	1899750	0	0.00	
82/11/10	6	8	M	PUB/1	SCHOOL	13	5354037	16230742	22.71	5909293	6.88	5600000	245763	4.59	4.59	904300	16.89	4499757	4651700	151943	3.24	42.03	4651700	4651700	0	0.00	
83/03/16	6	5	A	PVT	RETIREMENT COTTAGES	16	5127400	15458409	28.75	5085061	5.77	4163000	-962400	-18.77	18.77	728975	14.22	4398425	3134025	-126425	-3.05	5.53	3134025	3134025	0	0.00	
83/08/02	4	5	A	PVT	OLD AGE HOME	7	211112	439552	31.60	241825	9.14	190000	-21112	-10.00	10.00	55749	26.41	155363	142531	-13132	-9.22	13.59	142531	142531	0	0.00	
84/08/08	6	7	M	PVT	OLD AGE HOME	6	1249530	3634825	10.39	1320189	3.21	1225000	-24350	-1.96	1.96	27840	22.22	970490	961160	-9330	-0.97	2.53	961160	961160	0	0.00	
84/08/22	4	8	M	PVT	BUSINESS SCHOOL	12	2208022	5919836	26.83	2422976	2.56	3085000	876978	39.72	39.72	641350	29.05	1586672	2463650	876978	3.52	55.98	2463650	2463650	0	0.00	
84/11/02	4	8	M	PVT	ADD. TO OLD AGE HOME	12	2208022	5919836	26.83	2422976	2.56	3085000	876978	39.72	39.72	641350	29.05	1586672	2463650	876978	3.52	55.98	2463650	2463650	0	0.00	
85/07/25	6	5	M	PUB/1	BAY CARE CENTRE	16	588386	1532670	27.46	516234	3.07	560000	97069	5.67	5.67	102850	17.48	485536	452150	-33386	-6.88	6.88	452150	452150	0	0.00	
85/12/11	8	3	A	PUB/1	GYMNASIUM	18	247900	442487	34.78	283014	5.56	340000	92100	37.15	37.15	20300	8.19	227600	319700	92100	28.83	46.47	319700	319700	0	0.00	
86/02/26	8	7	M	PUB/1	ALT CUSTOMS STORE BLDG	10	1815932	4916120	9.61	1919493	9.36	1650000	-165832	-9.13	9.13	1363200	75.07	432632	286000	-165832	-5.81	28.20	286000	286000	0	0.00	
86/03/10	4	8	M	PUB/1	UNIVERSITY TEACHING BLDG	10	1417137	3495181	13.64	1526198	2.91	1717000	298863	21.16	21.16	333900	24.97	1643237	1363100	-27837	-2.03	36.64	1363100	1363100	0	0.00	
86/07/30	6	8	M	PVT	OLD AGE HOME	16	2441000	9529700	10.28	4160002	3.46	3870000	6140	0.16	0.16	1008750	26.11	2855110	2861250	6140	0.22	6.22	2861250	2861250	0	0.00	
87/02/17	8	8	M	PVT	OPPHOUSE	11	1363860	3099727	33.71	1625402	7.64	1510000	-821000	-33.43	33.43	441975	18.11	1999025	178025	-821000	-41.07	41.07	178025	178025	0	0.00	
87/02/17	8	8	M	PVT	RESIDENTIAL UNITS	20	303338	676427	64.26	1307483	1.58	20773219	773117	62.28	62.28	4824249	36.12	8177833	16150950	773117	4.79	97.50	16150950	16150950	0	0.00	
87/03/10	4	8	M	PUB/1	OLD AGE HOME	10	315742	693839	56.30	366001	11.09	310000	-5742	-1.82	1.82	47000	14.89	260742	263000	-2258	-0.71	2.14	263000	263000	0	0.00	
87/04/18	6	7	M	PUB/1	UNIVERSITY ADMIN BLOCK	13	1744668	3704454	14.24	1902356	3.93	1610000	-148668	-8.42	8.42	475405	26.94	1289263	1140595	-148668	-13.03	11.53	1140595	1140595	0	0.00	
87/10/20	4	7	M	PVT	UNIVERSITY TEACHING BLDG	7	2562451	5046691	4.79	2614930	1.57	3072000	509349	19.88	19.88	779467	30.82	1783184	2292533	509349	22.34	28.56	2292533	2292533	0	0.00	
87/12/10	8	7	M	PUB/1	TECHNICON TEACHING BLDG	6	12802192	24369885	4.27	13067483	1.58	20773219	773117	62.28	62.28	4824249	36.12	8177833	16150950	773117	4.79	97.50	16150950	16150950	0	0.00	
89/04/21	6	7	M	PUB/1	PRIMARY SCHOOL	4	2292922	3216524	8.48	2383042	3.46	2485000	192078	8.38	8.38	607941	35.24	1484981	1677059	192078	11.46	97.50	1677059	1677059	0	0.00	
90/10/23	8	6	M	PVT	CHURCH	9	1152076	1562663	22.67	1272251	7.75	1735000	582930	50.40	50.40	315545	27.39	838225	582930	582930	69.46	49.48	582930	582930	0	0.00	
91/08/07	8	7	M	PUB/1	UNIVERSITY TEACHING BLDG	10	1574711	1673375	20.59	1750053	5.26	1874000	297289	19.01	19.01	99045	6.29	1475644	1774955	297289	20.28	20.28	1774955	1774955	0	0.00	
91/11/20	8	8	M	PVT	UNIVERSITY TEACHING BLDG	13	1709547	1755135	29.91	1893340	8.65	1850000	140433	6.22	6.22	156500	9.15	1553047	1693500	140433	9.04	9.04	1693500	1693500	0	0.00	
TOTAL					25 MEMBERS ANALYSED	275	5508275	12718296		58621854		64064219	9037944			14831721		6049350	68231498	9037944			68231498	68231498			
MEAN						11	2201131	5087340	22.32	2540874	3.67	2562649	361588			392380	26.09	1607742	1908260	361588			1908260	1908260			

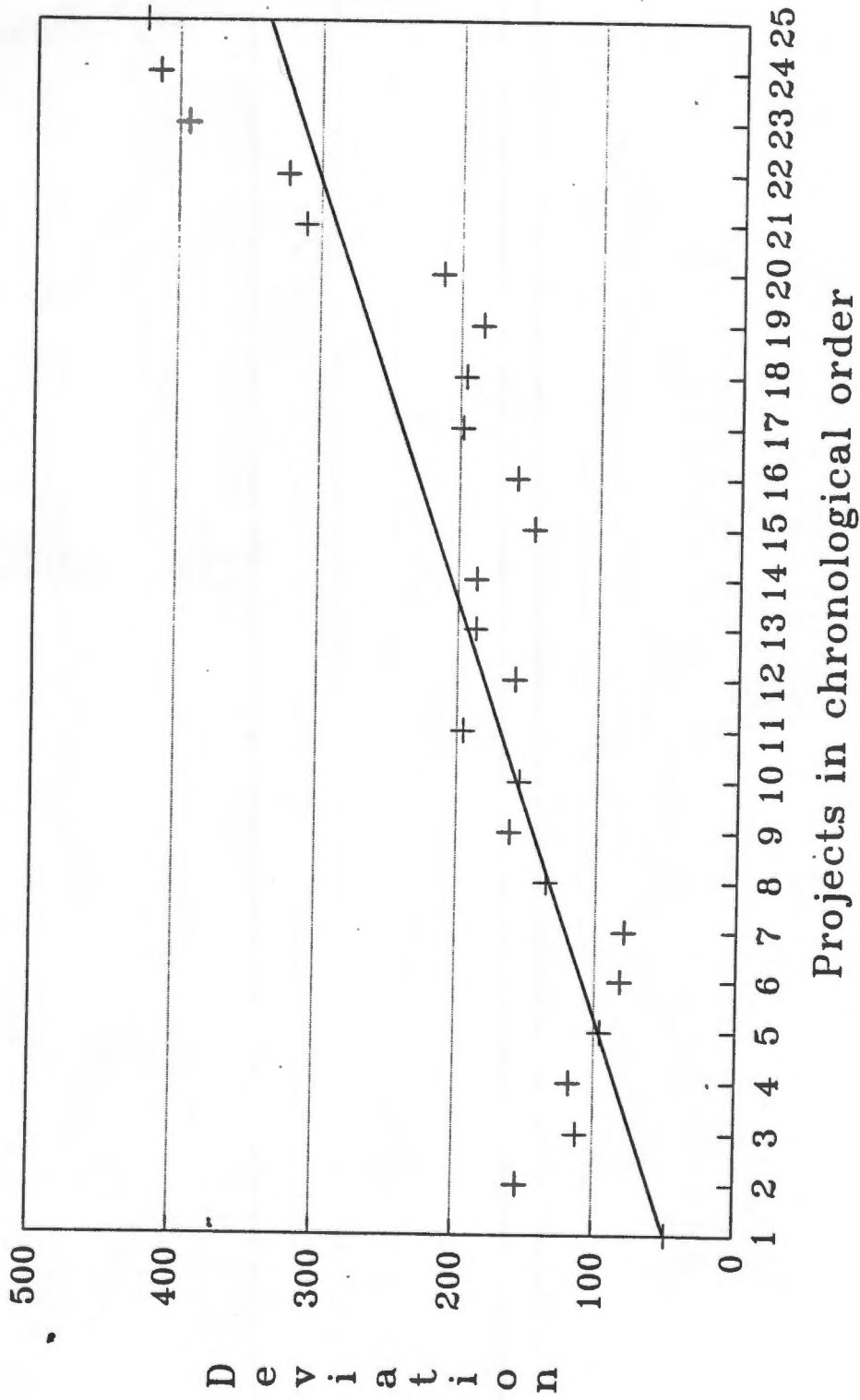
MEASURES OF ACCURACY

MEAN (MEAN/MEAN)	100.63
MEAN (MEAN/MEAN)	-02.03
MEAN (MEAN/MEAN)	107.70
MEAN ERROR	16.90
MEAN DEVIATION	21.20
STANDARD DEVIATION	31.16
Coefficient of Variation	99.96



Projects in chronological order

—■— % Rel. Deviation



+ Cum. Dev. Trend