THE UNIVERSITY OF SALFORD

The Effect of Contract Type and Size on Competitiveness in Construction Contract Bidding

A Thesis submitted for

the degree of Doctor of Philosophy

by

Derek Stephen Drew

Department of Surveying

The University of Salford

1994

To

Po Yin, Christopher and Benjamin

'Now if the estimates made in the temple before hostilities indicate victory it is because calculations show one's strength to be superior to that of his enemy; if they indicate defeat it is because calculations show that one is inferior. With many calculations, one can win; with few one cannot. How much less chance of victory has one who makes none at all! By this means I examine the situation and the outcome will be clearly apparent'

Sun Tzu, *The Art of War*, translated by Samuel B. Griffith (London University Press, 1963)

'Strange conjunctions of phenomena, particularly those of a trivial everyday kind, are so frequent in an ordinary life that we grow used to their unaccountableness, and forget the question whether the very long odds against such juxtaposition is not almost a disproof of it being a matter of chance at all'

Thomas Hardy, *A Pair of Blue Eyes*, (Oxford University Press, 1985)

CONTENTS

Page

	List of Tables	(viii)
	List of Figures	(xv)
	ACKNOWLEDGEMENTS	(xix)
	ABSTRACT	(xxii)
Chapter 1	INTRODUCTION	1
PART 1	BACKGROUND	
Chapter 2	THE CONSTRUCTION INDUSTRY AND THE COMPETITIVE ENVIRONMENT	8
	2.1 Introduction	9
	2.1.1 Management theories	10
	2.1.2 Theories of competition	11
	2.1.3 Economics and competition theory	12
	2.1.4 Management and economics theory	13
	2.2 The competitive environment	15
	2.2.1 The construction market	16
	2.2.2 Market structure	17
	2.2.2.1 Entry barriers in the construction market	18
	2.2.3 Character of the construction market	18
	2.2.3.1 Type and nature of construction work	18
	2.2.3.2 Location	22
	2.2.3.3 Clients of the construction industry	22
	2.2.4 Entry barriers and contract size and complexity	23
	2.2.5 Market sectors within the construction market	24
	2.2.6 Defining the construction market	26
	2.2.7 Market conditions	27
	2.3 The construction organisation	28
	2.3.1 Organisational structure of construction companies	28
	2.3.2 Operations of construction companies	29
	2.3.3 Strategic business units and project portfolio	30
	2.3.4 Ownership and size of company	30

2.3.5 Organisation of construction projects 32
2.4 Setting up the competition 34
2.4.1 Construction contract bidding systems 34
2.4.1.1 Construction contract bidding systems in Hong Kong 35
2.4.2 Entry barriers to bidding systems 36
2.4.3 Number and identities of bidders 38
2.5 Summary 39

Chapter 3 BIDDING AS A STRATEGIC PROCESS 42

3.1 Introduction 43
3.2 Strategic decisions 43
3.2.1 Levels of strategic decision making 45
3.3 The strategic response 46
3.3.1 The strategic domain 48
3.3.1.1 The effect of contract type 49
3.3.1.2 The effect of contract size 52
3.3.1.3 The effect of geographic area 53
3.3.1.4 The effect of market conditions 55
3.3.2 Decision to bid 55
3.3.2.1 Resources and changes in workload 59
3.3.2.2 Optimum efficiency 59
3.3.2.3 Resources 60
Personnel 60
Property 61
Finance 61
3.3.2.4 Resource implications 62
3.3.3 Submitting the bid 63
3.3.3.1 Baseline estimate 64
Cost efficiency 64
3.3.3.2 Mark-up 72
Bidding strategy 75
Constraint and preference driven bidding strategies 76
3.3.3.3 Competitiveness relationships between baseline estimate and mark-up 79
3.3.3.4 Serious and non-serious bids 79
3.3.3.5 Baseline estimate and mark-up variability 81
3.4 Outcome of the strategic process 81
3.4.1 Bidding performance 81
3.4.2 Maximum competitiveness and the market price 82
3.4.2.1 Perceptions of the market price 83
3.4.3 Competitiveness in the construction market 84
3.4.4 Competitive advantage 86
3.4.5 Variability in competitiveness between bidders 87
3.4.6 The effect of contract size and type 88
3.5 Summary 90

Chapter 4 MODELLING BIDDING COMPETITIVENESS 95

4.1 Introduction 96
4.2 Bidding models 96
4.2.1 Bidding literature reviews 97
4.2.2 Use and usefulness of bid modelling in practice 97
4.2.3 Difficulties in modelling bids 101
4.2.4 Reliability of bidding models 102
4.3 Modelling competitiveness in bidding 102
4.3.1 Modelling entire bid distributions 103
4.3.2 Modelling competitiveness relationships within bids 103
4.3.3 Modelling competitiveness relationships between bids 104
4.4 Measuring competitiveness in bidding 105
4.4.1 Competitiveness measures used by Flanagan and Norman (1982b) 106
4.5 Summary 109

PART 2 EMPIRICAL WORK

Chapter 5 METHODOLOGY 111

5.1 Introduction 112
5.2 Measuring competitiveness and variability in bidding 112
5.2.1 Classifying bidders according to competitiveness and variability in bidding 114
5.3 Measuring the effect of contract type, contract size and bidder size on competitiveness in bidding using regression analysis 116
5.3.1 Data preparation and entry 117
5.3.1.1 Public sector data 117
5.3.1.2 Data sample 118
5.3.1.3 Contract type definition 118
5.3.1.4 Contract type classification 120
Further classification according to contract type and size 121
5.3.1.5 Bidder coding 123
5.3.1.6 Bidder size classification 123
5.3.1.7 Alternative measures of bidder size 124
5.3.1.8 Updating 126
5.3.2 Development of models 126
5.3.2.1 Rationale behind selecting the chunkwise approach 126
5.3.2.2 Contract size 127

5.3.2.3 Contract type and bidder 131
5.3.2.4 Building the candidate models 131
Main effects 133
Interaction effects 133
5.3.2.5 Rationale behind the models 134
5.3.2.6 Bids selected for analysis 136
5.3.2.7 Number of bidders 137
5.3.3 Selection of best model and predictor variables 139
5.3.3.1 Forward chunkwise sequential variable selection algorithm 139
5.3.3.2 Ordering of the candidate models for testing 140
5.3.3.3 Bidder size 140
5.3.3.4 Comparison of best models based on individual and grouped bidder performance 141
5.3.3.5 Testing the robustness of the best model 143
5.3.3.6 Multivariate analysis of variance (MANOVA) 143
5.3.4 Transforming the model to satisfy the regression assumptions 144
5.3.5 Model verification, prediction and reliability 146
5.4 Summary 146

Chapter 6 COMPETITIVENESS AND VARIABILITY BETWEEN BIDS 148

6.1 Introduction 149
6.2 Replicating Flanagan and Norman's study 149
6.2.1 Comparison of bidding performances 150
6.2.2 Overall success rates 155
6.2.3 Success rates according to type and nature of work 155
6.2.4 Success and contract size 156
6.2.5 Overall comparison 157
6.3 Developing Flanagan and Norman's study 158
6.3.1 Competitiveness and bidding performance 158
6.3.2 Overall competitiveness 159
6.3.3 Competitiveness according to contract type 159
6.3.4 Competitiveness and variability in bidding 160
6.3.4.1 All bidders 161
6.3.4.2 Most frequent bidders 162
6.4 Summary 167

Chapter 7 DETERMINING THE BEST MODEL 170

7.1 Introduction 171
7.2 Individual bidder analysis 172
7.2.1 Utility of the candidate models 172
7.2.2 Results of the forward chunkwise sequential variable selection algorithm 174
7.2.3 Mallow's Cp 178
7.2.4 Sensitivity tests 178
7.3 Grouped bidder analysis 183
7.3.1 Utility of the candidate models 183
7.3.2 Results of the forward chunkwise sequential variable selection algorithm 185
7.3.3 Mallow's Cp 186
7.3.4 Sensitivity tests 187
7.4 Comparison of grouped and individual bidder behaviour 190
7.5 Testing the robustness of the individual model 193
7.5.1 F-test results at 1% significance level 194
7.5.2 Testing whether second order terms contribute to the prediction of competitiveness 194
7.5.3 New work only 195
7.5.4 Comparison of competitiveness measures 198
7.6 Summary 200

Chapter 8 SATISFYING THE REGRESSION ASSUMPTIONS 202

8.1 Introduction 203
8.2 Regression assumptions 204
8.2.1 Multicollinearity 204
8.2.1.1 Correcting multicollinearity 207
8.2.2 Normality 213
8.2.3 Homoscedasticity 215
8.2.3.1 Correcting heteroscedasticity 223
8.3 Transformation 223
8.4 Arcsin transformation 234
8.5 Weighted least squares 234
8.6 Summary 235

Chapter 9 MODEL VERIFICATION, PREDICTION AND RELIABILITY 237

9.1 Introduction 238
9.2 Model verification 238
9.2.1 Regression assumption assessment for candidate models 240
9.2.2 Best model verification 242
9.3 Model prediction 248
9.3.1 Contract type 252

9.3.2 Contract size 254
9.3.3 Individual bidder performance 255
9.3.4 Contract type and size 258
9.3.5 Bidder size 258
9.3.6 Bidder size, contract type and size 259
9.4 Reliability 260
9.5 Summary 263

Chapter 10 REFINING THE MODEL 266

10.1 Introduction 267
10.2 Contract type iterations 268
10.3 Bidder iterations 273
10.3.1 First round of bidder iterations 273
10.3.2 Second round of bidder iterations 276
10.4 Competitiveness predictions and reliability of the refined model 280
10.4.1 Competitiveness of bidders toward contract type and size 285
10.4.2 Competitiveness of bidders 288
10.4.3 Reliability of the refined model 290
10.5 Summary 292

Chapter 11 ADDING NEW BIDDERS TO THE MODEL 295

11.1 Introduction 296
11.2 Adding the 16th bidder to the model 297
11.3 Adding the 17th bidder to the model 299
11.4 An alternative approach 303
11.5 Summary 309

PART 3 SUMMARY AND CONCLUSIONS

Chapter 12 SUMMARY AND CONCLUSIONS 311

12.1 Introduction 312
12.2 Replicating Flanagan and Norman's study 316
12.3 Competitiveness and variability in bidding 317
12.4 The effect of contract type and contract size 320
12.5 The effect of bidder size 325
12.6 Possible connotations for the construction industry 327
12.7 Suggestions for further research 329

REFERENCES 332

APPENDICES

A	Original data set (in chronological order)	345
B	SPSS-X command file for selecting best model (using MANOVA)	378
C	SPSS-X command file for testing regression assumptions	382
D	Confidence intervals t for Szroeter's test statistic based on 5% level of significance according to different values of b for 776 cases	391
E	SAS command file for determining 95% prediction intervals	393

LIST OF TABLES

Table No.		Page
5.1	Contract type breakdown based on CI/Sfb building type classification	120
5.2	Further contract type breakdown according to new and alteration work	122
5.3	Bidding attempt / variable ratio per incremental increase in number of bidders for models 22, 18 and 12	138
6.1	Number of bidding attempts, average bid values and variability of bid values for Hong Kong contractors A, B and C	150
6.2	Mean percentage bidding ranges for contracts on which the Hong Kong and UK contractors made bidding attempts	154
6.3	Success rates of obtaining contracts for the Hong Kong and UK contractors	155
6.4	Success rates of obtaining contracts for Hong Kong contractors A, B and C according to contract type and nature of work	156
6.5	Size and range of contracts on which Hong Kong contractors A, B and C are successful	157
6.6	Overall competitiveness vs variability for Hong Kong contractors A, B and C	159
6.7	Competitiveness according to type for Hong Kong contractors A, B and C	160
6.8	Bidder classification according to type	164
6.9	Number of bidding attempts/successes overall and according to contract type	166
7.1	Summary of candidate model statistics for bidders modelled individually (for 6, 9, 12 and 15 bidders based on 5 contract types)	173

7.2	Summary of candidate model calculated and tabulated F values for bidders modelled individually (for 6, 9, 12 and 15 bidders based on 5 contract types)	176
7.3	Summary of candidate model statistics for bidders modelled individually (for 15 bidders based on 4 contract types)	179
7.4	Summary of candidate model calculated and tabulated F values for bidders modelled individually (for 15 bidders based on 4 contract types)	179
7.5	Summary of candidate model statistics for bidders modelled according to size (for all bidders based on 5 contract types)	184
7.6	Summary of candidate model calculated and tabulated F values for bidders modelled according to size (for all bidders based on 5 contract types)	185
7.7	Summary of candidate model statistics for bidders modelled according to size (for all bidders based on 4 contract types)	187
7.8	Summary of candidate model calculated and tabulated F values for bidders modelled according to size (for all bidders based on 4 contract types)	188
7.9	Summary of candidate model statistics for bidders modelled according to size (for 15 bidders based on 5 contract types)	190
7.10	Summary of candidate model calculated and tabulated F values for bidders modelled according to size (for 15 bidders based on 5 contract types)	191
7.11	Summary of best model statistics for bidders modelled individually and according to size, and corresponding best model summary of calculated and tabulated F values (for 15 bidders based on 5 contract types)	192
7.12	Summary of candidate model calculated and tabulated F values at 1% significance level for bidders modelled individually (for 15 bidders based on 5 contract types)	194

7.13	Summary of best linear and quadratic model statistics for bidders modelled individually, and corresponding summary of calculated and tabulated F values (for 15 bidders based on 5 contract types)	195
7.14	Summary of candidate model statistics with bidders modelled individually for new work only (for 15 bidders based on 5 contract types)	196
7.15	Summary of candidate model calculated and tabulated F values with bidders modelled individually for new work only (for 15 bidders based on 5 contract types)	197
7.16	Summary of candidate model statistics for bidders modelled individually using competitiveness measure of bidder's bid to lowest bid (for 15 bidders based on 5 contract types)	198
7.17	Summary of candidate model calculated and tabulated F values for bidders modelled individually using competitiveness measure of bidder's bid to lowest bid (for 15 bidders based on 5 contract types)	199
8.1	Pairwise correlation matrix between variables with correlations over 0.70	205
8.2	Regression summary statistics and largest variance inflation factor in the equation after (1) centering the independent continuous variable (2) using backwards stepwise regression and (3) transforming the x-variable according to exponential functions of 0.9, 0.75, 2/3, 0.5, 1/3, 0.25, 0.1 and natural log	212
8.3	Pairwise correlation matrix between variables left in the equation	212
8.4	Szroeter's test for continuous variables and Bartlett Box test for categorical variables	222
8.5	Regression summary statistics for lambda settings ranging from 2 to -5	224
8.6	Szroeter's test for continuous variables for lambda settings ranging from 2 to -5	225

8.7	Bartlett Box test for categorical variables for lambda settings ranging from 2 to -5	226
9.1	Regression assumption statistics for candidate models 1 to 22 (based on model 12 transformation)	241
9.2	A summary of candidate model 1 to 22 statistics based on 6, 9, 12 and 15 bidders	244
9.3	Summary of calculated and tabulated F values for candidate models 1 to 22 based on 6, 9, 12 and 15 bidders	245
9.4	Competitiveness of 15 bidders according to 5 contract types	263
10.1	Contract type variables remaining in the equation at lambda setting of -4.2, based on 4 contract types and 10 bidders with 713 (secondary schools) and bidder 24 as last dummy variables	271
10.2	Breakdown tables; contract size by contract type	272
10.3	Model utility statistics at lambda setting of -4.2, based on 3 contract types and 10 bidders	273
10.4	Regression assumption statistics at lambda setting of -4.2 based on 3 contract types and 10 bidders	274
10.5	Bidder variables remaining in the equation at lambda setting of -4.2 based on 3 contract types and 10 bidders	275
10.6	Model utility statistics at lambda setting of -4.2 based on 3 contract types and 8 bidders	277
10.7	Regression assumption statistics at lambda setting of -4.2 based on 3 contract types and 8 bidders	277
10.8	Bidder variables remaining in the equation at lambda setting of -4.2 based on 3 contract types and 8 bidders	278
10.9	Largest variance inflation factor (VIF) remaining in the equation after (1) centering the independent continuous variable (2) using backwards stepwise regression and (3) transforming the x-variable according to exponential functions of 0.90, 0.75, 2/3, 0.5, 1/3, 0.25, 0.1 and natural log at lambda setting of -4.2	279

10.10	Model utility statistics at lambda setting of -4.2 and x-variable at natural log based on 3 contract types and 8 bidders	280
10.11	Regression assumption statistics at lambda setting of -4.2 and x-variable at natural log based on 3 contract types and 8 bidders	280
10.12	Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at natural log based on three contract types and 8 bidders	280
10.13	Unrefined and refined model comparison of contract type and bidder variables remaining in the equation at lambda setting of -4.2	284
10.14	Regression coefficient breakdown for refined model according to contract type and bidder	287
10.15	Competitiveness prediction and reliability comparison of unrefined and refined models using selected cases	292
11.1	Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set with (1) bidder 150 and (2) bidder M as last dummy variables	297
11.2	Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set with (1) bidder 150 and (2) bidder M as last dummy variables	297
11.3	Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set with (1) bidder 150 and (2) bidder M as last dummy variables	298
11.4	Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with (1) bidder 150 and (2) bidder M as last dummy variables	298
11.5	Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with (1) bidder 150 and (2) bidder M as last dummy variables	298

11.6	Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with (1) bidder 150 and (2) bidder M as last dummy variables	299
11.7	Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set with (1) bidder 40 and (2) bidder M as last dummy variables	300
11.8	Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set with (1) bidder 40 and (2) bidder M as last dummy variables	300
11.9	Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set with (1) bidder 40 and (2) bidder M as last dummy variables	300
11.10	Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable	301
11.11	Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable	301
11.12	Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable	301
11.13	Model utility statistics at (1) lambda setting of -4.2 and x-variable at 0.5 (2) lambda setting of -4.4 with x-variable at 0.5, based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable	302
11.14	Regression assumption statistics at lambda setting of -4.2 and x-variable at (1) lambda setting of -4.2 and x-variable at 0.5 (2) lambda setting of -4.4 with x-variable at 0.5, based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable	302

11.15	Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at (1) lambda setting of -4.2 and x-variable at 0.5 (2) lambda setting of -4.4 with x-variable at 0.5, based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable	303
11.16	Model utility statistics at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder 3 contract type data set with (1) bidder 150 and bidder M, (2) bidder 40 and bidder M, (3) bidder 43 and bidder M, (4) bidder 48 and bidder M and (5) bidder 140 and bidder M as last dummy variables	305
11.17	Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder 3 contract type data set with (1) bidder 150 and bidder M, (2) bidder 40 and bidder M, (3) bidder 43 and bidder M, (4) bidder 48 and bidder M and (5) bidder 140 and bidder M as last dummy variables	306
11.18	Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder 3 contract type data set with (1) bidder 150 and bidder M, (2) bidder 40 and bidder M, (3) bidder 43 and bidder M, (4) bidder 48 and bidder M and (5) bidder 140 and bidder M as last dummy variables	307

LIST OF FIGURES

Figure No.		Page
3.1	Competitiveness factors in terms of constraints and preferences	77
4.1	Bidding performance of contractors	108
5.1	Classification of bidders according to competitiveness and consistency in bidding	115
5.2	Competitiveness and contract size	128
5.3	Competitiveness and bidder size	129
5.4	Degree of influence of contract size	130
5.5	Proposed candidate models for individual bidders	132
5.6	SPSS-X coding of independent variables	135
5.7	Proposed candidate models for bidders grouped according to bidder size (ie. small, medium and large)	142
6.1 a-c	Bid lines of UK bidders in relation to competitor bids	151
6.1 d-e	Bid lines of Hong Kong bidders 'A'and 'B' in relation to competitor bids	152
6.1 f	Bid line of Hong Kong bidder 'C' in relation to competitor bids	153
6.2	Scatterplot of competitiveness and variability for all the bidders in the sample	161
6.3	Scatterplot of competitiveness and variability for bidders with 10 or more bidding attempts	163
7.1 a	Candidate model plot of Mallow's Cp scores for bidders modelled individually (for 6 and 9 bidders based on 5 contract types)	180
7.1 b	Candidate model plot of Mallow's Cp scores for bidders modelled individually (for 12 and 15 bidders based on 5 contract types)	181

7.2	Candidate model plot of Mallow's Cp scores for bidders modelled individually (for 15 bidders based on 4 contract types)	182
7.3	Candidate model plot of Mallow's Cp scores for bidders modelled according to size (for all bidders based on 5 contract types)	186
7.4	Candidate model plot of Mallow's Cp scores for bidders modelled according to size (for all bidders based on 4 contract types)	189
7.5	Candidate model plot of Mallow's Cp scores for bidders modelled according to size (for 15 bidders based on 5 contract types)	191
7.6	Candidate model plot of Mallow's Cp scores with bidders modelled individually for new work only (for 15 bidders based on 5 contract types)	197
7.7	Candidate model plot of Mallow's Cp scores for bidders modelled individually using competitiveness measure of bidder's bid to lowest bid (for 15 bidders based on 5 contract types)	199
8.1	Tolerance values and variance inflation factors of variables entered into the equation	206
8.2	Tolerance values and variance inflation factors of variables entered into the equation after centering the independent continuous variable	209
8.3	Tolerance values and variance inflation factors of variables entered into the equation after (1) centering the independent continuous variable and (2) using backwards stepwise regression	210
8.4	Tolerance values and variance inflation factors of variables entered into the equation after (1) centering the independent continuous variable and (2) backwards stepwise regression (3) transforming the x-variable according to the exponential function of 2/3	211
8.5	Histogram of standardised residuals	214
8.6	Normal probability plot	214

8.7	Kolomogorov-Smirnov test statistics	215
8.8	Scatterplot of studentised residuals against the predicted values	218
8.9 a-j	Scatterplot of each of the independent variables left in the equation	220
8.9 k-t	Scatterplot of each of the independent variables left in the equation	221
8.9 u-z	Scatterplot of each of the independent variables left in the equation	222
8.10 a-j	Scatterplot of each of the independent variables left in the equation for lambda setting of -4.2	227
8.10 k-t	Scatterplot of each of the independent variables left in the equation for lambda setting of -4.2	228
8.10 u-x	Scatterplot of each of the independent variables left in the equation for lambda setting of -4.2	229
8.11	Scatterplot of studentised residuals against the predicted values for lambda setting of -4.2	230
8.12	Confidence intervals for Szroeter's test statistic for continuous independent variables according to lambda settings between +2 and -5	231
8.13	Probability values for Bartlett Box test statistic for categorical independent variables according to lambda settings between +2 and -5	232
8.14	Regression model summary at a lambda setting of -4.2	233
9.1 a	Plots of Mallow's Cp scores for candidate models 1 to 22 based on 6 and 9 bidders	246
9.1 b	Plots of Mallow's Cp scores for candidate models 1 to 22 based on 12 and 15 bidders	247
9.2	Regression model summary at a lambda setting of -4.2	249
9.3	Competitiveness prediction models according to contract type	253
9.4	Competitiveness prediction models according to bidder	256

9.5 Scatterplot of the 95% upper and lower prediction intervals, predicted values and actual bidding attempts according to bidder 262

10.1 Regression model summary at a lambda setting of -4.2, based on 4 contract types and 10 bidders with 713 (secondary schools) and bidder 24 as last dummy variables 270

10.2 Regression model summary at lambda setting of -4.2, based on 3 contract types and 8 bidders with FSH (Fire stations and hostels) and bidder M (bidders 9, 18, 109, 122, 127 and 148) as last dummy variables 281

10.3 SPSS-X coding of dummy variables for refined model at lambda setting of -4.2, based on three contract types and eight bidders with FSH (Fire stations and hostels) and bidder M (bidders 9, 18, 109, 122, 127 and 148) as last dummy variables 282

10.4 Refined model competitiveness predictions according to contract type 286

10.5 Refined model competitiveness predictions according to bidder 289

10.6 Scatterplot of 95% upper and lower prediction intervals, predicted values and actual bidding attempts according to bidder for the refined model 291

11.1 Regression model summary at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with bidder M as last dummy variables 304

11.2 Competitiveness predictions according to (1) bidder 150, (2) bidder 40, (3) bidder 43, (4) bidder 48 and (5) bidder 140 at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder/3 contract type data set with bidder M as last dummy variables 308

12.1 Simplified representation of competitiveness groupings 324

ACKNOWLEDGEMENTS

I would like to thank the following people for their time, help and guidance in the production of this thesis:

Alan Jameson, Drew Lamont, P.S. Leung and Alan Milne (Architectural Services Department, Hong Kong Government) and Phillip Lo (Levett and Bailey) who apart from allowing me access to their data, provided detailed explanations on their respective bidding procedures and answered all of my queries relating to the data. Isaac Lui (Chun Wo Construction and Engineering Co., Ltd.) and John Lavin (Gammon Construction Ltd.) for providing me with a valuable insight into local bidding practices.

All my colleagues at the Hong Kong Polytechnic, most notably Paul Fox, Dr. John Gilleard, Dr. Alan Griffith, David Picken, David Shoesmith, Johnny Tam and Professor Howard Ward for their encouragement, comments and advice on various aspects of the study. Catherine Chan for helping me to 'fine tune' some of the SPSS-X and SAS command files. Benedict Yeung for guidance on developing suitable spreadsheets. Tony Lau for general computer support and, in particular, arranging a special connection from my microcomputer to the main frame computer. Francis Lo for excellent draftsmanship and Irene Tsui and Christine Ng for typing some of my unintelligible notes.

Professor Roger Flanagan and Professor Peter Lansley (University of Reading), Professor Peter Hibberd (University of Wales), Dr. Richard Fellows (University of Bath), Professor Thomas Uher and Goran Runeson (University of New South Wales), John Macfarlane (University of Western Sydney) and Barry Symonds (Southbank University) for helpful comments, guidance and advice. I am particularly indebted to Professor Ranko Bon (Reading University) who visited my department for two months just at the time I was completing the analysis. His suggestion and encouragement to write a paper on the most important finding relating to this study proved priceless in helping me to clarify my thoughts in preparation for the writing up.

The vast majority of this research was undertaken with my principal supervisor, Professor Martin Skitmore, and myself being some 6,000 miles apart. I am truly indebted to Professor Skitmore in so many respects; for taking the time, trouble and effort to visit me on several occasions in Hong Kong and making the necessary arrangements for me to visit him at Salford University; for superb guidance throughout, meticulousness in detail, incredible patience and prompt responses to all of my queries. I regard myself as being extremely fortunate for having such a talented and gifted person as my main supervisor.

This study, however, would not have been possible without the support, knowledge and wisdom of two excellent local supervisors, Dr Jack Wing (Dean of Business Studies, Lingnan College) and Dr. H.P. Lo (University Senior Lecturer, Department of Applied Statistics and Operational Research, City Polytechnic). I thank Dr. Wing for providing me with an invaluable insight into research ethos, straightening out my thinking and writing on numerous occasions and giving me encouragement and support when I needed it most. Likewise, I thank Dr. H.P. Lo for advising me on many of the finer points relating to the methodology and guidance on analysing and interpreting the results.

From the bottom of my heart I thank my wife, Po Yin, for her relentless support and encouragement throughout this study. I also thank my children, Christopher and Benjamin, for sacrificing countless weekends and evenings together.

To all of these people and especially my family and supervisors, I am eternally grateful.

Finally, I would like to acknowledge Professor Skitmore's editing in the main text. Four co-authored papers were published during my PhD candidature; two papers appeared in refereed journals and two papers were presented at major international

refereed conferences (see reference section for details). The initial drafts of these papers were written by myself and Professor Skitmore edited the contents. Paragraphs extracted from some of these papers appear in the following sections: section 5.2.1, paragraphs 1 and 2; section 5.3.2.2, paragraphs 1 to 5; section 6.3.4.1 paragraph 2; section 6.4.3.2 paragraphs 2, 4, 5, 6 and 7 and section 11.3 paragraphs 3 to 6.

THE EFFECT OF CONTRACT TYPE AND SIZE ON COMPETITIVENESS IN CONSTRUCTION CONTRACT BIDDING

ABSTRACT

Flanagan and Norman (1982b) examined the bidding performances of three contractors. In developing this study, the aim of this research is to demonstrate through statistical modelling that, in terms of competitiveness, competing contractors are influenced, to varying degrees, by contract type and size and that a competitiveness relationship exists between contractor size and contract size.

Bidding behaviour between construction firms is regarded as the outcome of strategic management decisions undertaken in an economic setting. Contractors are seen to compete for construction work in a competitive environment made up of a series of market sectors, each containing an amalgam of contract types and sizes, while clients are viewed as initiators of the whole contracting process. Contractors are shown to respond to client demands by deciding on a strategic domain within which to operate, which contracts to bid for and, if opting to bid, the appropriate bid level.

Two approaches to modelling competitiveness are offered. The first approach examines the relationship between competitiveness and variability in bidding and a four-way classification system of bidder behaviour is developed. The main goal of this work, however, is contained in the second approach, which uses multiple regression to construct a competitiveness model - a prediction equation relating bidder competitiveness (the dependent variable) to the independent variables of bidder (analysed individually and also grouped according to size), contract type and contract size. The regression model shows that differences in competitiveness are greater for different contract sizes than different contract types. The most competitive contractors appear to be those with a preferred contract size range. The results are inconclusive in providing evidence that large bidders are more competitive on larger contracts and *vice versa*.

CHAPTER 1

Introduction

1 INTRODUCTION

The nature of the construction industry is such that contractors entering consistently low value bids are regarded as being more competitive than those entering consistently high value bids. Contractors may also be seen as being inconsistently competitive. In addition to mistake, competitiveness variability has been attributed to many factors including differences in cost estimates (Beeston 1983), mark-up policies (Fine 1975, Stone 1983), serious and non-serious bids (Skitmore 1989) and the effect of subcontracting (Flanagan and Norman 1985).

There is a relationship between competitiveness and variability since a contractor who is consistently competitive in bidding is by definition less variable. Over a series of competitions less competitive contractors are likely to be more variable in bidding, otherwise they would fail to get any work. One explanation for differences in bidding variability between contractors is for reasons just described. Another is that some contractors have preferred contract[1] types and sizes within the construction market and for which they bid more competitively.

Flanagan and Norman (1982b) examined the bidding performance of a small, medium and large contractor. They found that when bidding (1) the small contractor considered both contract type and size, (2) the large contractor was more successful in bidding for large contracts and (3) the medium contractor's competitiveness was not related to either contract type or size. Flanagan and Norman's study suggests that (1) competing contractors are influenced to varying degrees by contract type and size and (2) there is a relationship between size of contractor and contract size.

---

[1]A contract may comprise several projects for construction of building and/or infrastructure work. Although the term 'project' is often used in a construction context, in this thesis the term 'contract' is used as it more correctly denotes the object of the bidding process, ie. to secure a contract. Hence the term 'contract type' relates to the intended function of the project contained in the contract, eg. school or hostel. For consistency the term 'contract size' is used to denote the monetary value of a contract (usually the lowest bid).

A contractor's competitiveness is the outcome of strategic considerations. Strategies vary from contractor to contractor and appear to be very much dependent on company objectives. Male (1991b: 40) suggests that as part of their corporate strategy contractors formulate a strategic domain. He states 'The strategic domain sets the parameters within which senior management chooses to operate ... this may vary from a narrow domain in which bidders specialize in certain contract characteristics such as type and location to a broad domain which encompasses undertaking both building and civil engineering work'. In other words, the strategic domain sets out the market dimensions within which contractors plan to operate.

It follows that each firm manages its own strategic domain within a contract size continuum made up from a series of contract types. Depending on the contract type, the range of contract values contained within the contract size continuum may be broad or narrow. For smaller contractors, with more limited resources, this is likely to cover a smaller range of possible contract values at the smaller end of the contract size continuum than that of larger contractors. This, coupled with the fact that there are many more smaller contractors than larger contractors, means that the variety of potential contractors increases as the contract size decreases. Larger contractors will almost certainly be the lowest bidder for the larger contracts. However, either larger or smaller contractors have the potential of becoming the lowest bidder on the small contracts.

In the course of running the construction firm contractors are given numerous opportunities to bid for work both within and outside the strategic domain. Skitmore (1982) identifies that job desirability is influenced by many factors including favoured types within the contractor's expertise. It seems, therefore, that different contractors are likely to have varying degrees of preference towards the type and size of contract. This appears to be dictated, to some extent, by available resources and experience. Further considerations are: present and future workloads; the workload of the industry as a whole; and differences in perceptions of contractors concerning these matters.

Although competitive relationships can be considered within a bid or by examining bid distributions, construction contract bidding is essentially concerned with competitiveness relationships *between* contractors and the contracts they are bidding for which can vary considerably, particularly in terms of contract type and size, from one contract to the next.

The primary aim of this research is to demonstrate through statistical modelling that, in terms of competitiveness, competing contractors are influenced, to varying degrees, by contract type and contract size. A secondary aim is to demonstrate that a competitiveness relationship exists between bidder size and contract size.

By developing Flanagan and Norman's study the specific objectives of this research are to:

(1) measure the effect of contract type on competitiveness and variability in bidding;

(2) measure the effect of contract type and size on competitiveness in bidding;

(3) develop (2) to measure the effect of bidder size on competitiveness in bidding;

(4) exercise the development of suitable regression analysis methodology to model the effect of contract type, contract size and bidder size;

(5) devise suitable bidder classification systems for evaluating the competitive bidding behaviour of contractors.

By considering the competitiveness relationships of bids submitted to the client, the focus of this thesis is, therefore, on the bidding behaviour of contractors who are in competition with each other for various contract packages of construction work. The thesis is specifically concerned with modelling the effect that contract type and contract size have on the competitiveness level of different bidders. Two different approaches are developed. The first approach examines the relationship between competitiveness and variability in bidding from which a four way classification system of bidder behaviour is offered. The second more sophisticated approach, based on multiple regression, identifies the extent to which different contract types and range of contract sizes influence each bidder's competitiveness. Drawing upon the economies of scale theory, each bidder is modelled as having a preferred or optimum contract size at which it is most competitive. The emphasis is, however, on identifying the range of contract sizes within which bidders are competitive, rather than determining a particular optimum contract size. The model is not principally concerned with optimisation and is not, therefore, considered specifically as an operational research problem. It is a comparative model of contractors' bidding performance and focuses on identifying contractors' bidding behaviour, in terms of competitiveness, according to contract type and size. The effect of bidder size on competitiveness in bidding is also modelled.

This thesis is divided into three parts; background to the research is presented in Chapters 2 to 4, empirical work is contained in Chapters 5 to 11 and summary and conclusions are presented in Chapter 12.

Bidding behaviour between construction firms is regarded as the outcome of strategic management decisions undertaken in an economic setting. In Chapter 2 contractors are seen to compete for construction work in a competitive environment made up of a series of market sectors, each containing an amalgam of contract types and sizes. Clients are viewed as initiators of the whole contracting process and set out the nature and form of competition. In Chapter 3 contractors are shown to respond to client demands by strategically deciding a strategic domain within which to operate, which contracts to bid for and, if opting to bid, the appropriate bid level. Chapter 4 reviews previous empirical studies and identifies various approaches to modelling competitiveness.

The methodology is developed in Chapter 5. Bid data from five contract types was collected from the Hong Kong Government's tender reports on the basis of Flanagan and Norman's study. Three contractors were selected from the Hong Kong data and Flanagan and Norman's study was replicated in Chapter 6. Using the same three contractors the analysis was developed by introducing another preferred measure of competitiveness and also investigating the relationship between competitiveness, C' and competitiveness variability, C". All the data in the sample was used and a matrix produced to identify four classes of bidder behaviour. In selecting the most frequent bidders in the sample (ie. those who bid 10 times or more) this was extended to consider the effect of contract type on competitiveness .

Although this thesis offers a four way classification system to model competitive bidding behaviour, the main goal of this work is to build a good regression model - a prediction equation relating bidder competitiveness (the dependent variable) to the independent variables of bidder (analysed individually and also according to size), contract type and contract size.

A chunkwise approach was used and twenty two candidate models containing different chunk combinations of predictor variables were developed. In Chapter 7 the best of the candidate models was selected using a forward chunkwise sequential variable selection algorithm based on the F-test. In using this algorithm the best model according to individual bidder behaviour was determined by incrementally adding bidders into the analysis up to a pre-determined 15 bidder cut off point. All the bidders in the sample were then grouped according to size and the best model based on bidder size was found using the same algorithm. In comparing the best models according individual and grouped behaviour, it can be seen that a 15 bidder model based on individual behaviour is a better predictor of competitiveness.

The reliability of the 15 bidder best model was considered in Chapter 8 by examining the residuals to see if one or more of the standard least squares assumptions is violated. Each assumption was examined in turn and where necessary the model was transformed in such a way that it not only satisfies the regression assumptions but also that it remains the best model for predicting the dependent variable, competitiveness. The best model in its transformed state was verified as the best model in Chapter 9. The competitiveness predictions according to contract type and contract size were also observed and the best model's reliability examined by constructing 95% prediction intervals.

The 15 bidder model was refined in Chapter 10 by grouping together bidders with similar bidding behaviour patterns and prediction and reliability comparisons were made with the model before refinement. Finally, using the 15 bidder refined model as the starting point, Chapter 11 explored the effect of adding new bidders to the refined model.

An overall summary, conclusions and suggested further research are presented in Chapter 12.

PART 1

BACKGROUND

CHAPTER 2

The construction industry and the competitive environment

2 THE CONSTRUCTION INDUSTRY AND THE COMPETITIVE ENVIRONMENT

2.1 Introduction

Much of the constructors' work in the construction industry stems from contracting. This involves a customised design being constructed with the roles of the client and contractor being contractually defined. Contracting may be defined as 'a service which is related to individual construction work packages each one of which may be likened to a firm with a relatively short and finite life' (Cannon and Hillebrandt 1989c: 57).

Construction contract bidding is widely used in the construction industry as a vehicle for distributing work to willing contractors. It is seen by the majority of clients as being fair and likely to produce the lowest possible commercially viable tender price in the prevailing market conditions (Harris and McCaffer 1989). Construction contract bidding is the mechanism frequently adopted within the construction market for obtaining a price for this work. It is a special type of auction commonly referred to in economics and management science literature as a 'sealed bid auction' (Flanagan and Norman 1985). Sealed bidding is 'where all the bidders, supply the client with their terms and conditions in sealed envelopes which are opened at a fixed date' (King and Mercer 1988).

In this context, bidding is essentially a pricing problem. The bidder 'must choose a price high enough to provide sufficient contribution to overheads and profits, yet low enough to ensure that a sufficient volume of work is actually obtained ... in an environment of considerable uncertainty about the behaviour of the competitors' (Douglas 1989: 482).

This chapter describes the overall construction industry environment in relation to competition and comprises four sections. After first considering the theoretical development of this research in the context of management and economic theory, the competitive environment within which contractors operate and the influence it has over construction organisations are each discussed in turn. The client's role in setting up the competition is described in the last section.

2.1.1 Management theories

Management theorists have developed a systems approach to model the behaviour of firms based on an input-conversion-output model. Management theorists see firms as organisations which can be defined as arrangements of people or roles operating within a particular environment with which they must interact to survive. Organisations obtain inputs from their environment in the form of human, physical and financial resources and export outputs to the environment in the form of products, services and, less tangibly, behaviour and attitudes. The environment constrains the organisation through, at least, political, economic, social and technological pressures. Organisations receive feedback from their environment about the acceptability of their products or services, expressed for example in terms of purchasing patterns or financial support, which enables managers to make adjustments to inputs and the conversion process. They may exist in a steady state or increase in size and range of activities through increasing inputs and outputs. Systems thinking has been modified with the emergence of the contingency approach to management 'which argues there is no single best way to run a business and that mangers must adapt their style and methods to suit the circumstances' (Fryer 1990: 13).

Kast and Rosenzweig (1985) regard the organisation as a composite of several sub-systems - operating, coordinative and strategic. Each system is separated by a boundary which screens the inputs and outputs. The outermost boundary is between the strategic sub-system and the environment of the system. 'Strategic management is concerned with the management of the long term relationship of the company with its external environment' (Male 1991c: 50). Selecting which contracts to bid for and setting the appropriate bid level can, therefore, be regarded as a strategic management problem.

Management is essentially concerned with relationships, with management theory being centred on business strategy, organisation theory and the management of human resources. It has emerged from a composite of ideas drawn from many areas including economics and, certainly in its behavioural aspects, draws quite heavily on psychology. However, it seems to be deficient in the sense that 'there is no body of management theory in the way that there is an economic theory of the firm, in which all the component parts are interrelated to a total system' (Cannon and Hillebrandt 1989a: 6).

2.1.2 Theories of competition

Competition is defined as 'emulous striving for the same object; the struggle for existence or gain in industrial and mercantile pursuits' (Hayward and Sparkes 1986: 230). Competition theories can be found in the fields of economics and biology. Czepiel (1992 :16) defines basic economic competition as 'when a good or service is consumed, utility is created which has a value. Competition gets that value ... the buyer always wants to pay as little as possible for the product, while the seller wants to get as high a price as possible. Both are competing for the value created by the production and consumption of the good or service'. Henderson (1984) has suggested that biology may be more relevant than economics in the development of a useful competitive theory. In an earlier paper Henderson (1983) describes natural competition as the basic form of competition between living organisms for their necessary life resources. Organisms that more effectively obtain sustenance and that more efficiently process it preempt those resources from their competitors, thereby weakening the competitors. At the same time those resources are strengthening the organism. Over time, this process leads to the extinction of the less effective competitor through the process known as natural selection.

There are many parallels between economic and natural competition. Henderson

(1981, 1983) highlights the business implications of natural competition as follows:

(1) Businesses which continue in existence over time have a unique advantage over all others with which they compete;

(2) Businesses which are most similar to each other will compete most severely;

(3) Effective competition produces a wide range of sizes among competing businesses;

(4) Where one competitor has a clear visible superiority, there will be a very low level of competition from others;

(5) The smaller the number of key strategic variables in an industry, the smaller the numbers of competitors that exist;

(6) The successful entry of a new competitor requires a clear superiority over all existing competitors in some part of the market.

Czepiel (1992) concludes that a fundamental difference between natural competition and economic competition is that natural competition just happens through natural selection and mutation with those possessing the characteristics needed for continued existence surviving while those that do not eventually disappear. Economic competition, however, through strategic decision making is marked by carefully considered and tightly reasoned actions with long term survival being largely dependent on the strategies employed.

2.1.3 Economics and competition theory

The competition theory of firms has its roots firmly embedded in economics. The nature of competition and of market structure are the outcome of interaction between supply and demand. Two extremes of competition are monopoly and pure competition. Intermediate levels of competition are classed as imperfect. The concept of demand elasticity is usually regarded as the basic indicator of the nature of competition. Elasticity is a measure of the degree to which a change in price will result in a change of demand.

As Baker (1985) points out, the factor which really distinguishes imperfect competition is that the firm must take into account not only the external environment within which it must operate, but also the action of other competitors in the market place. The need for firms, under conditions of imperfect competition, to take into account the actions of their immediate competitors makes for a much more complex situation, and one demanding high levels of managerial skill. Under conditions of imperfect competition competitors are mutually interdependent, and so must allow for each other's actions when formulating their plans.

The study of competition places increasing emphasis upon the strategic choices made by participating firms and the impact which these have upon both the fortunes of their competitors and market structure. In making such choices, firms have to operate within multi-dimensional constraints which are common to them all. Microeconomic aspects of supply are concerned with the behaviour of the firm. In economics, the theory of the firm adopts a number of simplifying assumptions in order to provide a benchmark against which to compare real world behaviour. This includes the assumption that each firm's objective is to maximise profits, although it is recognised by many economists that firms in fact seek to satisfice rather than seeking to maximise. Most firms satisfice in the sense that they see survival as the primary objective and growth the second. In order both to survive and grow, firms will also tend to take the line of least resistance by seeking to operate in those markets with the largest and most stable demand.

2.1.4 Management and economics theory

Kast and Rosenzweig (1985) recognise that economics has strongly influenced managerial thought but also state that it is limited in explaining the behaviour of the firm as it treats the firm as a single person based on simplified assumptions. These limiting assumptions present an unreal picture of actual business organisations which may restrict the predictive value of the theory. Kast and Rosenzweig, however, identify that progress has been made with the work of Cyert and March (1963) who considered behavioural factors relating to the theory of the firm. Studies of industrial economics have also made significant contributions to managerial decision making. Hillebrandt (1985: 6) states 'increasingly the theories of organisation and management are being linked to economic theory to provide a more comprehensive approach to the understanding of business behaviour and hence ultimately to assist in decision making'.

With particular respect to the construction industry, Hillebrandt (1985) suggests that general economic theory deals inadequately with the method of price determination within the construction industry which is a discrete process for each contract and for each piece of work subcontracted, either by bidding or by some form of negotiation. Cannon and Hillebrandt (1989a: 6) state that although theories of the firm have developed from small entrepreneurial business to large firms in an oligopolistic environment, it still treats firms as being 'involved in processing standardised products, the sales of which are influenced by advertising expenditures'. Moreover, Skitmore (1989) observes that economists have devoted relatively little space to the consideration of pricing in the construction industry. Cannon and Hillebrandt (1989a) conclude that it remains inherently difficult to relate the economic structure, behaviour and performance of construction firms to theoretical structures. They identify the main problem as lying in the characteristics of the products of the construction industry and particularly in their one off nature and long gestation period.

The foregoing tends to suggest that management theory is more comprehensive at modelling strategic behaviour within construction firms, while economic theory seems to be more developed at modelling competitive performance between construction firms. Since competitive relationships between firms are based on management decisions that have taken place within a firm, the approach taken in the theoretical development of this research is to view the bidding behaviour of construction firms as the outcome of strategic management decisions undertaken in an economic setting.

2.2 The competitive environment

The construction industry environment within which contractors operate is seen by Newcombe et al (1990a) as consisting of the general environmental factors of politics and law, economics, sociology and technology as well as the competitive environmental factors of finance, plant, labour, management, suppliers, subcontractors, consultants and clients. This latter set of factors includes contracts undertaken by the organisation at local, national and international levels.

Newcombe et al (1990a: 48) state 'to define the competitive environment it is important to understand the distinction between an industry and a market ... an industry is an output concept whilst a market is a demand concept. For the strategist what is important is the nature of the competition, that is the market. Markets can be described and defined by the nature of competition. If the strategy of one company has a significant effect on the demand for the output of another firm, then it can be said that the two firms are in competition with each other and thus in the same market. In defining market boundaries it is the degree of substitutability which is the key factor'.

An organisation's competitive environment can therefore be defined in terms of markets. Porter (1980) has developed a structured means of examining the state of the competitive environment by considering the influence of five forces. Newcombe et al (1990a) relate these five forces to the construction industry as follows:

(1) New entrants: threat of new entrants is high for small contracts, however, for larger contracts the barriers of entry are considerable. Experience and expertise have become essential pre-requisites for larger contracts and the threats usually come from known competitors. Barriers of economies of scale of operation limit the ability of small firms competing for large contracts and vice versa;

(2) Substitutes: Traditional demarcations between design and construction being eroded with design and build and management contracting. These approaches

offer clients substitutes for the traditional competitive tendering methods;

(3) Buyers: bargaining power of public sector clients declining with switch to private sector projects in which private sector clients have been more demanding of the construction industry;

(4) Suppliers: since the construction industry has low capitalisation the bargaining power of suppliers and subcontractors is considerable and withdrawal of credit may lead to the contractors becoming bankrupt;

(5) Industry competitors: degree of rivalry between competitors in construction markets is dependent on (a) the extent to which construction firms are in balance which depends on market share and size of competing contractors (b) the state of the market ie. whether it is in a slump or boom period (c) the workload of competitors (d) the degree to which the work is differentiated, with less differentiation leading to greater rivalry.

2.2.1 The construction market

Economists define a market as 'whenever potential sellers of a good or service are brought into contact with potential buyers and a means of exchange is available. The medium of exchange may be money or barter' (Bannock et al 1987: 262). Competitive bidding markets are defined by Douglas (1989: 482) as 'those in which there are a number of sellers (who do not generally communicate with each other) who compete to provide a product or service to a single buyer. The buyer makes it known that he or she wishes to purchase a particular product or service, and the sellers tender their bids or quotes for the supply of that service. If the suppliers are quoting to a particular set of specifications, the buyer presumably chooses the lowest bid, whereas if there are quality differences in the products or services offered by the supplier, the buyer must decide which offers the best deal, by considering both the price and quality of services'.

In the context of the construction market the buyer is commonly referred to as the client and the seller as the contractor where the client has a need in the form of construction work which the contractor can satisfy for a mutually agreed price.

The nature of competition experienced within the market is influenced by market structure and characteristics (Bannock et al 1987).

2.2.2 Market structure

Economists see the most important features of market structure as being the number and size distribution of buyers and sellers which reflect the extent of monopoly. This in turn is affected by the existence or absence of barriers to entry (Bannock et al 1987).

The construction industry is highly fragmented with the dominant firm being the small contractor (Male 1991b). Porter (1980) defines a fragmented industry as one in which no company has a significant market share which usually comprises:

(1) large numbers of small and medium sized companies, and as Male (1991b) suggests, by implication this means a small number of large companies;
(2) a high incidence of privately owned companies;
(3) competitors being in a weak bargaining position with respect to both buyer and seller and that profitability is marginal.

Small firms have obvious different characteristics from large companies, including scale and scope of operations, ownership and management style and their state of independence (Carson 1985). Stocks (1991) considers small contractors as those that have limited resources, lack of expertise and limited impact on the market place. Evidence of the dominant firm being the small contractor can be found, for example, in the Hong Kong construction market where the number of firms engaged in building and civil engineering work employing 20 persons or less amounts to approximately 94% of the total number of construction companies. However, in terms of number of employees directly engaged this equates to only 49% and for gross value of construction work performed this amounts to only 20% (Hong Kong Government 1991).

2.2.2.1 Entry barriers in the construction market

Construction markets have low entry and exit barriers with low capital requirements especially at the low end of company size (Betts and Ofori 1992). Contractors' 'know-how' knowledge is easily transferable through hiring (Seymour 1987). Entry barriers at the lower end of the company size criterion are relatively easy. The reason for this is that the nature and sophistication of the client who commissions the work is likely to change as a firm grows in size. Briscoe (1988: 104) observes that 'small firms deal predominantly with individual householders and perhaps carry out some work for the corporate sector. Larger firms also deal with house buyers, but much of their workload stems from the industrial and commercial sector, and also from local authorities. The largest firms carry out most government contracts: they are also the organisations that deal with overseas governments'.

2.2.3 Character of the construction market

Briscoe (1988) suggests the character of construction markets is set by the type and nature of construction work, the geographical location and the nature of the client and that the exact type of competition experienced by the construction firm depends on all these factors.

2.2.3.1 Type and nature of construction work

The Standard Industrial Classification, which defines industries for the purpose of official statistics, lists the following activities under the heading 'Construction': '... erecting, repairing buildings; constructing and repairing roads and bridges; erecting steel and reinforced concrete structures; other civil engineering work such as laying sewers and gas mains, erecting overhead line supports and ariel masts, open cast mining, etc.'

The construction industry includes building and civil engineering firms engaged in new build work and repair, maintenance and improvements. Construction work is commonly divided into building and civil engineering work. Building and civil engineering work can be subdivided into either broad or narrow type groupings. Skitmore (1989) states that the types of buildings are usually denoted by function such as residential, commercial, industrial, educational and recreational with the building's function being largely associated with benefits to the consumer.

A comprehensive construction type classification system used for the UK construction industry is based on the CI/ SfB[1] construction indexing manual (Ray-Jones and Clegg 1976). This classifies type of work into nine main groupings. Each of these categories are then split into many sub-groupings. The nine main groupings with examples of sub-groupings are as follows:

(1) Utilities, civil engineering facilities eg. railway tracks, garages, piers;
(2) Industrial facilities eg. glasshouses, factories;
(3) Administrative, commercial, protective service facilities eg. offices, shopping centres, prisons;
(4) Health, welfare facilities eg. hospitals, nursing homes;
(5) Recreational facilities eg. restaurants, swimming pools;
(6) Religious facilities eg.temples, cathedrals;
(7) Educational, scientific, information facilities eg. schools, libraries;
(8) Residential facilities eg. housing, apartments;
(9) Common facilities, other facilities eg. laundries, kitchens.

The nature of construction work is commonly broken down into new build work and existing building alteration work. New build work is a term used to describe a construction facility which is constructed from new whereas alteration work is regarded as an all embracing term which includes conversion, modernisation, rehabilitation, extension, repair, maintenance and demolition work (Cook 1991).

---

[1] 'The Construction Index Samarbetskommitem for Byggnadsfrager (CI/SfB) is a co-ordination system developed for the construction industry which allows cross-referencing between drawings, specifications and technical literature. It originated in Sweden and in 1968 the RIBA (Royal Institute of British Architects) developed the System further' (Aqua Group 1992).

Griffith (1992), for example, subdivides new build work into:

(1) Replacement and/or erection of a new building;

(2) Extension of an existing building;

and existing building work into:

(1) Maintenance;
  - (a) Unplanned repair and maintenance;
  - (b) Preventative maintenance;

(2) Repairs and restoration;
  - (a) Modernisation;
  - (b) Refurbishment.

The Department of the Environment (Department of Environment 1992) splits construction work into twenty-two separate trades according to new build and repair and maintenance work. The principal divisions comprise:

(1) New build work;
  - (a) Public housing;
  - (b) Private housing;
  - (c) Other new work;
    - (i) industrial;
    - (ii) commercial;
  - (d) Other new work - public;

(2) Repair and maintenance;
  - (a) Housing;
  - (b) Other work - public;
  - (c) Other work- private.

Construction work can also be classified according to size. For example, small building works are described by Griffith (1992: 2-3) as 'minor building repair or maintenance task undertaken by a jobbing builder, to a new build project such as a major extension or even a complete building or structure procured under a shorter form of building contract' and 'will assume only a minor proportion of activity in the new build sector and, in the main will be concerned with extensions, alterations or improvement works (with) the greatest proportion of small building works occurring in the repair and maintenance sector'. He identifies that small building works have the following characteristics:

(1) limited scale;
(2) limited content;
(3) small quantities;
(4) they may be unspecified, of an uncertain nature or even be of an unknown nature prior to their commencement;
(5) short project duration.

In contracting, the type and nature of construction work is dictated by the make up of the contract package. This is determined by the client. For example, the contract package may consist of either or both new build work and alteration work. Some contract packages may be for construction work that is more standardised in design than other contract work. The contract package may comprise one or more building types. There is also likely to be specification differences and variability in the number of units contained in the packages. These packages are also likely to vary in content (eg. the contract package may contain either or both substructure and superstructure work).

The make up of the contract package according to type and nature will in turn influence the range and distribution of contract sizes. Contract size can be measured according to area or volume. This, however, does not take account of complexity. Hillebrandt (1985) states that it should be theoretically possible to measure the degree of complexity but acknowledges that the practical difficulties are great. It is suggested that the nearest readily available approximation for measuring complexity is the cost per square metre. Since cost reflects complexity to some extent, ie. if the construction work is very costly, it might well be complex (Naoum 1991), an alternative readily available measure that reflects, to some degree, both complexity and size of the contract package is the bid price submitted by the contractor.

Size and complexity of construction work would seem to be correlated with larger construction work tending to be more complex. The very smallest and simplest contract packages will almost certainly be for alteration work, although the scope of this work can vary quite considerably with massive and complex refurbishment projects. New build work will also generate a wide range of contract package sizes of differing complexity.

2.2.3.2 Location

The construction work that goes to make up the construction market is dispersed geographically. The extent of dispersion appears is affected by density of population and extent of geographical area. Hillebrandt (1985) suggests the small market share of any one contractor is more likely to occur in areas of relatively dense population where the amount of work within the area is substantial, so that a large volume of work is available to firms in the area without having to incur heavy transport costs. In such cases the client has a large choice of contractors which will lead to effective competition. Also a large volume of work in a confined geographical area will allow a greater degree of contractor specialisation. Hong Kong, for example, appears to fall into this category as it is both very densely populated and very limited geographically.

2.2.3.3 Clients of the construction industry

The type, nature, size and location of construction work that clients demand varies considerably. Construction clients themselves also vary considerably. They range from individuals through to large multinational companies and come from both the private and public sector. Shutt (1988) regards the private sector as any private owner, developer or private organisation and the public sector as any public authority, such as local authorities, nationalised industries and new town corporations. Hillebrandt (1985) classifies clients according to differing roles and objectives. The public sector is classified into commercial or industrial enterprises including nationalised industries, infrastructure and other community goods enterprises (eg. roads, prisons) and non-commercial social enterprises (eg. health care and water supply). The private sector is classified into owner occupiers and developers.

In addition, clients are dissimilar in the degree of knowledge they possess about the workings of the construction industry. Clients of construction may also be regular or irregular procurers of facilities and approach the industry frequently or on an intermittent basis (Fellows et al 1983). Masterman (1992) presents a client classification system in which clients are divided into public and private sector and sub-divided firstly into whether they are experienced or inexperienced and secondly according to whether they are primary or secondary constructors. For example, he regards all public sector clients experienced with primary constructors comprising government funded development agencies and local authorities and secondary constructors as central and local government.

2.2.4 Entry barriers and contract size and complexity

The structure and character of the construction market will influence the number of competitors in the market. Hillebrandt (1985) regards size of contract as a major determinant of the number of firms who can undertake the work, with complexity as another determinant. 'A large contract requires more of all inputs than a small contract, and only some of the total number of contractors in the country have these inputs available to them ... a complicated building can be constructed only by firms having control over the technical expertise required. This technical expertise has many components: for example, the variety and depth of technical skills, and the level of technology of the materials and processes' (Hillebrandt 1985: 25).

Male (1991: 17) points out that 'as project size and complexity increases there are fewer companies about to undertake particular types of project - through managerial capability and access to finance'. He also points out that 'These pose barriers to entry for particular types of project and hence arrange contracting into a project based vertical market defined by project size and complexity'.

Hillebrandt (1985) proposes two market scenarios based on size and complexity of work. One where there are many firms in the market and the other where there are few firms in the market. The distinction drawn between these markets is in terms of the size and complexity of work. For scenario 1 projects may be of a relatively straight forward type with many companies able to undertake the work. For scenario 2 the project may be larger and complex where there are fewer companies able to undertake the work. The degree of competition within these scenarios is shown to be dependent on the type of contractor selection system. For example, with respect to open tendering, this varies from approaching perfect competition (scenario 1) to oligopoly (scenario 2), while for single stage selective tendering this varies from partial oligopoly (scenario 1) to oligopoly (scenario 2).

Contract size and complexity are therefore important determinants in the number of contractors able to undertake work. Related to this is managerial capability and access to finance, the implications of which are discussed in Chapter 3.

2.2.5 Market sectors within the construction market

The structure and character of the construction market also shape the divisions of work within the market, thereby creating market sectors. Newcombe (1976) sees a series of different markets existing within the overall construction market, each requiring a different set of resources, skills and management expertise and comprise general contracting, civil engineering, speculative house building, property development, building products and plant hire. Langford and Male (1991) identify that the market is made up of four main areas, namely building, civil engineering, repairs and maintenance and materials manufacturing and that these may be sub-divided into market sectors. For example, they state that the building market is composed of housing, industrial and commercial markets. Fisher (1986) identifies market sectors within the building market as industrial buildings, commercial buildings, renovation work, private sector house building, public sector building, jobbing and maintenance work.

Lansley et al (1979) suggest an alternative view, that is with the exception of housing development, contractors do not consider demand in terms of market sectors, but in terms of technologies to execute project types. They found the main features that managers stated in assessing projects were project size, project complexity and construction method. In respect of construction methods, it would seem the broad divisions that occur within the construction market, in terms of type, are for building and civil engineering work and, with respect to nature of work, for new build and alteration work.

At a national level Lansley et al (1979) found that there was a clear distinction between building and civil engineering by some contractors but not by others. However, for smaller projects at a regional level there was a clear distinction for building and civil engineering work. Since civil engineering projects are less homogeneous than building projects (Raftery 1994), this may result in greater range of market sectors. Civil engineering market sectors may be viewed in terms of plant requirements for different types of project such as dredging and tunnelling equipment. Specialist plant availability and requirements are likely to have an important bearing on the number of contractors entering that particular market sector. On the other hand, building can be viewed in terms of method of fabrication and extent of prefabrication, with some contractors focusing their attention on particular construction methods.

The foregoing discussion tends to indicate that the construction market is made up of market sectors, although there appears to be a lack of consensus on the precise boundaries of these sectors. Newcombe et al (1990a: 48) suggests 'in defining market boundaries it is the degree of substitutability between products or services which is the key factor ... a civil engineering firm and a speculative house builder are in the same construction industry ... but in patently different markets because a bridge is no substitute for a house and vice versa'.

2.2.6 Defining the construction market

Hillebrandt (1985: 26) suggests that 'markets in the construction industry should ... be defined in terms of the total demand for a particular service of a certain degree of complexity and size of contract and in a geographical area which may be covered, without undue increases in costs, by firms likely to be capable of undertaking work of that type. The total number of firms interested in work of this type will be referred to as being in a particular market'. Male (1991b) develops this definition further by introducing the notion of a *project-based vertical market* defined by project size and complexity. He considers 'construction in terms of a geographically dispersed project-based vertical market that operates world wide from local to international arena, and as we go up the vertical market, defined by project size and complexity, there are fewer and fewer companies able to undertake particular types of project and fragmentation tends to decrease as the industry is segmented by overlapping project based market structures' (Male 1991b: 18). He also suggests that it is hierarchically structured in terms of company size with fragmentation being high at the smaller end of the vertical market structure in repair and maintenance work while for new build work fragmentation decreases according to project characteristics.

Male's definition could perhaps be further extended by viewing the market sectors on two levels in terms of main contract work and sub-contract work. It would seem that if the market for main contract work is project based then for sub-contract work it is likely to be specialist trade based.

Common threads in both Hillebrandt and Male's definitions of the construction market appear to be contract size and complexity, type of contract and location. With the exception of contract size and complexity these definitions appear to conform with the economists' view of the market which is seen as existing in two main dimensions: (1) product type and (2) geographic area (Shepherd 1990). It seems that project size and complexity is regarded as an additional important dimension in the construction market because of the wide range of contract sizes that exists within the construction market and it is this which, according to Hillebrandt (1985), is the major determinant of the number of firms able to undertake the work.

2.2.7 Market conditions

The total number of firms interested in undertaking construction work according to these three main dimensions appears to some extent dependent on market conditions. Market conditions are regarded by Thorpe and McCaffer (1991) as an all embracing subjective term which on a macro-(industry) level includes such factors as:

(1) the total construction order for all work;
(2) the total orders for each market sector;
(3) projected future orders;
(4) current and projected governmental policy and legislation;
(5) construction (input) price levels;
(6) cost of capital;

and on a micro-(company) level it will include an assessment of:

(1) local, national and international opportunities;
(2) competitor activity;
(3) volume of on-going work;
(4) order books.

In construction contracting the method of price determination is the reverse of manufacturing in that the contractor determines the price prior to production. Under this form of market structure the construction work is pre-demanded by the client (Male 1991b). In other words construction contracting is demand driven and as such the construction work demanded by clients fluctuates over time. These fluctuations create feast or famine for the construction firms involved (Newcombe et al 1990a) although these fluctuations are seen by Male (1991c) to be no worse than those experienced in other industries.

When the construction market is in recession there is normally less work available. This will inevitably lead to greater competition between contractors. Flanagan and Norman (1985) state that a fall in workload can be expected to affect all contractors and with very low workloads the opportunity cost will be low.

2.3 The construction organisation

The competitive environment also exerts major influences over the structure and operations of organisations. The points of contact between the organisation and its environment are of primary significance to an organisation's success. Strengths and weaknesses are internal and are determined by the organisation. Opportunities and threats are external and consist of environmental factors to which the organisation must respond. Environment generates the main risks and uncertainties for an organisation.

2.3.1 Organisational structure of construction companies

Construction companies are complex and a number of different corporate organisational structures have evolved ranging from the simple structure appropriate for the small company through a series of variations to the divisionalised structure and holding company pattern present in large companies. Robbins (1983) identifies three basic components to organisational structure. They are:

(1) complexity which relates the extent of structural differentiation which consists of horizontal differentiation, vertical differentiation and spacial dispersion;

(2) formalisation which is concerned with the extent to which the norms of an organisation are made explicit;

(3) centralisation which refers to the extent to which power is centralised or concentrated within the organisation.

Based on work by Channon (1973), Newcombe (1976) identified four forms of organisational structure relevant to construction:

(1) integrated: no division of the total task of the business into specialised functions with many unrelated activities grouped under a single individual;
(2) functional: business subdivided into a series of specialised functions;
(3) holding company: comprised a system of semi autonomous subsidiaries or companies, held together only as a corporate legal entity;
(4) multidivisional: general office, usually divorced from operations, which serviced and monitored the operating divisions.

2.3.2 Operations of construction companies

A construction company may be solely engaged with business activities within the construction industry or, with particular respect to larger companies, have a diversified range of interests outside the construction industry. Cannon and Hillebrandt (1989b) define diversification as the process by which firms extend the range of their business operations outside those in which they are currently engaged. They identify that diversification can be initiated by a firm within or outside the construction industry. Advantages to diversification in contracting identified by Cannon and Hillebrandt (1989b) are that it enables :

(1) greater spreading of risk;
(2) fluctuations in workload easier to overcome;
(3) an opportunity for more efficient use of available resources, notably skilled personnel and cash.

Edwards (1968: 118) states 'because a large conglomerate operates in many markets, it can (1) divert income from one market to another (2) subsidise its losses in one market from profits in another (3) make investments in production for one market with resources derived from another' and concludes it is thus immunised from some of the competitive pressures to which its specialised rivals must respond'.

2.3.3 Strategic business units and project portfolio

A multi-market firm that operates in more than one business arena or market manages a portfolio of businesses termed strategic business units (SBU) (Kerin et al 1990). Each business unit operates in its own unique market environment and deals with a specific set of customers and competitors. Newcombe (1976) defined firms in terms of the markets they were competing in by using a specialisation / diversification continuum. Four market diversification strategies were identified as single market, dominant market, related market and unrelated market.

Each contractor may therefore have a project portfolio (Ball 1988) which includes not only construction work but also investments of liquid capital from contracting in stocks, property, land and areas outside construction as well as a potential capacity. Potential capacity *(Ball 1988) in construction* refers to the capability of a company to undertake different types of construction work in the future and stems from organisational structure and the accumulated knowledge of management and support functions. Male (1991c) suggests potential capacity of contracting companies begins from site agent level upwards where a high level of subcontracting is undertaken.

2.3.4 Ownership and size of company

Organisational structure and operations seem to be very much dependent on the type of ownership and size of the company. Construction companies are often classified by ownership (eg. Department of Environment 1992, Hong Kong Government 1991) into four main groupings which comprise:

(1) sole proprietor: single person provides the capital, takes all the management decisions and incurs the risks;

(2) partnership: development from sole partnership, usually between 2 to 20 can combine together;

(3) limited liability company: association of people who contribute towards the joint stock capital of the company with personal liability limited to original

contribution. Ownership and management may or may not be divorced;

(4) public limited company: complex organisational structures with operating divisions which often reflect wide diversity of interests.

Type of ownership appears to have an important bearing on the numbers and sizes of contractors. It would seem, in terms of ownership, that the smaller projects in the construction market are likely to be dominated by sole proprietors and partnerships. As pointed out by Briscoe (1988), sole proprietors are flexible enough to respond very rapidly to change yet have a restricted financial basis and the rate of insolvency is high. Partnerships have the advantage that partners can bring new management skills into the firm and thereby permit a greater degree of specialisation of function. However, unlimited liability stifles growth and taking risks in pursuit of greater profit. The larger projects are more likely to be undertaken by limited liability companies and public limited companies. Fellows et al (1983) identify that limited liability overcomes unlimited liability with transferable shares. However, ownership may become divorced from management leading to a divergence of interests. Public limited companies find it easier to raise capital. The capital structure of a joint-stock company makes it easy for one company to acquire ownership of another. Briscoe (1988) observes that larger contractors typically have separate divisions for civil engineering, housing, property, overseas work and materials and plant supply. Usually the largest public limited companies operate across all national regions and frequently they own associated companies in foreign countries. They grow not only by increasing turnover in established markets, but also through acquisitions and mergers with other companies.

The most numerous type of firm found in the Hong Kong, according to ownership, is the sole proprietor (72%), which is followed by limited liability companies (15 %), partnerships (12%) and public limited company (0.03%) (Hong Kong Government 1988).

Hillebrandt and Cannon (1990) see contractor size as being important for three reasons:

(1) when the project size is large it often needs to be financed as well as actually undertaken on the building site;

(2) size gives confidence to the client in the capability of the company;

(3) an increase in facilities enables a spread of risk and also enables good ideas to be put into practice.

Edwards (1968: 117) summarises the advantages of a large firm over a small firm as 'a big firm can outbid, outspend, and outlose a small firm. It can advertise more intensively, do more intensive and extensive research, buy up the inventions of others, defend its legal rights or alleged rights more thoroughly, bid higher for scarce resources, acquire the best locations and the best technicians and executives. If it overdoes its expenditures, it can absorb losses that would bankrupt a small rival'.

The size of firm appears greatly to affect the ease to which the firm can obtain the necessary resources to undertake the contract. It will also influence the experience level as the larger firms are likely to have undertaken a broader range of contract values and therefore be in a position to undertake a greater variety of work. Additionally it will influence the strategy as larger firms are more likely to have a more formalised strategic plan and their decision making process is almost certain to be grouped rather than individual.

2.3.5 Organisation of construction projects

Fellows et al (1983) point out that not only are there large differences between firms in terms of size and scope of work, but within firms there is often a great diversity of activity. Typically a large construction company may be engaged in activities ranging from general building and civil engineering to materials manufacturing, property development trade specialisation and even open-cast coal mining. Many large contractors regionalise their operations; civil and engineering work is undertaken by separate divisions and property development, plant hire and materials production are executed by subsidiary companies. The greater the degree of diversification within an organisation, and the greater the number of contributors to projects undertaken by the organisation, the more necessary and difficult is the co-ordination of those diverse units to produce an integrated whole (Newcombe et al 1990a).

For most construction contracts the main contractor has overall responsibility for organising the construction contract. However, for contracts which are large and complex a joint venture may be formed in which a consortium of firms group together to undertake the construction work.

It is common practice for main contractors and joint ventures to employ subcontractors who often undertake the majority of the construction work. Subcontracting has become more prevalent in the construction industry because of increasing technical complexity of projects, changes in employment legislation over the past 20 years, increasing pressures on employers to reduce fixed costs (Gray and Flanagan 1989) coupled with inherent short term variability of geographically dispersed construction workloads, necessitating organisational flexibility (Male 1991c). The extent of this growth in UK has been studied by Abdel-Razek and McCaffer (1987).

Gray and Flanagan (1989) identify that subcontractors can be broken down into four distinct groups:

(1) design, manufacture, supply and fix
(2) design, supply and fix
(3) supply and fix
(4) fix only

The National Economic Development Office (1978) identified that with such high levels of subcontracting the role of the main contractor has become one of organising, co-ordinating and procuring inputs into the production process and also providing core services of management expertise, experience, backup and resources from an established organisation and an ability to carry contractual risks and obligations for large and complex projects.

The high use of subcontracting gives the contractor organisational flexibility, reduces capital lock up in fixed and human assets and is seen as an effective mechanism for production cost control by sub-letting work packages at a known price, generally through competition (Male 1991c). Thorpe and McCaffer (1991) identify that the size and uniqueness of a project dictate the extent to which contractors decide whether or not to sub-contract work normally undertaken by themselves.

This project organisation has led Ball (1988) to suggest that construction is a hierarchial industry designated by size of firm where many small companies are tending to act as subcontractors to the large companies. Stocks (1984) has characterised the building process as the 'organisation of organisations'. It is perhaps only for the very smallest projects that the subcontracting phenomenon does not occur.

2.4 Setting up the competition

The nature and form of the competitive arena for a contractor is largely determined by the client and/or advisors. Hillebrandt (1985) regards clients as the initiators of the whole construction process. Although this appears to hold true for contracting work, contractors are able to create demand through speculative projects (Male 1991b).

2.4.1 Construction contract bidding systems

There is a variety of competitive bidding systems available for selecting contractors to undertake construction work. Common bidding systems used in the construction industry include:

(1) open tendering: any or a restricted number of contractors based on an

approved list can compete;

(2) selective tendering (single stage): contractors are invited to bid and award of contract is based on the bid submitted;

(3) selective tendering (two stage): contractors are invited to bid and award of contract is based on subsequent negotiation;

(4) serial/continuity tendering: combining competition initially and then negotiation for a series of similar contracts.

An important distinction between these systems is that for (1) and (2) the contract is normally awarded on the basis of competition only (usually to the lowest bidder), whereas for (3) and (4) award of contract is normally on the basis of initial competition followed by subsequent negotiation. It should also be noted that the award of contract for many 'competition only' construction contracts is based purely on the assessment of bid prices. However, in some cases the award of contract assessment may be based on other additional criteria such as time, where each contractor is required to propose the contract period, quality (eg. lift installations) and design (eg. civil engineering work).

2.4.1.1 Construction contract bidding systems in Hong Kong

In Hong Kong, lump sum tendering based on firm bills of quantities appears to be the dominant procurement system for building work. It is commonly used in both the private and public sector as a means of obtaining competitive tenders.

Selective tendering is commonly practised in the private sector. In the public sector, with the exception of contracts with special requirements, the Hong Kong Government uses restrictive open tendering based on its own set of rules as the means of obtaining bids (Hong Kong Government 1980). For those exceptions single stage selective tendering is used (Hong Kong Government 1990). The Hong Kong Housing Authority, though once users of serial tendering, now use single stage selective tendering.

It is common practice for construction clients in Hong Kong to split the project into a series of separate contracts. This appears to stem from two building development characteristics peculiar to Hong Kong; high land costs and political uncertainty. High land costs coupled with political uncertainty have led many developers to look for a quick return on their capital outlay. Keeping design and construction time to a minimum is regarded by most Hong Kong clients as essential and in terms of Flanagan's study (Flanagan 1990) on construction clients' priorities ranks second only to cost. Since many of the high rise buildings in Hong Kong require piled foundations, a common procedure in optimising development time is for the client to let the foundation work under a separate contract to a specialist contractor (Davis, Langdon and Seah International 1994). The superstructure work is then designed while the foundation work is being carried out. In the same way it is common practice for prime cost sums for nominated subcontractors to be included in the bills of quantities, particularly for electrical and mechanical installations. The system of splitting work into separate contracts is also adopted by the Hong Kong Government which commonly splits the substructure, superstructure shell and fitting out work into separate contracts.

2.4.2 Entry barriers to bidding systems

The choice of bidding system used by the client will influence the ease with which the contractor can enter or exit the competition. Selective tendering systems appear to be more restrictive than open tendering systems as the contractor can only normally bid upon receiving an invitation either directly from the client or from the client's representative, whereas for open tendering the onus is on the contractor to bid by responding to an advertisement.

Related to this is the extent to which contractor prequalification is formalised by the client and/or advisors. Prequalification has been defined as 'a process of determining a candidate's competence or ability to meet the specific requirements for a task involving a wide range of criteria for which information is often qualitative or subjective' (Russell and Skibneiwski 1988). One of the objectives of the prequalification process is to try and ensure that the selected group of bidders will submit genuinely competitive bids.

Private sector clients appear to have more flexibility in contractor prequalification since public sector clients, mainly for the sake of public accountability, are forced to adopt strict procedures. Carefully structured prequalification systems appear to be generally under used in the construction industry. This results in (1) subjective bidder selection and (2) the involvement of too many bidders. Subjective practices may result in the unnecessary exclusion of bidders who would satisfy prequalification criteria, and the selection of bidders who would not satisfy prequalification criteria. Flanagan and Norman (1985) state that if a bid list is drawn up without attention being paid to the relative efficiencies and experience of the contractors, this is likely to lead to the client paying a higher price. In addition they state that there is at least some possibility that the contract will be won by a relatively inefficient and inexperienced contractor .

Fellows (1992) found that clients classify contractors by project type (specialism), then by size of organisation and region of operation with the following major qualifiers to be acceptable to clients:

(1) general experience and reputation;
(2) financial standing and record;
(3) quality assured;
(4) prior business relationship.

Male (1991: 15) states that 'any form of prequalification differentiates one group of contractors from another, since the group of contractors that prequalify are seen to have the expertise to carry out the project and, by implication those not selected do not'. Hillebrandt and Cannon (1990) point out that differentiation between contractors is possible only until selection has taken place; thereafter competition is on price alone. They also comment that (unrestricted) open tendering does not even allow this degree of product differentiation because the tender price is the only criterion adopted.

2.4.3 Number and identities of bidders

The choice of bidding system coupled with bidder selection practices has a direct bearing on the degree of competition since it affects both the number and identities of bidders competing for a particular contract. For example, open tendering systems are likely to provide a greater variability in both number and identities of bidders since the client and / or client advisors have less control over the particular combination of bidders that is likely to compete for any given contract.

The effect of introducing additional contractors to the competition will reduce the probability of success of any one contractor and can be expected to increase the elasticity of the probability of winning the contract with a particular bid price (Flanagan and Norman 1985). A greater number of bidders in competition with one another tends to reduce the value of the lowest bid (McCaffer 1976; Wilson et al, 1987) and tends to produce a smaller coefficient of variation, probably due to the increased level of competition (Skitmore, 1987b).

The identities of individual bidders are important since different bidders achieve different levels of competitiveness. Skitmore (1981) examined the implications of a virtually random prequalification procedure in which it was shown that identification of the most competitive bidders was a crucial missing factor. Schweizer and Ungern-Sternberg (1983) comment that an addition in the number of bidders above four or five has only a marginal impact on competitiveness. Also that an improvement in the quality of information made available to bidders will have a much sharper impact on the competitiveness of bidders than will an increase in the number of bidders. Flanagan and Norman (1985) point out that improvements in information need to be a more efficient method for increasing the competitiveness of bids than increasing the number of bidders. They suggest that one relatively costless method of improving the information base of bidders can be accomplished by selecting contractors with experience of the contract type.

2.5 Summary

A brief review of management and economic theory indicates that management theory is more comprehensive at modelling strategic behaviour within construction firms, while economic theory seems to be more developed at modelling competitive performance between construction firms. Since competitive relationships between firms are based on the outcome of management decisions that have taken place within a firm, the approach taken in the theoretical development of this research is to view the bidding behaviour of construction firms as the outcome of strategic management decisions undertaken in an economic setting.

The construction industry environment within which contractors operate is seen to consist of general environmental factors as well as competitive environmental factors. Since contracting is demand driven the competitive environment can be defined in terms of markets. Markets can be described and defined by the nature of competition. The nature of competition is influenced by the market structure and characteristics. The construction industry is highly fragmented with the dominant firm being the small contractor. Construction markets have low entry and exit barriers with low capital requirements, especially at the low end of company size. The character of construction markets is set by the type and nature of construction work, the geographical location and the nature of the client, and the exact type of competition experienced by the construction firm depends on all these factors. Definitions of the construction market indicate that it exists in three main dimensions: (1) contract type and nature (2) contract size and complexity (3) geographic area. The total number of firms interested in undertaking construction work according to these three dimensions is affected by prevailing and perceived future market conditions.

The type and nature of construction work undertaken within the construction market is diverse, producing a series of market sectors within which contractors compete for work. Contract size and complexity is regarded as an important dimension in the construction market because of the wide range of contract sizes that exists within the construction market and it is this which is regarded as the major determinant of the number of firms able to undertake the work. A readily available measure that reflects to a degree both contract size and complexity is the bid price submitted by the contractor. The influence geographic area has on the market seems to be largely dependent on the extent of geographical area and population density. Geographic area appears to have less influence in markets of limited area in which transportation costs are reduced. In markets of high population density a larger volume of work leads to a greater choice of contractors to undertake the work which in turn reduces the market share of any one contractor.

In contracting the type and nature of construction work is dictated by the make up of the contract packages which is determined by the client. The type and nature of construction work in the contract packages influences the complexity of work, distribution and range of contract sizes. In terms of contract type and contract size construction contracting can therefore be arranged into a series of contract based vertical market sectors, each made up of varying combinations of contract types and bounded by contract size and complexity.

The construction environment exerts major influences over the structure and operations of organisations. Construction companies are complex and a number of different organisational structures have evolved. A construction company may be solely engaged with business within the construction industry or, with particular respect to larger companies have a diversified range of interests outside the construction industry. Organisational structure and extent of operations seem to be very much dependent on the type of ownership and size of the company.

The nature and form of the competitive arena for the contractor in construction contracting is largely determined by the client and/or advisors. The choice of bidding system coupled with bidder selection practices has a direct bearing on the degree of competition since it affects both the number and identities of bidders competing for a particular contract. An increase in numbers of bidders above four or five has only a marginal impact on competitiveness. The identities of individual bidders are important since different bidders achieve different levels of competitiveness.

In describing the overall construction industry environment this chapter reviews the competitive environment within which contractors operate. Contractors are seen to react to this environment by making strategic decisions. This is now considered in Chapter 3.

CHAPTER 3

Bidding as a strategic process

3 BIDDING AS A STRATEGIC PROCESS

3.1 Introduction

Chapter 2 defined the competitive environment for construction contracting in terms of markets. Definitions of the construction market indicate that it exists according to three main dimensions: (1) contract type and nature, (2) contract size and complexity and (3) geographic area. This chapter establishes that contractors respond to these markets by making strategic decisions at different levels and stages of the strategic process. At the corporate strategy level contractors define a strategic domain. The strategic domain establishes the market dimensions within which contractors plan to operate and compete for work. Contractors make decisions on which contracts to bid for at the business strategy level. If opting to bid, the baseline estimate is formulated at the operational strategy level and then fed back to the business strategy level where the senior management decides the appropriate bid level at an adjudication meeting. The bid, which can be regarded as the outcome of the strategic decision process, is then submitted to the client. In describing the strategic decision process at the different levels and stages, this chapter identifies the underlying factors which influence competitive bidding behaviour and in doing so highlights the effect of contract type and contract size on competitiveness in construction contract bidding.

This chapter is set out in three sections. The first section identifies and relates different levels of strategic decision making to the bidding process. The second section examines the strategic response made by contractors and the last section discusses the outcome of the strategic process.

3.2 Strategic decisions

Strategic decisions define the boundary between the firm and the external environment. It is the point of contact between the firm and the environment and strategic decisions can shift this boundary. Male (1991b) suggests for analytical purposes, it is useful to think of a company having a permeable boundary that delineates its internal workings from the external business environment. Langford and Male (1991: 31) utilised the term 'spheres of influence' to indicate that the boundaries of a company, especially in construction are very movable.

Contract bidding, like all other forms of pricing, is essentially about contractors making strategic decisions in respect of which contracts to bid for and the bid levels necessary to secure them (Skitmore 1989). Strategic decisions are defined by Newcombe et al (1990a: 42) as 'any decision at any level of the business which impacts on the whole organisation and a tactical decision is one which does not exhibit any of the above characteristics'. They identify the characteristics of strategic decisions as relating to:

(1) defining the scope of the organisation's activities including the extent of diversification of services and markets;
(2) matching the organisations's activities with the environment in which it operates including matching the strengths and weaknesses of the firm to the opportunities and threats in the market place and the changing environment;
(3) matching the firm's activities to the capabilities of the firm and to its resources;
(4) assessing major resource implications arising from strategic decisions;
(5) evaluating the effect on operational and administrative decisions;
(6) meeting expectations and values of the key stakeholders in the business;
(7) assessing the high degree of uncertainty about environmental forces and outcomes;
(8) determining the impact of the decision on the whole organisation.

Cusack's investigation (Cusack 1981) of decision making in construction companies concluded that decisions were based on experience. Lansley et al (1980) established that 'organisational experience' in management is a key factor responding to market conditions with the breadth of experience being 'particularly important in enabling firms to develop alternative organisational method appropriate to the different types of work they needed to undertake'. Jarman (1978) concluded that large companies do not tackle business ventures with little knowledge or expertise.

3.2.1 Levels of strategic decision making

Strategic decision making in construction contracting is seen by Newcombe et al (1990a) and Male (1991a) to occur at the following levels within an organisation:

(1) Corporate strategy

Andrews (1987: 13) defines corporate strategy as the 'pattern of major objectives, purposes, or goals and essential policies and plans for achieving those goals, stated in such a way as to define what business the company is in or is to be in and the kind of company it is or is to be'. Benes and Diepeveen (1985) state that planning at the corporate level starts with an agreement on the objectives of the firm and on the strategy needed for their realisation. Barnard (1981) states that 'objectives are the decision rules that enable management to guide and measure the firm's performance towards its purpose'. Grinyer (1972) classifies objectives into economic objectives (eg. growth of turnover, earnings, market share in existing markets, number of markets in which the firm operates, stability of annual gross turnover, gross profit, return on investments and in utilisation of scarce physical or human resources held by the firm) and non-economic objectives (eg. internal political, external political, meet aspirations of employees, serve clients and the general community well, maintain a good industry reputation).

Corporate strategy denotes the most general level of strategy in an organisation and in this sense embraces other levels of strategy and is therefore concerned with the competitive positioning of the whole company and the management of the relationship of the total firm with its environment (Male 1991a). Porter (1979) has shown that corporate strategy involves:

(1) positioning a firm in relation to the five forces previously described in

Chapter 2;

(2) influencing their balance within an industry;

(3) exploiting industry change and its effect on the forces.

In respect of a construction firm, 'corporate strategy could involve issues such as the type of client, both existing and potential, the range of projects that the firm could undertake and in what geographic locations; the impact of the economy of the firm; relations with suppliers; what new companies may be entering the markets; and finally, any new services the firm wishes to offer' (Male 1991a: 1).

(2) Business strategy

Whereas corporate strategy is concerned with the competitive position of the whole company and the management of the relationship of the total firm with its environment, the second level of strategic decision making is referred to as business or competitive strategy and is 'about how to compete in a market' (Johnson and Scholes 1993: 11). Male (1991a) identifies that this is typified in contracting by a decision to bid for a particular project and that it is a firm's bidding strategy.

(3) Operational strategy

Under business strategy there exists a third level of strategy, known as operational strategy (Johnson and Scholes 1993) which is concerned with how the other functions of the firm contribute to the other levels of strategy. In contracting this has been identified by Newcombe et al (1990a) as being at the project end of the organisation, for example, the chief estimator's decision on pricing strategy for a major contract and the method decisions taken by a site manager.

3.3 The strategic response

Most contractors recognise that they cannot undertake work in all the sectors of the construction market. 'The customers are too numerous, widely scattered and varied in their buying requirements' (Kotler 1988: 279). Therefore, as part of their corporate strategy, contractors need to identify market sectors within which to compete. Hillebrandt and Cannon (1990), however, point out that up until the mid 1970's contractors' major marketing efforts were not directed toward seeking work in a particular market area but getting on the tender list as they saw the dominant decision factor being that of price. However, since this time a steady fall in demand has created an awareness to strengthen marketing efforts considerably, although these activities are still being developed in a largely ad hoc manner.

Grinyer (1972) and Barnard (1981) suggests contractors need to consider:

(1) geographic areas within which the firm will operate;
(2) types of structures or civil engineering works it will seek to construct;
(3) types of services it will offer (ranging from the complete package deal to specialist subcontracting);
(4) type of client it will favour;
(5) maximum contract size;
(6) period of maximum commitment to various (market) sectors;
(7) timing of any changes in these aspects of business.

The type and location of projects is reckoned by Lansley et al (1979) to be by far the most important factor in determining the direction of the construction organisation. In a survey of eight large contractors Bell (1981) concluded that these contractors tended to operate regionally and undertook similar work in various regions and that they considered labour availability, the location and the size of project to be important.

Benes and Diepeveen (1985) suggest that it is the competitive strength of the firm which management needs to consider when deciding its policy on the product/market combination, that is, the turnover per product for each market sector. Ramsay (1989) sees market segmentation becoming more prevalent, not only in services provided by the contractor, but also specialisation in the type of work sought. This allows the contractor to seek and establish a special relationship with target clients, particularly in growth industries such as retailing and should include:

(1) deciding on whether to satisfy most segments of the market or focus specifically on one or two segments;
(2) prioritising allocation of resources;
(3) identifying exactly where the firm is superior to its competition;
(4) combining parts or processes of the firm to create synergy.

3.3.1 The strategic domain

Male (1991b) introduces the concept of strategic domain to construction contracting and states 'the strategic domain sets the parameters within which senior management chooses to operate. Some senior managements define a narrow domain - perhaps a regional geographic market for constructing to contract on building projects. Others may specialise by project types within this. Others may define a broader strategic domain undertaking both civil and building projects'. In other words, the strategic domain establishes the market dimensions within which contractors plan to operate. This includes making decisions on which contract type and size of contracts to compete for and the extent of geographical area within which to undertake the construction work.

Since contractors will win only a proportion of the contracts they bid for, the strategic domain is most likely to be set at a level where number of bidding opportunities exceed the contracting capacity of the contractor. Male (1991b) suggests that developing the strategic domain involves:

(1) studying the markets which the firm is now involved or likely to be involved and assessing future trends, for example, by type of product, type of client, the method of production and the length of time to produce;
(2) determining the total volume of each section of the market, its past trend and the factors which affect demand;
(3) deciding on the common factors in each market group. The general value of

contracts may be similar in one group to another;

(4) assessing of the probable competition in the different markets;

(5) analysing the profitability of the different types and sizes of construction projects.

Marsh (1987) also suggests the contractors' business can also be usefully defined according to class of work which includes (1) technical expertise with certain types (2) size \ value constraints which are largely dependent on finances and contractual risk. Also there should be a business policy in which it is determined (1) what lines of business constitute the contractor's market (which presumably includes contract *type preferences)* (2) what limitations is the contractor going to place upon himself in terms of size of contract.

3.3.1.1 The effect of contract type

A contractor's strategic domain can be defined according to a number of contract types and may comprise undertaking all or specialising in certain contract types within one or more sectors of the construction market. The strategic domain may also include only undertaking new build work or alteration work or both.

An important variable influencing the scope of the strategic domain according to type seems to be the size of contractor. Most large contractors appear to work in more than one market sectors simultaneously. Shash (1993), for example, defined the scope of work undertaken by 83 top UK contractors into four broad categories of work made up of housing, building (ie. non-housing), industrial (ie. power plants, refineries etc.) and engineering (ie. highways, harbours and airports etc.). Of the 83 contractors, 26% undertook work in one of these categories, 38% in two categories, 22% in three categories and 11% in all four categories. Within these categories 18.8% of contractors focused on building work only and 28.8% on housing and buildings.

Bell (1981) found that in examining the marketing attitudes of eight large UK contractors:

(1) contractor policies varied from one contractor where all sectors of the market sectors of the industry are within its capabilities to another which stays with the traditional 'proven to work' construction;

(2) some contractors appeared to be more flexible in their policy towards type of work (no specific mention was made in respect of specific types of work, except that two of the contractors avoided housing work);

(3) profitable and of high quality construction work appeared to be important.

When interviewing large contractors Hillebrandt and Cannon (1990) found in general the contractors are prepared to undertake any type of building or civil engineering work with the following exceptions:

(1) some firms do not have the skills required to undertake very large projects of a very specialised nature and which occur infrequently such as nuclear power stations, oil platforms and refineries;

(2) a few firms are specialists in a particular type of work either in their main operations or as specialist contractors in a particular field;

(3) a few companies have now effectively withdrawn from overseas work;

(4) all contractors wished for a broad and balanced range of activities since it enables them to take advantage of growth in a particular sector of the market and restricts their exposure to risk in any one of them.

On the other hand medium size companies usually concentrate in one area both spacially and by product (Jarman 1978). Jarman (1978) also found that small companies specialised in maintenance and repairs which the large builders avoided unless they had a rolling programme. Norris (1984) points out that repairs and maintenance work, due to its nature, tends to comprise a large number of minor jobs, many of which only require the employment of one operative. Consequently, this type of work is ideally suited to the small local builder. Male (1991b) also suggests that there is a relationship between size of contractor and repair and maintenance work and new build work Repair and maintenance favours small companies but acts against large company operations by the relatively small amount of work by value undertaken by the larger company categories within the industry. However, he states some large contractors have responded to this by setting up 'small' works divisions or subsidiaries. For new build work the industry the construction industry has a distinct hierarchial structure, with the larger companies capturing the work by value.

Norris (1984) states that the economic advantages associated with size of firm are dependent upon the type and nature of the work undertaken; 'At the one end of the scale, repair and maintenance entails carrying out a large number of very small jobs which in most cases only require the services of a single craftsman. This type of work is suited to the local firm which is close to where the work is required, operates with low overheads and the minimum amount of supervision. At the other end of the market, large national firms have significant advantages when undertaking large projects'.

Specialist contractors may be large, such as those specialising in house building (Ball 1988) or small; for example, Flanagan and Norman (1982b) found a small contractor who successfully specialised in constructing local schools. It appears therefore that it is the size of market that limits the degree of specialisation (Hillebrandt 1985) rather than the size of contractor. Contractors do not specialise more in the type of work they undertake because:

(1) fluctuations in demand for work of any particular type and location make it risky to place too much reliance on one market;
(2) construction is a complex assembly process, therefore if the contractor is successful in one type of work he may fairly easily transfer his skills to a related work type;
(3) markets are determined by geographical spread as well as type and size of work, therefore the total work available in one market may be relatively small (Hillebrandt, 1985).

It should also be noted that a contractor's domain in terms of contract type can also linked to client type. Regular clients of the construction industry generate a range of one or more project types that fit into one or more market sectors. Contractors respond to this demand through determining their market mix of clients and contract type. Fellows (1992) found that contractors classify clients as public or private by building function, project size and location.

3.3.1.2 The effect of contract size

Contractors' strategic domains can also be defined according to the range of contracts sizes they wish to undertake. Most contractors, as part of the strategic planning process, identify a turnover they wish to attain for a given year. King (1990) found the most common method of quantifying or measuring a contractor's need for work was a comparison of the current project backlog against the annual projected turnover with a lower ratio indicating a greater need for work. Hillebrandt (1985) points out that for most construction firms each contract accounts for an important proportion of total turnover and that this dependence on a few contracts is a feature of construction firms in the industry and has important repercussions on the operation of firms. Fine (1974) points out that the range of job size should be considered so as to achieve the turnover desired. The state of the market will also provide an indicator to assess the turnover available in the market without tackling jobs that are too small.

Ferry and Brandon (1984) state that for each contractor there is an optimum size of contract that will suit its particular structure and resources. Fine (1974) points out that large organisations are geared to dealing with large contracts so these will be chosen in preference to smaller ones. In examining the marketing attitudes of eight large UK contractors, Bell (1981) found that all but two of the contractors aim for large projects. Of the two exceptions one appeared to have no group policy whilst another had upper and lower limits. It was pointed out that this latter company had lower resources than other contractors. Shash (1993), in a study of 83 top UK contractors, found that 56% of the surveyed contractors obtained an average contract size of between one to five million pounds. When interviewing large contractors Hillebrandt and Cannon (1990) found that:

(1) no contractor will undertake small contracts except where he is obliging an existing client. The reason is that the overhead costs of managing small contracts are disproportionate to their total value. This is their explanation for their not undertaking repair and maintenance work but being willing to bid for large renovation schemes.

(2) at the other end of the scale, there is a limit to the size of project which they will handle on their own. This is a function of risk on contract relative to the total workload of the company with joint ventures being the answer to this type of problem.

At the other end of the scale Shutt (1988) identifies the reasons why smaller building firms tend to carry out smaller works as follows:

(1) smaller firms have lower overhead costs and so can do smaller jobs cheaper than the bigger firms, who carry higher overheads to cope with larger jobs;
(2) smaller firms have lower overhead costs and so can do smaller jobs cheaper than the bigger firms, who carry higher overheads to cope with larger jobs;
(3) lack of finance for carrying out larger works;
(4) personal attention by a small builder is appreciated by clients.

Ferry and Brandon (1984), however, state that large firms very often create 'small works' sections of the main company to deal with those contracts which are small and which cannot carry the overheads of a giant corporation. In respect of clients, Shutt (1988) points out that much of the work for public bodies is on a large scale, then the firms doing public work tend to be of a medium to large size.

3.3.1.3 The effect of geographic area

The extent of the international contractor's strategic domain in terms of geographic area can be considered in world-wide terms. Bon (1993) undertook a survey of the various construction markets world-wide in which market attractiveness was scored according to 'fastest growing', 'most profitable' and 'most open'. It would seem, therefore, that in international contracting 'market attractiveness' is a key factor in the planning of a strategic domain. The extent of contractors' strategic domain on a national level varies from country to country. Chapter 2 identified two important factors affecting the influence of geographic area as being density of population and extent of geographic area. In the larger, more sparsely populated countries the extent of contractors' strategic domain may be classified, for example, according to the different areas of operation such as local, regional and national. Briscoe (1988) suggests the smallest firms restrict their operations to local markets, but as a firm grows it is likely to expand into the wider regional market. Also larger firms operate nationally and they are likely to have regional divisions or trading companies to enable the firm to compete effectively in all areas of the country and only the very largest firms tend to pursue contracts in international markets where the degree of competition is intense. These characteristics can be found in specific studies of contractors. For example, Flanagan and Norman (1982b) studied a small contractor who worked within a 20 mile radius of a county town, a medium contractor who undertook work throughout the county and a large contractor who operated nationally. Bell (1981) in a study of large contractors found that, apart from national projects most undertook their work from regional offices.

There therefore appears to be a correlation between size of contractor and area of operation with larger contractors covering a wider area of operation[1]. This correlation can also be linked to the size of contract. Hillebrandt (1985) points out the reason why firms do not go outside a certain geographic area of operation is that the input costs in terms of fixed and variable become excessive in relation to the total costs. However, for larger projects this phenomenon decreases, thereby making it possible for contractors to cover larger distances.

Strategic domain differences in terms of geographic area are likely to become less apparent in smaller, more densely populated countries. In Hong Kong for example,

---

[1] It should be noted, however, that subcontractors specialised in a particular type of work may operate over a wider geographical area than main contractors for a given turnover (Hillebrandt 1985).

the influence of geographic area appears to be minimal. Most contractors tend to operate territory wide with the exception of undertaking work on some of Hong Kong's more remote islands (Davis, Langdon and Seah International 1994). Hong Kong's construction market, therefore, appears to exist largely according to two main market dimensions, that of contract size and type.

3.3.1.4 The effect of market conditions

The scope of a contractor's strategic domain is likely to be affected by both prevailing and perceived future market conditions. For example, if contractors' workload is low because of market conditions and/or it is perceived that there will be a scarcity of future work, in order to maintain the same level of work, some contractors may consider broadening the scope of their strategic domain, thereby increasing the total number of contractors interested in competing for a particular contract. With ever changing market conditions, Benes and Diepeveen (1985) call for flexible planning at the corporate level and *Lansley et al* (1980) suggest that flexibility is an increasingly important attribute for the success or survival of the construction organisation. To cope with market changes Thorpe and McCaffer (1991) recommend that a flexible attitude needs to be adopted with decisions on market sector, public or private client, new work, engineering or building, repair and maintenance and decisions on geographic region always being kept under review. Sidwell (1984), however, comments that moving into new and unfamiliar markets places greater strain on the efficiency and skills of the company. Hillebrandt (1985) points out that it is probably easier for a contractor to move into a market for a different end product than to move into a market of a greatly different size of work because the managers he employs will be able to deal with a certain size of work, be unwilling to manage something much smaller and are untried in managing anything larger.

3.3.2 Decision to bid

In the course of running the construction firm, it is at the business strategy level where contractors are given numerous opportunities to bid for work both within and outside the strategic domain. The contract decision selection problem essentially targets at identifying the decision which will result in the most favourable outcome (Male 1991c). Multiple criteria that influence project selection have been classified by Mohanty (1992) as intrinsic criteria (comprising project identification ability, resource requirements and availabilities, the past experience of the organisation in managing the project, management attitudes, the time horizon of the project) and extrinsic criteria (comprising the risk return ratio, the market environment, government policies and regulations, the socioeconomic climate, legal and technological implications).

Mohanty (1992) also points out that:

(1) project identification needs to be carried out with the utmost care, because unless projects are properly identified, it is impossible to utilise the resources available to the enterprise optimally;

(2) resources are invariably a constraint in that they limit the alternatives that can be considered ... it is essential for the organisation to choose projects so that the resources at its command are most fruitfully employed, and the dividends accruing from them to the organisation are maximised;

(3) past experience has a substantial influence on the selection of projects with a conservative management style being less conductive to change;

(4) managerial attitudes strongly influence the final decision in project selection;

(5) willingness of an organisation to choose and implement a project depends on its time characteristics with a general preference for projects that promise returns within a short time;

(6) risk/return ratio is seen as a dominant factor, and has often been the sole criterion for the choice of project;

(7) a decision maker seeks projects within a favourable market environment;

(8) policy considerations may affect both the profitability and the manageability of any project.

In a questionnaire survey to contractors aimed at identifying important factors in contractors' contract selection decisions, Odusote and Fellows (1992) found that client related factors ranked as the most important factor followed by type of work and value of the contract. They identified the following important client related factors:

(1) the ability to pay;
(2) good relationship with important regular clients;
(3) the ability to provide client satisfaction.

For type of work Odusote and Fellows (1992) identified the following factors as important:

(1) the margin of profit projected for the contract;
(2) the contractor's workload;
(3) the contractor's chances of getting the job;
(4) the time available in which to tender;
(5) the current estimating workload of the company.

Skitmore (1982) points out that job desirability is influenced by many factors including favoured contract types within the bidder's expertise area. It seems, therefore, that different bidders are likely to have varying degrees of preference towards the type, size and location of the contract. These are dictated to some extent by their available resources and experience. Further considerations are present and future workloads, the workload of the industry as a whole and differences in perceptions of bidders concerning these matters.

In deciding to bid, the contractor has a two-stage decision process to make - whether to bid or not and if the former, the various bids and alternatives he could offer together with the likely consequences of each decision option (Skitmore 1989). As construction contracting is largely demand driven (Male 1991b), in making the decision to bid, contractors are likely to consider both their current workload and future available work in the construction market. Hillebrandt and Cannon (1990) state that timing is exceedingly important and managers look at the ability to resource the project and the impact on the forward trading. Smith (1986) suggests that if the timing is right, it would suit the contractor to move smoothly from a successfully completed contract to a new one which, if existing resources are used, could save a great deal in capital expenditure, in which case the contractor will be more competitive. Thorpe and McCaffer (1991) state that contractors' senior managers are making judgements that balance market opportunities with risk.

Contractors' decisions to bid is seen by Hillebrandt and Cannon (1990) to be influenced by:

(1) the skill of the contractor to undertake the work;

(2) client payment arrangement;

(3) degree of competition;

(4) current workload in the estimating department;

(5) previous experience of undertaking work in a particular area.

Marsh (1987) suggests the factors contractors need to consider in deciding whether to bid are:

(1) the likelihood of the project ever happening;

(2) the value of the opportunity;

(3) the costs of trying to realise the opportunity;

(4) the chances of success;

(5) the risks to the bidder if he wins.

Thorpe and McCaffer (1991) suggest that contractors avoid contracts that are too large for their size, outside their experience range, likely to stretch their available resources including cash, well beyond their normal geographical area of operation, or contracts that have unusually onerous conditions of contract. Farrow (1976) states 'a company should not ... submit tenders for types of work unknown to it or beyond its experience or expertise both in terms of scale or technical complexity'.

3.3.2.1 Resources and changes in workload

Contractors do not have unlimited resources nor do they bid on only single contracts. Since 'relatively few projects account for the major operations of a firm' (Cannon and Hillebrandt 1989: 57), winning a particular contract will carry implications for the resources available to undertake future contracts. Flanagan and Norman (1985) state that 'in economic terms the contractor in formulating a bid for any one contract must take into account both the direct costs and opportunity costs of the contract. Opportunity costs reflect the contractor's currently available resources, and the effect on resource availability of winning the particular bid competition ie. if a contract is won scarce resources will be employed on that contract which will not be available for use on future contracts'.

Flanagan and Norman (1985) consider the impact of workload changes in relation to opportunity costs which, if a contractor chooses to submit a bid, appears to have a direct bearing on a bidder's competitiveness. They state 'If the contractor has been successful on a number of recent bids it is likely that he will be working near capacity. The opportunity costs of any additional contract are likely to be relatively high. In contrast, if a number of unsuccessful bids have been submitted, workload is likely to be low and may approach zero. Indeed with extensive spare capacity opportunity costs may approach zero. This leads to the appealing conclusion that tender prices should be sensitive to the market condition of the tenderer. A tenderer can be expected to submit a relatively high price when workload is high and a relatively low price when workload is low'.

3.3.2.2 Optimum efficiency

Economic theory of the firm suggests firms operate most efficiently when they are operating just under capacity of their total resources. If the firm attempts to operate beyond this point the firm may run into assorted bottlenecks making it less competitive. Achieving optimum efficiency therefore becomes an issue of balancing the resources in hand with the size of the proposed contract.

3.3.2.3 Resources

Resources may be defined as those parts of the decision environment which are at the decision makers' disposal in accommodating the decision (Ansoff 1987). Although information can be regarded as a resource (Betts 1990), resources usually include personnel, property and finance (Ramsay 1989).

3.3.2.3.1 Personnel

Skitmore (1989) identifies personnel within the organisation as including workmen, managers, administrators, executives and directors and considers that it is the managers who have a role in the organisation to be formally responsible for resources and, therefore, resource allocation. Pilcher (1985) presents the management process by identifying alternative plans in terms of matching a companies objectives with available resources. In relation to this Ansoff (1987) has identified three different types of decisions in organisations which have resource implications. These decisions comprise:

(1) operating decisions ie. the resource conversion process. Key decisions include: pricing, establishing a market strategy, production scheduling and budgetary allocations among functions. These key decisions have been related by Male (1991) to construction companies as bidding, establishing which project type, site planning and departmental and project budgets;

(2) administrative decisions ie. optimizing the use of resources in a company;

(3) strategic decisions ie. resource allocation while focusing on the relationship of the company with its external environment.

Cannon and Hillebrandt (1989c) believe that the number of contracts which a contractor can undertake is more or less fixed by its management or skills capacity. They see management as the principal resource of construction companies and it is the lack of this resource that places the greatest constraint on limiting the opportunities for growth (Hillebrandt and Cannon 1990).

3.3.2.3.2 Property

Property, termed 'physical resources' by Johnson and Scholes (1993) is interpreted by Skitmore (1989) as consisting of such physical assets as land, buildings, machines and materials. Skitmore (1989) points out that the extent to which property is affected by the project decision is minimal as many effects of undertaking construction work are of a temporary nature. However, he also states that property becomes a more important factor when there is a need to increase the company size by acquiring further land and buildings to accommodate expanding permanent staff and also acquire some large items of plant which would be used on multiple projects.

3.3.2.3.3 Finance

Monetary resources have been classified by Harris and McCaffer (1989) into short term and long/medium term finance. They point out that short term capital is needed to overcome immediate cash flow problems such as purchasing materials, hiring plant, paying labour and subcontractors whereas long term capital is required either to start the business or to carry out expansion programmes including purchasing buildings, plant and equipment and to carry stocks of materials. Harris and McCaffer (1989) also identify a range of sources for both short term and long/medium term finance. Short term sources include bank overdraft and loan facilities, private sources, taxation concessions, hire purchase, creditors, internal transfer and factoring. Long term sources include retained profits, shares merchant bank, finance corporations debentures and government grant.

Seymour (1989) points out that a larger firm will have greater access to cheap finance (via either loan market or internal funding) and better production resources. This not only enables the contractor to bid for larger contracts but also to diversify into technical and construction related services that will enable the contractor further to differentiate the product. As these factors may also enhance the reputation of the firm, the size of the contracting company is likely to provide a significant firm-specific advantage. Debt capacity as determined by Cannon and Hillebrandt (1989) includes the size of firm, its potential growth, its business risk and asset structure and state that large firms are able to borrow funds and raise equity more easily than small firms and have greater flexibility in deciding whether to use retained earnings. Therefore, the ease to which capital can be raised gives a construction company greater flexibility in the size of project a contractor can undertake. Stocks (1991) states that lack of financial resources is an inhibiting factor in small firms.

Pilcher (1985) points out that the cost of borrowing capital or raising funds from other sources clearly plays a major role in the determination of the cost of capital and, because a firm frequently has more opportunities in which to invest, needs to determine those projects which are expected to give rise to a greater return are acceptable and vice versa. He also points out that funds may not be available to the company or it may have chosen to restrict its capital investment over a given period.

3.3.2.4 Resource implications

The extent to which a bidder can operate in the construction market is, therefore, influenced by its available resources. The ease to which it can obtain these resources appears to be related to its size. Property related resources do not appear to an important factor in obtaining new work, unless the company needs to expand because of the new work (Skitmore 1989). Skitmore (1989) also states that the physical and monetary size of a project affects the companies resources and particularly finance and management. Financial resourcing becomes increasingly important, particularly with larger projects (Hillebrandt 1985). However, Hillebrandt and Cannon (1990) identify management (and not fixed capital) as the most important determinant of the capacity as well as the capability of construction firms. The managerial skills capacity gives the contractor greater flexibility in the work it undertakes.

Odusote and Fellows (1992) found that contractors do not attach too much importance to availability of resources since resource constraints can be easily overcome by obtaining extra resources from alternative sources, such as hire, lease and subcontracting, when those at the contractor's direct disposal cannot cope with the work-in-hand. Male (1991c) states that the high use of subcontracting gives the contractor greater organisational flexibility and reduces the need for capital lock-up.

Milne (1980) observes that tendering and accepting work without adequate financial managerial or manpower resources will mean that, at times, the value of work-in-hand will go beyond that which the principals of the firm can successfully control. The unnecessary additional work, even if secured at high rates, may prove to be a source of difficulty resulting in low return or possible loss.

3.3.3 Submitting the bid

Models of the bid preparation process, (eg. Flanagan and Norman 1989 and Betts 1990), identify a large range of activities which highlights that the strategic process is based on many decisions. Hillebrandt (1985) discusses the problems of the firm in the pricing situation, and considers these as three stages in the decision making process: the first is the cost of undertaking the project (prime cost); the second is the lowest worthwhile bid price (lowest mark-up); and the third is the problem of winning a profitable contract (balancing various prices and mark-ups the contractor could put in against the likelihood of obtaining the job in competition).

If the contractor opts to submit a bid, the pricing of the bid normally comprises a two stage formulation process consisting baseline estimate and mark-up. It has been said that long-term differences between bidders' pricing are a reflection of their relative efficiencies - more efficient bidders tending to enter lower bids (Flanagan and Norman 1985), thereby over a series of competitions being more able to achieve greater level of competitiveness.

3.3.3.1 Baseline estimate

The baseline estimate is compiled at the operational strategy level of an organisation, normally by a contractor's estimator. Andrews (1990) regards estimating as an essential but subordinate part of the bidding process and that its purpose is to assess the likely prime cost and pattern of overheads of the work to be done; and to highlight and evaluate risks. It is commonly referred to in literature (eg. Chartered Institute of Building 1983, Upson 1987, Cook 1991) as the cost estimate. The baseline estimate is a reflection of actual cost to the contractor plus some profit/risk allowance and also subcontractors' cost and profit. Since it is not made up purely of cost the term 'baseline estimate' is preferred.

Risks and uncertainties affecting the baseline estimate have been divided by Raftery (1994) into technical (eg. adequacy of site investigation), logistical (eg. sourcing materials, plant and labour), construction (eg. productivity) and financial (eg. short term escalation / inflation).

The degree to which the baseline estimate affects competitiveness can be considered by breaking the it into two components; fixed and variable. Fixed items, such as provisional and prime cost sums do not affect competitiveness and are, therefore, identical for every bidder. Variable items, however, which do affect bidders' competitiveness are those priced by bidders and are normally made up of preliminaries and builder's work.

3.3.3.1.1 Cost efficiency

In formulating their baseline estimates different contractors are able to achieve different levels of cost efficiency. Johnson and Scholes (1993) identify four sources of cost efficiency. These comprise economies of scale, supply costs, product process design and experience.

(1) Economies of scale

Economies of scale are those features of increasing size which account for increasing returns to scale. The causes of falling efficiency as the size of firm increases are described as diseconomies of scale. Internal economies of scale are those which arise from the growth of the firm independently of what is happening to other firms and arise from an increase in the scale of production. External economies of scale accrue due to the advantages of lower average costs which a firm gains from the growth of industry.

Advantages arising from internal economies of scale as seen by Stanlake (1988) comprise:

(1) technical economies such as increased specialisation in and greater divisibility of resources for larger firms;

(2) marketing economies such as bulk buying in which larger firms can obtain preferential terms in buying goods at lower prices and dictate the quality and delivery much more efficiently than the smaller firm;

(3) financial economies in which a large firm is a more credit worthy borrower providing greater security on more favourable terms. A larger firm has access to more sources of finance including the issuing of shares and debentures;

(4) risk borrowing economies in which large firms benefit from the law of averages. Total demand for new work is more stable and predictable than with small firms where variations in new work will tend to have a relatively larger impact on total business. The larger firm is able to reduce risk by means of a policy of diversification in which it is likely to have a diversified market structure. A small firm with a restricted market is much more vulnerable to changes in market conditions.

In respect of the construction industry Male (1991b) suggests that economies of scale do exist and that they are predominantly in the areas of managerial expertise and financial management.

For each particular industry there will be some optimum size of firm in which the average cost reaches a minimum. As firms grow beyond this optimum size, efficiency declines and average costs begin to increase. Economists have usually attributed the major cause of diseconomies to management difficulties which can be related in terms of managerial ability. The entrepreneurial skills required to manage large companies are, it seems, limited in supply so that it is often difficult to match the increase in the supply of other factors with a corresponding increase in the supply of management ability. Management difficulties occur in the form of co-ordination, control, communication and morale.

The prices of inputs may also have an effect. For example it may be difficult to obtain increased supplies of labour which leads to a firm attempting to increase the scale of production having to increase the price of its units.

Male (1991b) identifies the following reasons for diseconomies of scale in the construction industry:

(1) low overheads critical to success, especially in selective (and open) tendering;
(2) range of project types diverse with each project being unique;
(3) unique client demands;
(4) demand varies according to location;
(5) smaller companies favoured with lower overhead costs, however, larger companies gain through managerial and financial efficiency but suffer increased overhead costs;
(6) design changes in respect of project type;
(7) changes in local regulation requirements;
(8) high product differentiation through pressure of client requirements and operation of the procurement and tendering process;
(9) presence of exit barriers with the possibility of a contractor withdrawing once a project has been completed, especially at the lower end of the vertical market. However, as project type increases, project

duration increases making it more difficult to disengage from a market.

Economy of scale theory tends to suggest that cost efficiency is to some extent linked to matching the size of contractor to the size of contract in that larger contractors are able to achieve greater cost efficiency for larger contracts and vice versa. It is possible that, if the proposed contract size matches the contractor's size then, all other things being equal, the contractor may be able to achieve greater cost efficiency and therefore be in a position to bid more competitively.

(2) Supply costs

Johnson and Scholes (1993) see that supply costs influence an organisation's overall cost position and are of most importance to organisations which act as intermediaries, where the added value through their own activities is low and so the need to identify and manage inputs is critically important to success.

Major sources of supply in construction contracting appear to originate from materials supplier and domestic subcontractor quotations. Davis Langdon and Seah International (1994) point out that in Hong Kong, for example, there is a wide variety of sources and quality of materials with correspondingly wide price variation and that the prices of imported materials are heavily influenced by exchange rates. Walker and Rowlinson (1990) identify an extensive list of countries from which the Hong Kong construction industry's basic materials are obtained. The list includes China together with a host of other Far East countries, to countries as far away as North America and Europe.

It is also common in Hong Kong for main contractors to split the work into subcontract packages. Ganesan (1981) concluded that the Hong Kong construction industry is characterised by a high level of subcontracting and large numbers of small sub-contracting firms. Main contractors tend to carry out very little construction work themselves, apart from possibly the concrete structure, and prefer to employ small subcontractors and labour only gangs (Davis, Langdon and Seah International 1994). A survey of 17 building contracts showed that the work subcontracted was never less than 92.5% (Lai 1987). A study by Chan and Pau (1980) found a multi-level nature of contracting/subcontracting hierarchy ranging from principal subcontractor (responsible for the whole subcontract package) through to high, mid and low level subcontracting. Fox (1989) states there can be many levels in the subcontracting hierarchy and that this is largely dependent on project size, nature of work and market demand. Walker and Rowlinson (1991) point out that the number of subcontract packages is dependent on the policy of the individual main contractor with some contractors limiting the number of sub-contractors in order to improve co-ordination and integration of the subcontract work.

The impact of supply costs on cost efficiency and therefore competitiveness would therefore appear to be largely dependent on the bidder's ability to select a particular combination of materials suppliers and domestic subcontractors who as a collective group are able to offer a competitive price which the bidder is then able to incorporate into the baseline estimate.

(3) Product process design

'In contracting the design is normally undertaken elsewhere and the contractor has limited ability to differentiate his product from those of other contractors on technical merit. However, there are other ways in which the contractor can offer the client a service such as shorter contract duration, quality of work and good client-contractor relationships. They can offer a variety of services which are different from the traditional contracting service including design and build, management contracting, project management, financial packages, equipment and furnishing the building, maintenance contracts and management of the facilities' (Hillebrandt and Cannon 1990: 22).

(4) Experience

Johnson and Scholes (1993) see experience as a key source of cost advantage. They identify the work of the Boston Consulting Group which established important relationships between the cumulative experience gained by an organisation and its unit costs which is described as the experience curve. The premise of the Boston Consultant Group findings is that in any market sector of an industry price levels tend to be very similar for similar products. Therefore what makes one firm more profitable than the next must be the level of its costs. The experience curve suggests that an organisation undertaking any tasks learns to do them better over time.

Cost is also seen by the Boston Consultant Group as a function of market share. Johnson and Scholes (1993) also point out that it is the relative market share which matters and that in highly fragmented industries (which presumably includes the construction industry) it is quite possible to operate profitably without dominating a market sector. The objective is to have more experience than anyone else in that sector.

Kerin et al (1990) identify three major sources of cost reduction arising from cumulated experience effects as:

(1) exogenous progress which refers to cost reductions that are the result of advances in general technical knowledge, inputs from suppliers and customers, and feedback from customers;

(2) economies of scale which relates to the potential of large businesses to operate at a lower unit cost than their smaller counterparts;

(3) basic improvements arising from cumulated output effects is concerned with concerted efforts by firms to lower costs by exploiting various potential sources of cost reduction which include labour efficiency, work specialisation and methods improvements, new production processes, getting better performance from production equipment, changes in resources mix, product standardisation, product redesign.

With respect to construction contracting Thorpe and McCaffer (1991) point out that due to the nature and previous history of construction companies, each will have a unique level of competence in different types of work and corporate efficiency and therefore different levels of competence result in companies specialising or preferring certain market sectors or types of work. They also state that detailed knowledge gained from previous works puts them at an advantage when tendering for similar projects. In addition, required items of specialised plant may be available in house.

Male (1991b) considers that a main contractor's experience stems from the degree of repetitive work that is allowed through the ability to obtain projects of a similar type. The experienced bidder appears to have a number of advantages over the inexperienced competitor. These may be classified as offsite and onsite. Offsite factors include proven managerial skill, problem awareness (Flanagan and Norman 1982b), greater accuracy in cost estimating, greater competitor awareness, greater market price awareness and greater confidence in being able to complete the project in accordance with the client's brief - less risk premium needed in the bid. Onsite factors include operative skill - learning curve, plant availability, proven material suppliers and domestic subcontractors, site management skill, team awareness.

Flanagan and Norman (1985) relate efficiency[2] with knowledge and experience of previous contracts. A highly efficient contactor is regarded as having extensive knowledge of previous contracts similar to the contract being tendered for and an inefficient contractor with little previous experience of this type of work. Flanagan and Norman (1985) state 'it is much more likely that a contractor will formulate his bid price on the basis of knowledge of his own relative efficiency and experience rather than on

---

[2]Based on work undertaken by Kortanek et al (1973), Flanagan and Norman (1985) define efficiency in terms of direct plus opportunity costs to which is added a competitive advantage fee.

the basis of reacting in a highly strategic way to what he expects his competitors to do'.

Experience is also related to expertise in management. Since the construction industry is project based and therefore short term and finite, there is a constant juggling of site managers between projects. Hillebrandt and Cannon (1990) found that most large contractors expressed a preference for obtaining as large a proportion of their senior managers from within an organisation as they:

(1) already possess the necessary training;
(2) are available when projects come on stream;
(3) have a strong identification with the company's general philosophy, name and its approach to the management of sites which become highly desirable given the mobility and isolation from head office together with the employment of subcontractors.

Norris (1984) points out that small firms suffer from a lack of management expertise and found in a survey of 112 firms that over three quarters were owned by craftsmen and of these only 15% had any managerial experience or training prior to owning their business.

A greater level of expertise of management should give the contractor a greater flexibility undertaking projects in terms of size and complexity. Related to this is the name of the firm in the sense that it 'embodies past experience, reputation and specialist expertise as a major factor of firm specific differentiation as it enables the contractor to compete effectively against all others in the industry by the differentiation of the firm in the bid situation. The name of the firm reflects the expertise of the firm's workforce and that human capital in the form of a skilled and experienced workforce is a major firm-specific ownership advantage to the contractor that ensures product differentiation and additionally affects the rate of tendering success' (Seymour 1989: 47).

Experience should enhance a contractor's confidence to meet specification requirements of the contract in terms of quality of materials and standard of workmanship and additionally complete the contract on time. This in turn should enable a contractor to reduce risk allowances and therefore be in a position to achieve greater efficiency in terms of cost.

3.3.3.2 Mark-up

The baseline is combined with a mark-up to form the bid. The bid level is decided at the business strategy level of an organisation. Skitmore (1988) defines the meaning of estimating and bidding as 'estimating is the process of working out likely costs and bidding is the process of converting an estimate into a tender price.' Most bidders undertake this conversion process at an adjudication meeting in which the bidder may make some final adjustments to the baseline and also a tactical decision on the level of mark up. The adjudication of an estimate and its conversion to a tender are the responsibility of management and that process is a separate commercial function based on the cost estimate and its supporting reports and documents (Chartered Institute of Building 1983). Azzaro et al (1987) interviewed 11 main contractors and 2 subcontractors whose average turnover varied from less than £10 million to over £1,000 million and found that the management at an adjudication meeting comprised a director, estimator(s) and contract staff. They also concluded that there is virtually no difference between sizes of contractors in the adjudication procedures they adopted.

Hillebrandt and Cannon (1990) state that in actually determining the bid price companies start with the estimated costs and then take into consideration the scope of the work, the likely risk, the likely competitors, the volume of work in hand, the influence of the project on the future workload and their ability to provide all necessary resources for the project. Apart from profit considerations some bidders incorporate the estimated value of other considerations such as site overheads into their mark-up. Since the number of bidders varies from competition to competition, bidders typically adjust their bids to reflect the competition (Carr

1983). Flanagan and Norman (1982a) state that the optimal mark-up for a particular contractor will also be affected by the identities of other firms on the bid list .

De Neufville and King (1991) identify two ways for compensating for risk when developing a bid. One is to develop a standard cost estimate not considering risk and varying the mark-up depending on the risk. The second method is to develop a cost estimate that adjusts productivity factors or adds contingencies based on the risk of each item being estimated and then applying a standard mark-up to this risk compensated estimate. De Neufville and King (1991) found that in practice most contractors used the latter method.

Hillebrandt and Cannon (1990) identify the following risk areas in the price determination process:

(1) errors by the company itself eg. estimating mistake, poor management;
(2) difficulties arising with other parties to the process;
(3) technical risks of the job eg. ground conditions;
(4) financial risks of the job;
(5) onerous contract conditions;
(6) employment of unsuitable subcontractors.

Hillebrandt and Cannon (1990) state these risks bear little relation to the size of contract so that it is difficult to put a percentage on to the mark-up for them. They also state that in general a company which has a large number of smaller projects is likely to be subject to less risk overall than a company of similar size with a few large contracts. Broemser (1968), however, postulates that a large job in relation to a contractor's capacity implies an increase in risk and that therefore the contractor would add a higher mark-up to cover this. At the small end of work the requirement of the management would be great, but at the same time the management could be employed on larger jobs - hence its opportunity cost on small jobs is high. Therefore the cost size relationship would be expected to be U-shaped.

In respect of pricing risk in relation to complexity, Hillebrandt (1985: 158) states 'it might be expected that the cost associated with risk would increase with complexity of the project and therefore that the difference between the cost of all inputs and cost would rise as the complexity of the product increases'.

Barnes and Lau (1974) point out that some contractors do not draw a clear distinction between the factors which influence the profit margin to be sought and risk allowances and cite the example that some contractors add a bigger mark-up to estimates if the invitation documents do not show a high level of technical competence, implying *that a high incidence of scope of changes is likely.*

Different bidders apply different mark-up policies which may be variable or fixed (Skitmore 1989). This in turn influences mark-up levels and thus competitiveness. Authors such as Chartered Institute of Building (1983), Harrison (1981), Marsh (1987), Upson (1987) and Shash (1993) have suggested many different factors that are considered in setting mark up values. For example factors identified by Upson (1987) include work in hand, bids in hand, availability of staff, profitability, ability of architect or other supervising officer, contract conditions, site conditions, construction methods and programme, market conditions and identity of other bidders. Shash (1993) conducted a review of American and British literature and identified 55 potential *factors affecting contractors' bidding and mark-up size* decisions.

Each factor is likely to modify the bidding behaviour, and therefore affect the competitiveness, of each contractor to varying degrees. Of these Flanagan and Norman (1982a) identify five major factors which comprise size and value of contract and construction or managerial complexity to complete it, regional market conditions, current and projected workload of the bidder, type of client and type of project.

3.3.3.2.1 Bidding strategy

Bidding strategy is concerned with setting the mark up level to a value that is likely to provide the best pay-off. Flanagan and Norman (1982b) state that bidding strategy in general is affected by the type of project and by the value range. McCall (1977) states 'different kinds of jobs require different cost structures for materials, labour, subcontracts, equipment, and other direct costs. Most mark-up policies do not recognise various proportions of overhead, which arise from shifts in the ratios of types of direct costs or differing types of work. Once overhead for different types of work is established, overhead cost information can be used to increase profits. Job size is a factor that also influences how much mark-up a particular job should bear. Assuming a consistency in the policy of cost classification, jobs within each type of work should allow for the overhead mark-up percentages to vary inversely with job size. A large job requires a lower percentage mark-up than a small job if the two jobs are identical in size. Failure to consider this principle causes many contractors to overprice large jobs and underprice small jobs. Overcompensating for job size leads to the reverse - overpricing small jobs and underpricing big jobs'. Hillebrandt (1985) makes reference to an unpublished paper by Fine (1970) who found that, in general, the larger the contract the smaller the percentage profit. Barnes (1972) found that the majority of companies showed their highest profit in their dominant size range.

The strategic selection of mark-up values has been considered extensively in the operations research literature (eg. Friedman 1956, Park 1966, Gates 1967, Morin and Clough 1969, and Whittaker 1970). As pointed out by Male (1991a) standard bidding models presume that bidders attempt to maximise their expected profit, however, the bidder may be attempting to fulfil other objectives including minimising expected losses, minimising profits of competitors or obtaining a contract, even at a loss, in order to maintain production. Raftery (1991) identifies the range of objectives which a contractor might hold at a particular moment or with respect to a particular contract as including the following:

(1) maximise profit on each individual project;

(2) maximise return on the capital invested in the firm;
(3) minimise losses;
(4) maintain production and the employment of the firm's labour force;
(5) enhance the personal status of the owners/managers by undertaking prestige projects;
(6) to gain a foothold with a new client who is the potential source of much future work;
(7) to gain a foothold in a new geographical area;
(8) not to offend a valued client by refusing to bid even though the firm does not have the spare capacity to take on the contract should its bid be accepted.

Fine (1975) has identified several strategies including random bidding when work is low, selective bidding, and severely competitive bidding with claim back options within the limits of the contract. Stone (1983) has also suggested that some firms aim at lower standards of work than others and that there are differences in efficiency and therefore cost.

3.3.3.2.1 Constraint and preference driven bidding strategies

Factors that affect the bidding decision are shown to fall into three main categories namely job characteristics, economic environment and competition condition (Carr and Sandahl 1978). Based on this rationale, factors influencing bidding behaviour, and therefore competitiveness, may be grouped into those affecting (1) group behaviour, (2) individual behaviour, and (3) contract characteristics (see Figure 3.1). The degree to which these factors influence competitiveness levels is dependent on the baseline estimates and levels of mark-up emanating from the bidders' strategies or policies.

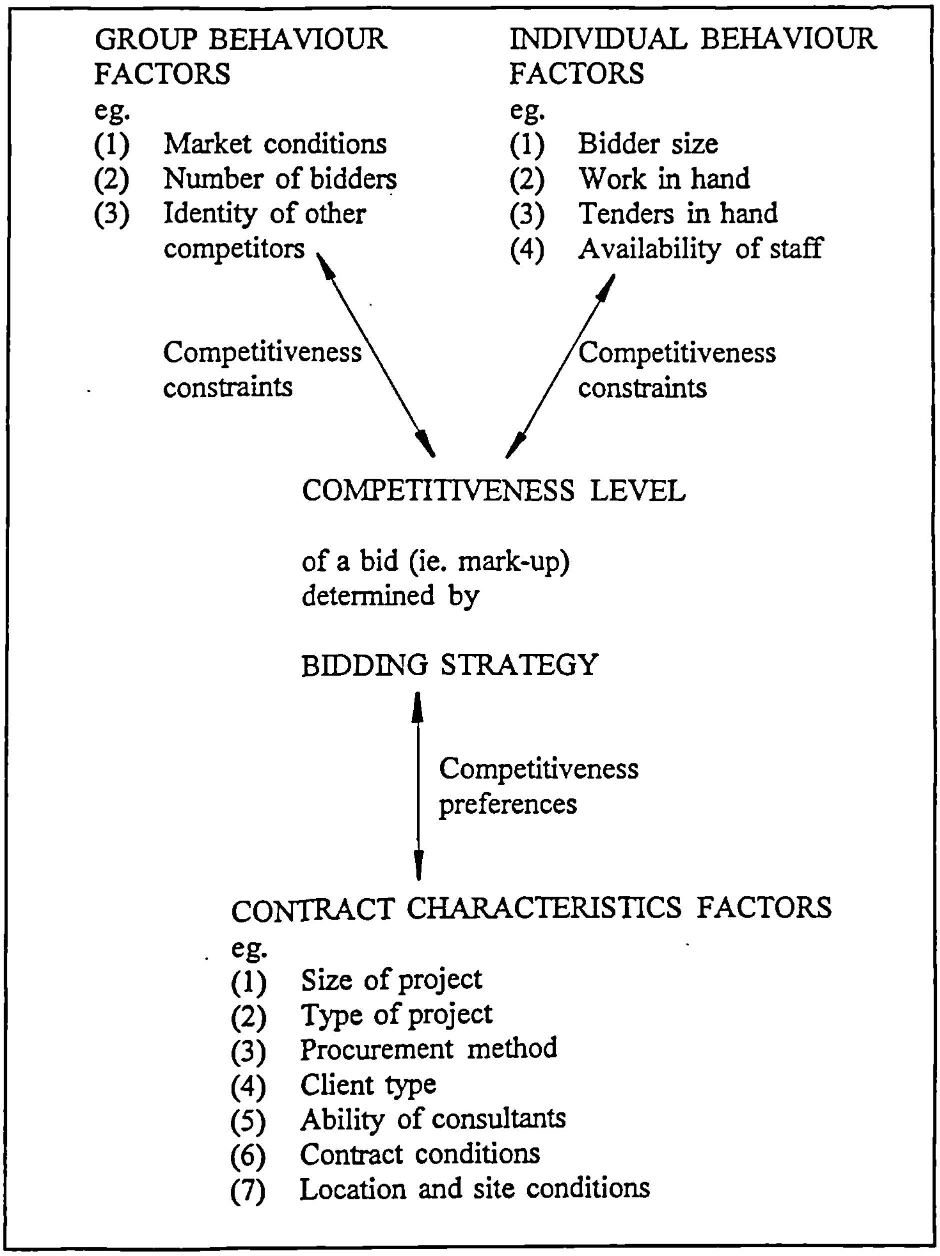


Figure 3.1: Competitiveness factors in terms of constraints and preferences

In determining mark up levels, different bidders have differing degrees of selectivity between contracts. Those who are more selective concentrate on particular contract characteristics such as type and size. Those who are less selective place less emphasis on contract characteristics than on other factors such as workload or resources available. Bidders who carefully select contracts for which they enter serious bids may be regarded as 'market' or 'preference driven'. Those bidders who place most emphasis on workload may be regarded as 'resource' or 'constraint driven'. These categories are neither exhaustive nor mutually exclusive and some bidders may place equally high or low emphasis on market and resource factors.

Separating selective from constraint based strategies is a reflection of the two complementary approaches economists have developed in studying business behaviour. One is to try to explain business behaviour through the goals of the firm, the argument being that decision makers **select** the actions and strategies that they perceive best contribute to reaching the firm's goals. The other holds that market conditions and competition drives or **constrains** a firm's behaviour (Thompson 1989: 251). It also effectively reflects Gabor's work on pricing behaviour (Gabor 1977) that separates 'market oriented' from 'resource-based' pricing approaches.

The idea of preference and constraint driven bidders can also be related to Porter's work (Porter 1985) in which he identifies three strategies;

(1) cost leadership: firm aims for the lowest cost and achieves superior profitability from an above average price margin.

(2) differentiation: firm strives to differentiate its products such that it can raise price more than the cost of differentiating and thereby achieve superior profitability.

(3) focus: firm concentrates on a particular segment of the market and applies either a cost leadership or differentiation strategy.

Bidders who adopt a cost leadership strategy are likely to be constrained by their ability to cut costs in an attempt to achieve superior profitability rather than be selective towards certain contract characteristics. However, bidders who choose a focus strategy are likely to place a greater emphasis on preference rather than constraint.

The ideas of preference or constraint driven is not directly applicable to bidders who use a differentiation strategy. These bidders are hoping to win contracts through, for example, reputation even though their bids may not be the lowest. It is worth noting that such a strategy is likely to be more successful in the private sector. This is because public accountability in the public sector normally means that contracts have to be awarded to the lowest bidder only.

3.3.3.3 Competitiveness relationships between baseline estimate and mark-up

In practice the mark-up is normally constrained to be above the baseline estimate, although on occasions, such as when there is a paucity of construction work and competition is therefore extremely keen, it may overlap the baseline estimate. The bidder has the choice of pitching the mark-up at one of three levels:

(1) at a loss;
(2) at neither a profit nor a loss (ie. break-even);
(3) at a profit.

A smaller baseline estimate and mark-up means a lower bid which indicates greater competitiveness. Competitive advantage can be related to a bidder's baseline with a smaller baseline being indicative of a greater competitive advantage over other bidders. The size of mark-up can be regarded in terms of competitive desirability with a smaller mark-up reflecting greater competitive desirability.

3.3.3.4 Serious and non serious bids

Skitmore (1982) introduces the concept of bidders having either constant and variable mark-up policies through a contract desirability continuum. For example, a bidder who has a variable cost estimate and mark-up has alternative options. These have been outlined by Skitmore (1989) as follows:

(1) decline to bid;

(2) return tender documents;
(3) submit a cover price;
(4) produce a rough estimate and add mark-up;
(5) add 'non price features'(ie. qualify the bid);
(6) produce a detailed estimate and add mark-up.

Opportunities to withdraw from the competition are identified in options (1) and (2). Thorpe and McCaffer (1991) see the decision to tender as a three stage process with options to withdraw at the pre-selection stage (for selective tendering), after receiving the full contract documentation but before preparing the bid and after the estimate has been prepared and the tender is ready to submit. Upson (1987) points out that the decision to withdraw during the competition may be because the contractor becomes overwhelmed with enquiries and/or has had a number of recent successes.

Although contractors do not really want the work they may still bid because:
(1) clients and consultants may have given the impression to the contractor that failure to submit a tender will prejudice future enquiries or resent the contractor picking and choosing contracts for which tenders are submitted (Upson 1987);
(2) they want to make it more difficult for competitors to determine their strategy;
(3) they want to deny their competitors the chance of entering the competition in their place.

In instances such as these bidders are more likely to want to minimise the cost of preparing the bid by submitting a cover price or producing a rough estimate and adding a high mark-up. Contractors may also add 'non price features' in instances where:
(1) they do not want to undertake a particular section of work;
(2) they want to change certain contract conditions which they perceive as being particularly onerous;

(3) they want to create an opportunity for post contract competition negotiation with the client.

According to Skitmore (1989), only bids derived from producing a detailed estimate and adding mark-up with or without non-price features can be regarded as a genuine competitive bid. Other actions could be regarded as less or non-competitive in which it is less likely that the contractor will succeed in undertaking the work. Bids submitted to the client, therefore, may be classified into serious and non serious bids.

3.3.3.5 Baseline estimate and mark-up variability

Differences in baseline estimates between bidders is considered by Beeston (1983) to be the major component of bid variability. The variability of baseline estimates has been attributed to three factors: (1) inherent unpredictability (eg. site performance, weather conditions); (2) uncertainty due to incomplete design and future cost levels; and (3) costing errors (Skitmore 1982). As bidders have only an imperfect knowledge of the direct costs of a building contract, they allow different contingency values according to their perception and attitude to the risks involved.

The extent to which the mark-up affects variability in bidding is dependent on the variability of the mark-up itself between contracts. This is directly related to strategic considerations and includes whether the practice of submitting serious and non-serious bids is adopted by the contractor.

3.4 Outcome of the strategic process

3.4.1 Bidding performance

Bidding performance is concerned with the competitive relationships between bids submitted by bidders in competition with each other to the client. Since a bid is an estimate of the (unknown) market price most bidders submitting a genuine bid are attempting to submit a bid which is low enough to win the contract but high enough to make a profit. In bidding for contracts awarded solely on the basis of price competition only, the bidder is normally aiming to submit the lowest bid. In bidding systems where the contract is awarded on the basis of initial competition and subsequent negotiation a bidder normally aims to submit a bid so as to be 'in the frame' for the negotiation stage.

3.4.2 Maximum competitiveness and the market price

At the time of submitting the bid the maximum level of competitiveness can be taken to be the lowest bid. All other bids, in terms of competitiveness, are relative to the lowest bid. In the course of technically checking the lowest bid the bid price will become the optimum bid. The optimum bid has been defined as 'the lowest priced evaluated bid which has undergone a process of assessment to identify and, where necessary, to price the consequences inherent in the submission' (Merner and Smith 1990). In this assessment process the bid price may or may not change.

The optimum bid normally forms the market price. At the time of preparing the bid the market price exists but nobody knows its value. Each bidder is trying to estimate that price. It is only known when the client enters into a contract with the successful bidder. The market price has been referred to as the 'winning bid' (McCaffer and Thorpe 1991).

Market prices can be classified as true or false. True market prices occur where the contract is awarded to the bidder with the optimum bid (ie. the lowest priced evaluated bid).

False market prices occur when the contract is awarded to bidders who do not have the optimum bid. Reasons for this include:

(1) price is not the most important factor in awarding the contract (Raftery 1991);

(2) there may be political reasons for awarding the contract to a particular contractor (Raftery 1991);

(3) favouritism towards a certain bidder;

(4) unfair post competition negotiation with bidders under a supposedly competition only tendering system in which a bidder who did not have the initial optimum bid wins the contract;

(5) where the optimum bid is disregarded because of problems with the bidder rather than the bid itself. For example, at the time of awarding the contract the client may consider that the bidder no longer meets the required prequalification criteria; the bidder's current workload may have become too high; the bidder has insufficient working capital. In such cases usually the next lowest satisfactorily assessed bid forms the market price.

3.4.2.1 Perceptions of the market price

Bidders' perceptions of the market price may be manifested in a small range of bids being received for certain projects. This small range may be indicative of collusion between bidders[3] or due to an existence of a perceived 'norm'.

A genuine bid may be interpreted as a reflection of the perceived 'norm' - that is what contractors think the market price is for a particular contract at a certain point in time. Since a bid is essentially an estimate of the (unknown) market price, the consistency between bidders is an indication of the degree of consensus concerning the value of market price which, in turn, is influenced by such factors as the predictability of the market price and experience of the bidders.

The importance of the market in the context of pricing has been stressed on different occasions. The first person to emphasize the importance of the market on

[3] The little evidence that is available suggests that collusion with other bidders is a rare occurrence in construction contract bidding and is generally restricted to highly specialised work where bidders virtually monopolise the field (Skitmore 1986).

building prices is Fine (1974) who proposed the term 'socially acceptable' prices to represent the market price. Skitmore (1987a: 13) cites references to personal communications which include '... prices are market driven ... prices vary according to market conditions ... knowledge of the market is pretty important ... tender prices are considered to be determined by market forces ... builders know the going rate'.

Ferry and Brandon (1984) state that contractors will occasionally admit they can write down the cost of the job before they start pricing it, or that they work out the yardstick before pricing a government job ... many clients assist the building contractor by naming the (approximate) value of the contract when enquiring if the contractor is willing to tender ... the building grapevine of sub-contractors ensures that the anticipated contract sum is well circulated.

Contractors in their bidding may also be influenced as to what the perceived 'norm' is for a particular building type. Fine (1974) claims that bids varied dramatically between two projects in which the tender documentation was identical in every respect except name and also found evidence to suggest that nurses' homes cost the community about four times as much as almost identical student hostels.

3.4.3 Competitiveness in the construction market

The key aspect of the environment to the individual firm is the market or markets within which it competes (Johnson and Scholes, 1993). Competitiveness has been defined by Baker and Hart (1989: 5) as 'an advantage which may be derived from price, quality, speed of delivery or design which enables a company to secure work at the expense of its rivals'. Czepiel (1992: 18) states that 'competition determines which of the competitors gets a larger share of the market value (and that a) superior competitor, one able to more accurately and efficiently produce and sell those satisfactions valued by customers, will obtain a larger share while competitors with essentially equivalent products and resources should receive approximately equal shares'. For any given market or market sector firms will assume differing positions of competitiveness. Baker (1985) and Kotler (1988) identify the range of competitive positions that a firm will occupy as dominant, strong, favourable, tenable, weak, non-viable. Newcombe et al (1990) suggest that the competitive position of a contractor can be determined by considering:

(1) level of demand in the construction industry;

Bid prices will tend to be lower when general market conditions are slack and higher when the construction market is buoyant. Thorpe and McCaffer (1991) see that bidding efficiency is required in both depressed and buoyant markets and state that in depressed markets the success rate declines with more tenders need to be produced to maintain the companies turnover. However, in buoyant markets the increased bidding opportunities need evaluating to ensure that the company makes the best use of its opportunities.

(2) the relevant competitors;

It should be noted that not all firms in a particular market are competitors. Based on Newcombe's work (Newcombe 1976), Fellows et al (1983) presents a method of mapping a particular strategic group of competitors which illustrates that the degree of diversification of services and markets covered, and geographical decentralisation are the two key ways of grouping construction companies.

(3) the market leadership of the firm;

The usual source of power in a market is market share but, due to the fragmentation of the construction industry, this is rarely achieved by construction firms (Newcombe et al 1991a).

Stocks (1991) suggests that a firm's competitive position is established by a combination of its market share and other factors resulting from past strengths and weaknesses, and competitive economics. He also points out that small companies or divisions of large firms may specialise in parts of a market where they are not in competition with larger firms.

3.4.4 Competitive advantage

It is through the process of making strategic decisions that contractors will be seeking to gain competitive advantage. Male (1991c) defines competitive advantage as where a company has superiority over its competitors. Competitive advantage arises from a firms choice of markets to serve, its distinctive competencies, and pattern of resource deployment that give it an edge over competitors in chosen markets (Kerin et al 1990). 'Each business firm, in order to survive, must determine the boundaries of its particular position so that it does not compete on identical terms' (Ramsay 1989: 27) therefore a company needs to identify its competitive differential advantage (Stocks 1991). Stocks (1991) points out that those strengths may lie in areas of competence which provide a competitive edge, such as a particular skill, resource, facility, expertise or combination of them.

Porter (1980) states that the primary objective of the business firm is to obtain and sustain competitive advantage over other competitors. Porter (1985) also proposes a value chain concept for identifying and exploiting competitive advantage. This consists of all the value activities (which comprise both primary activities such as line operations, and support activities, such as overheads) performed by firms plus profit margin. Porter argues that every value activity embodies technology of some kind. In linking them together, value activities become the 'discrete building blocks of competitive advantage'.

Porter (1990) contends there are three conditions to sustain competitive advantage and these relate to:

(1) a hierarchy of sources which are split into low order and high order. Low order sources can be easily copied by competitors, high order sources require more advanced skills to achieve them.
(2) the number of distinct sources of advantage a company possesses
(3) constant improvement and upgrading of advantage.

Betts and Ofori (1992) promote the use of Porter's techniques in construction strategic planning as part of a survival strategy. They also identify the following reasons why construction offers little opportunity for the application of concepts such as these in construction strategic planning:

(1) the contracting firm has little opportunity to differentiate its product as many project parameters and variables are determined before the firm is engaged;
(2) most contractors are small and construction is a highly fragmented industry;
(3) each project is unique and few construction firms have a structured feedback system;
(4) much construction work is relatively simple and the technological progress is rather slow.

3.4.5 Variability in competitiveness between bidders

Bidders entering consistently low value bids over a series of competitions are considered to be more competitive than those entering consistently high value bids. Bidders may also be inconsistently competitive. Distinct from mistake, competitiveness variability has been ascribed to many factors including differences in cost estimates (Beeston 1983), mark-up policies (Fine 1975, Stone 1983), serious and non-serious bids (Skitmore 1989), the effect of subcontracting (Flanagan and Norman 1985) and the influence of perceived 'norms'.

There appears to be a relationship between bidding competitiveness and variability since a bidder who is consistently competitive is by definition less variable in bidding. It follows that less competitive bidders are likely to be more variable in bidding otherwise they would fail to get any work. One explanation for differences in bidding variability between bidders is for reasons just described. Another is that through the strategic decision making process some bidders have preferred contract types and sizes within the construction market for which they bid more competitively.

3.4.6 The effect of contract type and size

Flanagan and Norman (1982b) examined the bidding performance of a small, medium and large bidder. They found that when bidding (1) the small bidder considered both contract type and size, (2) the large bidder was more successful in bidding for large contracts and (3) the medium bidder's competitiveness was not related to either contract type or size. Flanagan and Norman's study suggests that, in terms of competitiveness, competing contractors are influenced, to varying degrees, by contract type and contract size. This degree of influence is reflected in various strategic decisions made at the different levels and stages of the strategic process.

At the corporate level contractors define a strategic domain which sets out the market dimensions within which contractors plan to operate. This includes deciding which types and sizes of contract to compete for within the different market sectors of the construction market. It is at the business strategy level where corporate strategy is implemented. From time to time, various bidding opportunities for construction work arise from both inside and outside of the contractor's strategic domain. Contractors need to make decisions on whether to bid for the work and, if opting to bid, deciding on the appropriate bid level. If the type and/or size of contract falls outside the contractor's strategic domain it seems more likely that the contractor will either choose not to submit a bid, or submit what is considered to be an uncompetitive bid. If, however, the contract falls within the contractor's strategic domain it is more likely that the contractor will seriously consider competing for the work.

It can be seen that decisions on whether to bid and bid level are influenced by a multitude of factors. These have been classified into those affecting (1) group behaviour (2) individual behaviour and (3) contract characteristics. Those contractors who are more selective concentrate on particular contract characteristics such as contract type and size. Contractors who display these characteristics have been termed 'market' or 'preference driven'. Those who are less selective place less emphasis on the contract characteristics than on other factors such as workload or resources available. These have been termed 'resource' or 'constraint driven'. These categories are neither exhaustive nor mutually exclusive and some bidders may place equally high or low emphasis on market and resource factors.

It seems, therefore, that the effect of contract size and type on competitiveness in construction contract bidding is influenced, to an extent, by the degree of preference a contractor places on these variables. The competitiveness effect of contract type and contract size on the bidding performance of preference driven contractors is likely to be greater than that for constraint driven contractors. Preference driven contractors are more likely to submit competitive bids consistently for preferred types and sizes of contract and in doing so be less variable in bidding between contracts than constraint driven contractors.

Flanagan and Norman's study also suggests that, in terms of competitiveness, there is a relationship between bidder size and contract size. It seems that most contractors gear themselves up to undertake a portfolio of contracts that fall within a preferred contract size range. This contract size range appears to be related to the size of the contractor. Smaller contractors, due to the influence of resource constraints, are likely to have a smaller preferred contract size range than larger contractors. This range would appear to be confined to the smaller end of the contract size continuum. Larger contractors, however, have the flexibility to undertake a wider range of contracts. It seems, however, that most larger contractors prefer to work within a range of minimum and maximum contract values.

Economic scale theory suggests that larger size contractors undertake larger contracts with increased rates of efficiency. Economic value will therefore depend, to some extent, on matching the size of contractor to the size of contract. Thus, if the proposed contract size is within a contractor's preferred size range then it is likely that the contractor will construct the work more efficiently and bid more competitively. Linked to this is Male's notion that the construction market is a contract based-vertical market defined by contract size and complexity (Male 1991b). As one moves up the contract size continuum the total number of potential competitors becomes fewer and fewer. Since the upper end of the contract size continuum is likely to consist solely of larger bidders, larger bidders will almost certainly become the lowest bidder for the larger contracts. Although smaller contracts appear, *prima facie*, to favour the smaller bidder in becoming the lowest bidder, either larger or smaller bidders have the potential of becoming the lowest bidder.

It seems that contract type and size may serve respectively as proxies to experience and resources. Experience appears to be a key factor that permeates every stage of the strategic process. Managerial skills capacity gives the contractor greater flexibility in the work it undertakes and is regarded by Hillebrandt and Cannon (1990) as the most important determinant of the capacity and capability of construction firms. Differing sizes of contracts require differing amounts of resources. Economic efficiency appears, to some extent, to be dependent on linking the right size of contractor with the size of contract.

Construction contract bidding is primarily concerned with the competitiveness relationships between bidders and the contracts they are bidding for which can vary considerably, particularly in terms of contract type and size, from one contract to the next. As part of an effective planning and bidding strategy contractors need to have sufficiently similar experience to execute the contract efficiently and the ability to acquire the necessary resources efficiently to match the requirements of a contract so as to maximise the chance of achieving the expected profit margin.

3.5 Summary

Strategic decisions define the boundary between the firm and the external environment. Contract bidding, like all other forms of pricing, is essentially about contractors making strategic decisions in respect of which contracts to bid for and the bid levels necessary to secure them. Strategic decision making in construction contracting is seen to occur at the corporate, business and strategy levels within an organisation.

Most contractors recognise that they cannot undertake work in all sectors of the market and as part of their corporate strategy define a strategic domain which sets the parameters within which senior management chooses to operate. In other words, the strategic domain establishes the market dimensions within which contractors plan to operate. This includes making decisions on which contract type and size of contracts to compete for and the extent of the geographical area within which to undertake the construction work.

A contractor's strategic domain can be defined according to the number of contract types and may comprise undertaking all or specialising in certain contract types within one or more sectors of the construction market. The strategic domain may also include only undertaking new build work or alteration work or both. A contractor's strategic domain can also be defined according to the range of contract size it wishes to undertake. Strategic domain differences in terms of geographic area are likely to become less apparent in smaller, more densely populated countries. In Hong Kong, for example, the influence of geographic area appears to be minimal since most contractors tend to operate territory wide with the exception of undertaking work on some of Hong Kong's more remote islands. Hong Kong's construction market, therefore, appears to exist largely according to two main market dimensions, that of contract size and type.

In the course of running the construction firm, it is at the business strategy level where contractors are given numerous opportunities to bid for work both within and outside of the strategic domain. Job desirability is influenced by many factors including favoured contract types within the bidder's expertise area.

In deciding to bid the contractor has a two-stage decision process to make -

whether to bid or not and the bid level to secure the contract. In deciding whether to bid contractors are likely to consider both their current workload and future available work in the construction market. Economic theory of the firm suggests firms operate most efficiently when they are operating just under capacity of their total resources. If the firm attempts to operate beyond this point the firm may run into assorted bottlenecks making it less competitive. Achieving optimum efficiency therefore becomes an issue of balancing the resources in hand with the size of the proposed contract. Management, rather than fixed capital, has been identified as the most important determinant of the capacity as well as the capability of construction firms. The managerial skills capacity gives the contractor greater flexibility in the work it undertakes. Contractors do not attach too much importance to availability of resources since resource constraints can be easily overcome by obtaining extra resources from alternative sources, such as hire, lease and subcontracting, when those at the contractor's direct disposal cannot cope with the work-in-hand.

If the contractor opts to submit a bid, the pricing of the bid normally comprises a two stage formulation process comprising baseline estimate and mark-up. Long-term differences between bidder's pricing are a reflection of their relative efficiencies - more efficient bidders tending to enter lower bids, thereby over a series of competitions being more able to achieve higher levels of competitiveness. Four sources of cost efficiency have been identified as comprising economies of scale, supply costs, product process design and experience.

The baseline estimate is combined with a mark-up to form the bid. Different bidders apply different mark-up policies which may be variable or fixed which in turn influence mark-up levels and thus competitiveness. Bidding strategy is concerned with setting the mark up level to a value that is likely to provide the best pay-off. Standard bidding models presume that bidders attempt to maximise their expected profit. However, the bidder may be attempting to fulfil other objectives including minimising expected losses, minimising profits of competitors or obtaining a contract, even at a loss, in order to maintain production.

As part of their bidding strategy, different bidders will have different degrees of preference towards the individual contract characteristics, such as size, type and location of proposed contracts. In determining mark up levels, different bidders have differing degrees of selectivity between contracts. Those who are more selective concentrate on particular contract characteristics such as type and size. Those who are less selective place less emphasis on contract characteristics than on other factors such as workload or resources available. Bidders who carefully select contracts for which they enter serious bids may be regarded as 'market' or 'preference driven'. Those bidders who place most emphasis on workload may be regarded as 'resource' or 'constraint driven'. These categories are neither exhaustive nor mutually exclusive and some bidders may place equally high or low emphasis on market and resource factors.

Bidding performance is concerned with the competitive relationships between bids submitted by bidders to the client. Since a bid is an estimate of the (unknown) market price most bidders submitting a genuine bid are attempting to submit a bid which is low enough to win the contract but high enough to make a profit. At the time of submitting the bid the maximum level of competitiveness can be taken to be the lowest bid. All other bids, in terms of competitiveness, are relative to the lowest bid. In the course of technically checking the lowest bid the bid price will become the optimum bid.

Flanagan and Norman (1982b) examined the bidding performance of a small, medium and large bidder. They found that when bidding (1) the small bidder considered both contract type and size, (2) the large bidder was more successful in bidding for large contracts and (3) the medium bidder's competitiveness was not related to either contract type or size.

Flanagan and Norman's study suggests that, in terms of competitiveness, competing contractors are influenced, to varying degrees, by contract type and contract size. It seems that the effect of contract size and type on competitiveness in construction contract bidding is influenced, to an extent, by the degree of preference a contractor places on contract type and contract size. The competitiveness effect of contract type and contract size on the bidding performance of preference driven contractors is likely to be greater than that for constraint driven contractors. Preference driven contractors are more likely to submit competitive bids consistently for preferred types and sizes of contract and in doing so be less variable in bidding between contracts than constraint driven contractors.

Flanagan and Norman's study also suggests that, in terms of competitiveness, there is a relationship between bidder size and contract size. It seems that most contractors gear themselves up to undertake a portfolio of contracts that fall within a preferred contract size range. This contract size range appears to be related to the size of the contractor. Smaller contractors, due to the influence of resource constraints, are likely to have a smaller preferred contract size range than larger contractors. This range would appear to be confined to the smaller end of the contract size continuum. Larger contractors, however, have the flexibility to undertake a wider range of contracts. It seems, however, that most larger contractors prefer to work within a range of minimum and maximum contract values.

In describing the strategic process this chapter has highlighted the effect of contract type and contract size on competitiveness in bidding. Contractor size also appears to be an important related variable. Modelling competitiveness in bidding is now discussed in Chapter 4 as a prelude to developing a suitable methodology for measuring the effect of contract type and size on competitiveness in bidding.

CHAPTER 4

Modelling bidding competitiveness

4 MODELLING BIDDING COMPETITIVENESS

4.1 Introduction

Chapters 2 and 3 examined the issues surrounding the effect of contract type and size on competitiveness in contract bidding. This chapter, on modelling competitiveness in bidding, is in three sections. The first section reviews the bidding literature and highlights some of the complexities and difficulties in modelling bids. The second section describes the different approaches to modelling competitiveness in bidding, while the third section identifies and compares various competitiveness measures.

4.2 Bidding models

Allocating resources by means of some auction process is widespread and ranges from open auctions of works of art or property, to sealed bid auctions of oil exploration rights or construction contracts. Specific auction methods include sealed bid, progressive and Dutch (Engelbrecht-Wiggans 1980).

Flanagan and Norman (1985) point out that it is only in recent years that a coherent body of theory has been developed in which the pricing and efficiency implications of bidding as a method of resource allocation have been examined. Harris and McCaffer (1989), however, comment that although the subject of competitive bidding has attracted investigations and research by both contracting companies themselves and a variety of academics, disappointingly the results of these investigations and efforts to remove some of the uncertainty are far from conclusive. Skitmore (1991b) identifies part of the problem lies with an understandable reluctance for commercial companies to publish their findings.

4.2.1 Bidding literature reviews

Reviews of bidding literature include those by;

(1) Stark and Rothkopf (1978) who produced a comprehensive bibliography relating to bidding;

(2) Engelbrecht-Wiggans (1980) who provides a useful system for classifying a wide variety of approaches to different types of bidding situations;

(3) King and Mercer (1988) who classify bidding approaches according to basic probability, game theoretic, probabilistic strategy and non-price;

(4) Skitmore (1988) who discusses the development of bidding models and classifies current work into contract opportunities, decision outcomes and competitors' bidding patterns;

(5) Skitmore (1989) who builds up a conceptual model of the contract selection/bidding environment by breaking down the decision making problem into outcome environment, time related and non-deterministic aspects and then defines various options available to the decision maker. He also describes the various statistical approaches that have been made to aspects of the problem.

4.2.2 Use and usefulness of bid modelling in practice

A model is an approximation of the real situation and the value of any model depends on how good an approximation it is (Engelbrecht-Wiggans 1980). There are a variety of techniques that can be used in modelling. These include game theory (analysis of reactionary competitors), decision theory (analysing situations of uncertain outcomes), operations research (optimising outcomes of simultaneous decisions), multi-criteria decision making (resolving conflicting objectives), simulation, behavioural science (predicting human behaviour), statistical techniques and economic analysis.

Models may be classified as longitudinal or cross-sectional. Longitudinal or time series uses observations that have been recorded over time in a particular situation.

Cross-sectional analysis uses different observations from different firms in the same business environment at the same point or period of time. Hence, cross-section analysis largely eliminates the problem of uncontrollable variables that change over time, but it introduces other factors that may differ between and among firms at a particular point in time (Douglas 1987).

Skitmore (1988) states that the task of fundamental research in bidding is to produce a general model expressed in terms of well established laws, axioms or propositions upon which future systems and techniques may be developed and concludes that research in this area is progressing on three levels - systems, techniques and models. Skitmore (1989) also points out that much of the literature that deals with construction pricing concentrates on the formulation of optimal pricing for contracts. For example, Friedman (1956) and subsequent researchers, such as Park (1966), Gates (1967), Morin and Clough (1969) and Whittaker (1970) treat the bid as an 'optimisation' problem. Optimisation is defined as 'the process by which the best solution or result may be obtained'(Kempner 1980: 287). As such, these models fall within the realms of operational research which is concerned with the application of quantitative methods in decision making. In more specific terms operational research is an approach that emphasizes optimal managerial decision making, adopting the scientific method as a framework for problem solving with emphasis on objective rather than subjective judgment and with certain assumptions about organisations and participant behaviour being made by the operations researchers or management scientists (Kast and Rosenzweig 1985).

There appears to be a gap between theory and reality, and bidding models do not seem to be much used or considered outside the research circles. For, example Wong (1978), Stark (1976) and Lansley (1983) have found that contractors do not favour the use of bidding models. Ahmad and Minkarah (1988) found that less than 11% of the top American contractors use some form of mathematical modelling for determining proper mark-up size. Gates (1983) abandoned all mathematical strategic models in favour of a non-mathematical approach, based on the Delphi technique, entitled Expert Subjective Pragmatic Estimate (ESPE).

Cusack (1981) suggests that although most contractors possess, or have access to, extensive information in one form or another, most of them fail to make use of this information to support or improve their decision processes. Skitmore (1986) found there is little evidence of using feedback as a basis for decision making being used in practice and, in citing previous work, identifies the reasons for lack of use as including communication problems, lack of managerial skills, imperfect knowledge about future markets, complexities of the construction process, environment uncertainties and limited amount of time available to the decision maker with which to make the decision. A conclusion reached by Skitmore (1989) in later work is that the construction industry reveals no existence of any substantive approach in producing a model that reflects the truly pivotal factors in the environment being modelled, especially with regard to the types and amounts of available data and the ability to process this information rapidly enough to be useful to the decision maker.

Some researchers (eg. Spooner 1971, Barnes 1980) claim that all bidding models that are based on statistical theory are not useful. Others advocate that the use of bidding models will give the contractor a competitive advantage when bidding against competitors (eg. Morin and Clough 1969, Wade and Harris 1976, Gates 1976, Carr and Sandahl 1978, Benjamin 1979). Others suggest that the combination of managerial judgement with statistical bidding models is the best approach (eg. Furest 1976, De Neufville et al 1977, Grinyer and Whittaker 1973, Shaffer and Micheau, 1971).

Male (1991a) observes that although much effort is now spent in the development of mathematical procedures and models towards defining the most effective bidding strategy for contractor performance, bidding models may not, however, reflect the true bidding situation, which is perhaps why contractors may not display much interest in such procedures.

Shash (1993) identifies the failure of mathematical models to be attributable to five factors namely:

(1) models oversimplify the real world situation;

(2) models are incomplete;

(3) distraction of researchers' attention due to the Friedman \ Gates' model controversy;

(4) models only consider number of bidders as the prevailing factor;

(5) models require excessive use of data.

Male (1991a) identifies the weaknesses of bidding models as follows:

(1) standard models purport to show how to make choices in a situation of risk without accounting for both organisation and environment;

(2) standard models presume that bidders try to maximise their expected profit, however, the contractor may be attempting to fulfil other objectives;

(3) different objectives require different strategies, but this diversity is not closely reflected in standard models;

(4) standard models fail to consider the competitive situation of the firm and to identify those factors which have an influencing impact on profit;

(5) standard models fail to consider constraints faced by the firm such as geographic location, class of construction, equipment parameters, government laws and regulations, building requirements and financial constraints.

Raftery (1991) identifies the limitations of bidding models as including the following:

(1) the possibility of errors in bid models is almost certain;

(2) bid models are not dynamic;

(3) bid models are based on limited information and time frame;

(4) market conditions and competitors' behaviour constantly changing;

(5) bid models are based on the assumption that competition is purely on price with no collusion among the bidders, no cartel and there is no revealing of prices.

4.2.3 Difficulties in modelling bids

King and Mercer (1980) state that it is certainly difficult to build and exploit models of bidding situations that are realistic, relevant and useful to those making the key decisions and conclude that there is surprisingly little progress towards a generally agreed approach which is practical and relevant in a range of situations.

It appears that the failure, weaknesses and limitations of bid models stem from the complexities and uncertainties inherent in the bid process itself. Each bidding event is unique. It is a non-deterministic process in which bidding events need to be considered in terms of their probability of occurrence (Skitmore 1989) and in which the lowest bid may be hypothesized to fall within a continuum of potential lowest bids (Skitmore 1981). Benjamin (1972) states that the events taking place are not truly random in the classical sense as the data are not generated from repeated measures of the same experiment. Flanagan and Norman (1982b) observe that when contractors are constantly in competition with one another the pattern cannot be regarded as random. The strength of this observation is largely dependent on competing bidders consistently conforming to some adopted bidding strategy.

From the contractors' viewpoint Harris and McCaffer (1989) akin competitive bidding to roulette: sometimes they win when they think the price is high; sometimes they lose when their price is low. Ferry and Brandon (1983) state that contractors take their place in the bidding order by chance and that in the long term they appear to win contracts in direct proportion to the number of contracts they are bidding against. The random nature of the bidding process 'ensures that contracting companies will be unable to plan their companies' activities with much certainty' (Harris and McCaffer 1989). However, bidders seek to have the best set of contracts despite the limits to the number of contracts that can be handled at any one time and that construction companies have multiple and conflicting objectives such as meeting target profits, turnover, entering new markets, courting new clients etc. (Skitmore 1988).

Ahmad and Minkarah (1988) and Green (1989) consider that there are many factors, other than pure economic, that are considered in bidding strategy decisions. Barnes and Lau (1974) investigated the bidding policies of 16 plant contractors and found that none of the contractors used a policy for determining profit margins which excluded judgment or feel and that each considered the combination of circumstances was so different from one bid to another that any policy which eliminated flexibility would be harmful.

Couzens (1991) suggests that bidding decisions are largely heuristic in nature since they are generally made based on experience, judgement and perception, therefore, any model or system should focus on supporting, rather than replacing the judgments and perceptions of the decision makers. Raftery (1991) takes this a stage further by commenting that the problems of bidders will not be solved until there is a comprehensive decision support model which can capture the full complexity of the situation.

4.2.4 Reliability of bidding models

One conclusion reached by Engelbrecht-Wiggans (1980) is that bidding models have seldom been analysed for their robustness with the question of how much small changes in the model affect the analysis and resulting conclusions. King and Mercer (1988) also stress in their review the need for developing models that are reliable to assist those pricing contracts. This shortcoming has also been recognized by Skitmore (1990) who points out that the biggest emphasis in estimating research (of which bidding forms a part) today is in the reliability of the techniques used. He also comments that statistical probability offers the greatest potential for modelling reliability.

4.3 Modelling competitiveness in bidding

Much of bidding research is concerned with modelling bidding behaviour by considering competitiveness relationships. Baker and Hart (1989) identify that competitiveness can be modelled at national, industry, company and product level and can be measured using profit ratios, sales measures, market share and export growth. Over recent years a multitude of techniques for modelling competitive behaviour have been proposed. Pearce and Robinson (1991) have developed a reference guide describing various general competitiveness analysis techniques available to managers.

Competitiveness in bidding can be modelled by analysing (1) entire bid distributions, (2) competitiveness within bids and (3) competitiveness between bids.

4.3.1 Modelling entire bid distributions

Studies on the distribution of bids by various researchers have produced conflicting results. In a survey undertaken by Skitmore (1988) it was found that out of 29 studies the distributions produced were: normal (9), lognormal (7), uniform (4), gamma (3), positively skewed (3) and other types (3). Beeston (1983) suggests that a typical distribution of competitive tenders for the same contract is almost symmetrical. 'There is a very slight skewness to the right (ie. negatively skewed) but this is so small that it can for practical purposes be ignored' (Beeston 1983: 110). He also acknowledges that the degree to which the distribution is positively skewed will give an indication of the bidders' competitiveness, with a greater positive skew indicating greater competitiveness. Skitmore (1987b) concurs with this latter point. De Neufville et al (1977) and Skitmore (1982) found a competitive relationship between the number of bids and market conditions but have proposed no model.

4.3.2 Modelling competitiveness within bids

With respect to modelling competitiveness within bids, Skitmore (1981), Fuerst (1977) and Rothkopt (1980) suggest that a model containing both a variable cost estimate and mark-up is a more realistic model than models in which either both or one of the variables is fixed. Much of the literature (starting with Friedman, 1956) is devoted to developing suitable bidding strategy models which focus on setting the mark up level to a value that is likely to provide the best pay-off.

The majority of bidding strategy models are based on statistical theory and a pure theoretical approach using historical data to assess the probability of winning the job with a given amount assuming that competitors will follow the same bidding patterns in the future that they have followed in the past. They differ from one another either in the way of calculating the profit or in the mathematical form of determining the probability of beating a specific competitor and how to combine these probabilities to determine the probability of winning. The models have developed from single variable (eg. Friedman 1956) to multivariate (eg. Broesmer 1968).

4.3.3 Modelling competitiveness between bids

Modelling competitiveness between bids is concerned with analysing the bidding performance of bidders by considering the relationship between bids submitted by bidders in competition with each other. Benjamin (1969) found that the identities of contractors vary with the type and size of project, location and client. When modelling competitiveness longitudinally according to type, McCaffer (1976) found that there are occasions when contractors who in the long term have equal shares of high and low bids have phases of varying length when they display a run of low or high bids.

Thorpe and McCaffer (1991) see no generally accepted way of quantifying the effect of market conditions on tender price levels. McCaffer et al (1973) demonstrated that changes in tender prices in response to market conditions could be modelled using regression techniques.

4.4 Measuring competitiveness in bidding

Competitiveness in construction contract bidding can be measured using discrete or continuous scales. Discrete scales, such as nominal or ordinal, are regarded as lower order scales in that only the frequency or percentage in predefined competitiveness categories can be determined; with ordinal scales only the competitiveness order is known. However, with continuous scales both the order and distance between competitiveness values are known. Of the two continuous scales the ratio scale has an advantage over the interval scale that the competitive values are absolute rather than relative. By beginning at absolute zero, ratio scales have absolute rather than relative quantities therefore comparisons of absolute magnitude can be made (eg. a bidder with a competitiveness value of one is twice as competitive as a bidder with a competitiveness value of two).

This thesis focuses on comparing the bidding performance of bidders. For most practical purposes it is sufficient to consider the bids in relation to a baseline. Baselines include the designer's estimate, a bidder's baseline estimate, or the mean, median or lowest of the bids entered for a contract.

Apart from being based on an interval scale rather than a ratio scale, using the designer's estimate as a competitiveness baseline has the disadvantage that the information sources on which the estimate is based is likely to be historical rather than current, making it not so responsive to changes in market conditions (De Neufville et al 1975). Also the technique used in determining the bid is likely to be different from that of the bidders.

Using baseline estimates of different bidders as a competitive baseline has the disadvantage that the contents of various bidders' baseline estimates and mark-ups is likely to be based on different sets of inclusions and exclusions. Also since the breakdown of bids is regarded by most bidders as confidential, it is quite likely that most bidders in the sample will be reluctant to co-operate in comparative studies of this nature. Using the mean or median bid entered for a contract suffers from the disadvantage that it does not provide a maximum (or minimum) level of competitiveness and as such can only be measured using an interval scale.

The lowest bid represents the maximum level of competitiveness and can, therefore, be measured on a ratio scale. All competitiveness values will be absolute and also easier to understand since all values will be positive (or negative). There are good theoretical reasons for assuming that the expected value of the winning bid is equal to the true value of the contract (eg. Milgrom 1981, Wilson 1979). Beeston (1983) is of the opinion that it should be practicable to improve bidding performance by studying one's own results in relation to the winning bid which can be assumed to be the lowest bid.

4.4.1 Competitiveness measures used by Flanagan and Norman (1982b)

Since this research sets out to develop a study undertaken by Flanagan and Norman (1982b), each of the competitiveness measures used in Flanagan and Norman's study is now considered in detail. Flanagan and Norman (1982b) measured the competitiveness of each bidder in terms of success rates ie.

$$S = 100(s/n) \qquad (4.1)$$

where

S = success rate

s = number of successes

n = number of bidding attempts

A higher percentage denotes a higher success rate and vice versa.

Competitors' bids were also expressed by Flanagan and Norman as a percentage relative to the bidder's bid ie.

$$C = 100(c-x/x) \qquad (4.2)$$

where

C = measure of competitiveness

c = competitor's bid

x = bid value entered by the bidder

Greater negative values indicate greater competitiveness and vice versa, except in those cases where the bidder's bid is the lowest bid. In these instances no negative values are generated and therefore zero becomes the greatest competitiveness value.

This measure is used to analyse the bidding performance of each bidder in competitions in which the bidder had made a bidding attempt. Flanagan and Norman (1982b) presented this measure diagrammatically in their paper (see Figure 4.1). Each contract where the bidder had made a bidding attempt is consecutively numbered and shown separately on the x axis. Each dot on the graph represents a bid by a competitor. The bidder's bid line is drawn at zero percent. Negative percentages are classed as low bids and positive percentages are classed as high bids.

A measure of bid variability within the bidding distribution is determined by using the coefficient of variation resulting from the aggregate mean percentage bidding range for each of bidder. This is expressed as:

$$R = 100(h-l/l) \qquad (4.3)$$

where

R = mean percentage bidding range

h = high bid

l = low bid

In the next chapter, which describes the methodology used in developing Flanagan and Norman's study, these measures are compared with an alternative preferred measure of competitiveness.

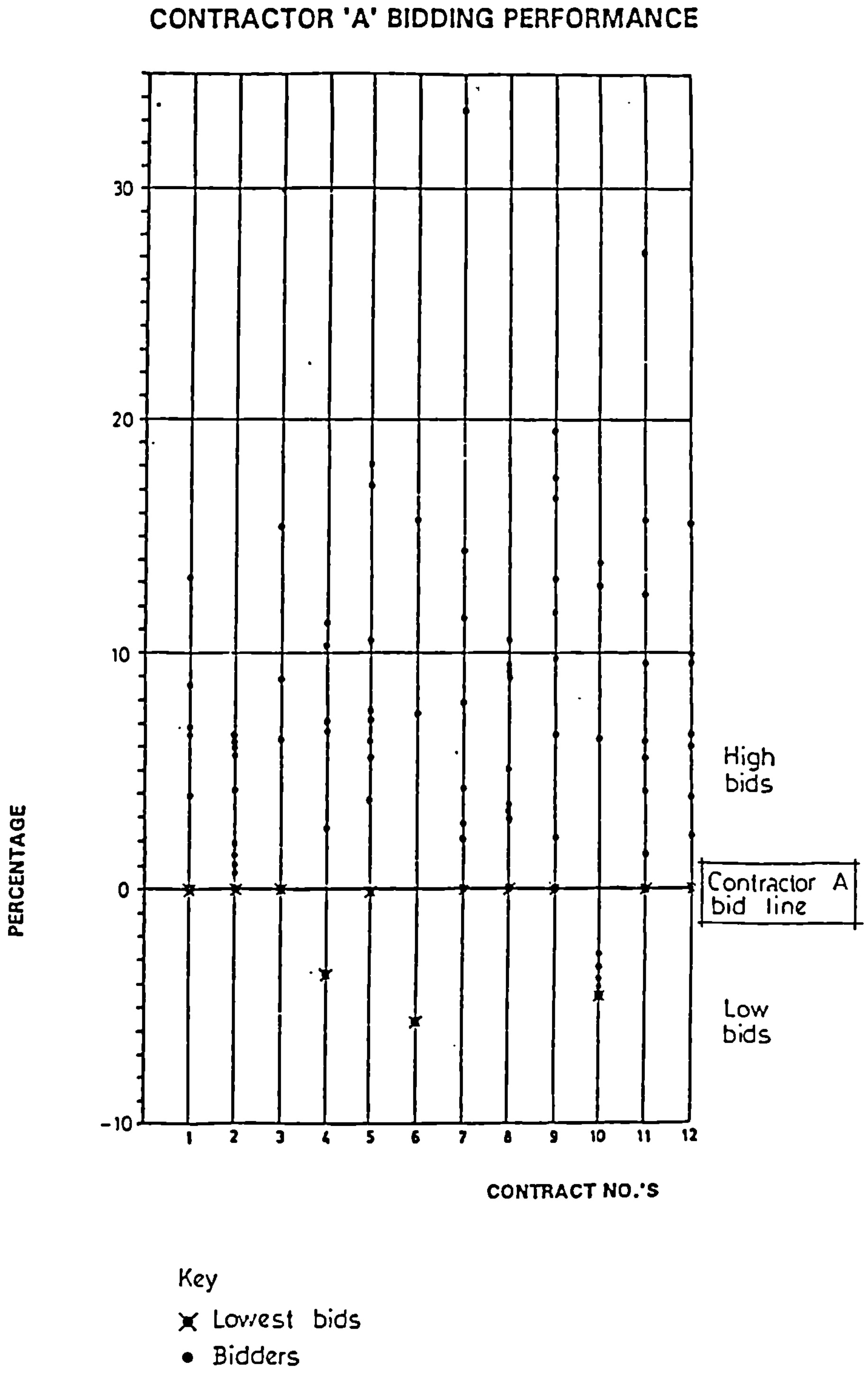


Figure 4.1: Bidding performance of contractors (Flanagan and Norman 1982b)

4.5 Summary

Although the subject of competitive bidding has attracted investigation and research by both contracting companies themselves and a variety of academics, disappointingly the results of these investigations and efforts to remove some of the uncertainty are far from conclusive. There appears to be a gap between theory and reality and bidding models do not seem to be much used or considered outside research circles. It is certainly difficult to build and exploit models of bidding situations that are realistic, relevant and useful to those making the key decisions and conclude that there is surprisingly little progress towards a generally agreed approach which is practical and relevant in a range of situations. It appears that the failure, weaknesses and limitations of bid models stem from the complexities and uncertainties inherent in the bid process itself. Part of the problem lies in the fact that many factors, other than pure economic, are considered in bidding strategy decisions.

Much of bidding research is concerned with modelling bidding behaviour by considering competitiveness relationships. Competitiveness in bidding can be modelled by analysing (1) entire bid distributions, (2) competitiveness within bids and (3) competitiveness between bids.

Modelling competitiveness between bids is concerned with analysing the bidding performance of bidders by considering the relationship between bids submitted by bidders in competition with each other. This thesis focuses on comparing the bidding performance of bidders. For most practical purposes it is sufficient to consider bids in relation to a baseline. Baselines include the designer's estimate, a bidder's baseline estimate, or the mean, median or lowest of the bids entered for a contract. Of these measures the lowest bid appears to be the best measure of competitiveness. The lowest bid represents the maximum level of competitiveness and can, therefore, be measured on a ratio scale. All competitiveness values will be absolute and also easier to understand since all values will be positive (or negative). There are good theoretical reasons for assuming that the expected value of the winning bid is equal to the true value of the contract (eg. Milgrom 1981, Wilson 1979). It should be practicable to improve bidding performance by studying one's own results in relation to the winning bid which can be assumed to be the lowest bid.

Having reviewed previous empirical studies and various approaches to modelling competitiveness in bidding, the next chapter describes the methodology that was used in this work to model competitiveness.

PART 2

EMPIRICAL WORK

CHAPTER 5

Methodology

5 METHODOLOGY

5.1 Introduction

This research is based on a study undertaken by Flanagan and Norman (1982b) which examines the effect of contract type, contract size and bidder size on contractors' bidding performance. This particular study was chosen as the starting point for the research over other studies because it is considered to be the closest study that examines the principal variables of interest. The overall approach to the methodology is to replicate and develop this study. Replicating the study permits direct comparisons to be made and provides a platform on which to develop the work.

The methodology used to fulfil the aims and specific objectives of this research is set out in three sections. The first section compares the measures of competitiveness and variability in bidding used by Flanagan and Norman (1982b) with an alternative preferred measure which is used in developing Flanagan and Norman's study. The second section describes the method taken to classify the bidding behaviour according to competitiveness and variability. The data and regression methodology used to model the effect of contract type, contract size and bidder size on competitiveness are described in the third section.

5.2 Measuring competitiveness and variability in bidding

The competitiveness measures used by Flanagan and Norman (1982b), described in the previous chapter, are used for the purposes of replicating Flanagan and Norman's study using Hong Kong data. In developing Flanagan and Norman's study a preferred alternative competitiveness measure is offered. Competitiveness (C), is measured by the ratio of lowest bid to bidder's bid ie.

$$C = x_{(1)}/x \tag{5.1}$$

where

C = measure of competitiveness

x = bid value entered by an individual bidder

$x_{(1)}$ = value of lowest bid entered for the contract

Maximum and minimum competitiveness are respectively constrained between one and zero[1].

Each bidder's mean competitiveness (C') is determined from a series of past competitions. Bidding variability is measured using the standard deviation (C"). Smaller standard deviations indicate smaller variability in bidding (and, therefore, greater consistency) and vice versa.

This measure of competitiveness has an advantage over Flanagan and Norman's measure shown in Equation 4.1 in that it is a continuous variable on a ratio scale. Both the order and distance between competitiveness values is known. Success, however, is a discrete variable and success rates are based on variables produced from a nominal scale. Therefore the distance between values, in terms of competitiveness, is not known.

This measure of competitiveness also has a number of advantages over Flanagan and Norman's measure as shown in Equation 4.2. First, it is easier to calculate. Second, all the values are positive with higher ratio values indicating greater competitiveness and vice versa. Third, the competitiveness baseline is set at the maximum level of competitiveness, a level common to all bidders. Fourth, as the scale is logarithmic (ie. the log of this variable will be the same as log $x_{(1)}$ - log x), competitive differences will become more pronounced nearer unity, the end of

[1]It should be noted that zero is a theoretical minimum. In reality no bidder would be able to obtain this value as the bidder's bid would have to be approaching infinity.

the scale which is likely to be of greatest interest (ie. maximum competitiveness) [2]. The logarithmic scale will also dampen any possible non-constant variance (non-constant variance, or heteroscedasticity as it is otherwise known, constitutes a regression assumption violation). Fifth, it is more adaptable to transformation; log transformations can be used since there will be no zero values and arcsin transformation can be used since the scale is between one and zero. Sixth, both competitiveness and variability in bidding can be derived from the same measure, thus eliminating the need to use a separate measure of bid variability shown in Equation 4.3.

5.2.1 Classifying bidders according to competitiveness and variability in bidding

By considering C' together with C" various classes of bidding behaviour can be measured and represented cross-sectionally (see Figure 5.1). The more competitive bidders ie. bidders who attain higher C' values are likely to have submitted the greatest proportion of serious bids in previous competitions. Bidders with high C' and low C" values represent (from the client's viewpoint) sensible bidders, as they are consistently competitive. In contrast, bidders with high C' values but high C" values represent suicidal bidders as, besides being serious, they are also erratic - fatal behaviour in competitive bidding. Conversely bidders with low C' values and low C" values are non-serious as they are consistently uncompetitive. Consequently bidders with low C' and high C" values (termed silly here) are generally uncompetitive but erratic, not an uncommon characteristic in construction contract bidders. Although a rather crude and insensitive classification

[2]This phenomenon is illustrated in the following example: Given that maximum competitiveness is unity, in the case where the lowest bid is $10 million and the bidder's bid is $11 million, the competitiveness score is 0.91 (ie. a competitiveness difference of 0.09 per dollar difference $1 million); in the case where the lowest bid is $10 million and the bidder's bid is $20 million the competitiveness score is 0.50 (ie. a competitiveness difference of 0.50 per dollar difference of $10 million). The competitiveness difference per $1 million dollars in the latter case is only 0.05 as opposed to 0.09 as is shown in the former case.

system, this does have considerable intuitive appeal in reflecting the underlying pivotal characteristics of the actual behaviour of participants in competitive bidding environments.

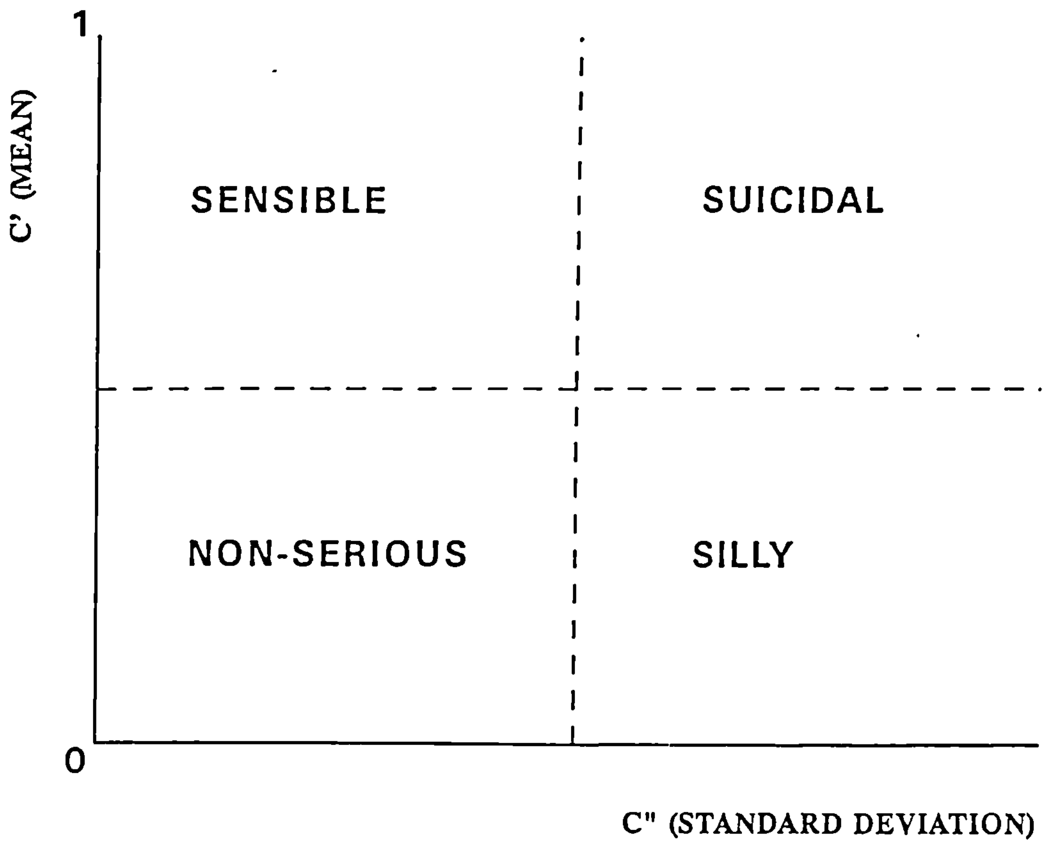


Figure 5.1: Classification of bidders according to competitiveness and consistency in bidding

This four-way classification - sensible, suicidal, non-serious and silly is important from the client's viewpoint. Sensible and non-serious are essentially low risk bidders, whilst suicidal and silly are essentially high risk bidders. Non-serious and silly on the other hand, are essentially high cost bidders. Which class of bidder is to be prequalified ultimately depends on the client's attitude to risk and cost trade-off. It is also important for bidders to be able to identify their competitors and themselves in terms of these classes.

A bidder's likely classification can be deduced according to discrete variables such as contract type, location or client. These variables can be analysed individually or, providing there is sufficient data, according to any desired combination. In this analysis, bidders' competitiveness toward contract type is analysed.

The dividing axes are based on the mean competitiveness (C') and standard deviation (C") of the bidders in the sample. The most frequent bidders, ie. those who bid ten times or more in the sample, were selected for analysis as it is considered that the results obtained would be more representative of their bidding behaviour.

5.3 Measuring the effect of contract type, contract size and bidder size on competitiveness in bidding using regression analysis

Although simple to apply, classifying the competitiveness of bidders according to different contract types purely on the basis of competitiveness and variability is limited in modelling competitive bidding behaviour. The predictive capability of such a classification system is unknown. In addition bidders' competitiveness in relation to contract size cannot be fully accounted for.

A major disadvantage of using this approach is that it does not account for different size contractors bidding for different ranges of projects. As demonstrated later in the analysis (see Table 6.1) smaller contractors are likely to attain smaller average bid values than large contractors. Since this measure of competitiveness will produce greater ratio differences for smaller contracts, it is likely to show smaller contractors to be less competitive than the larger contractors and also more variable in their bidding simply because they are more likely to have bid over a narrower range of smaller projects. One approach in reducing this problem may be to divide the contracts up into different bands of contract sizes and recalculate the competitiveness of bidders according to each contract size band. Eliminating this problem may be accomplished by modelling the competitiveness of bidders using regression analysis. One of the assumptions in using this technique is that the random error has a constant variance. If this assumption is violated the competitiveness model needs to be transformed in order to satisfy the assumption.

Since competitiveness and contract size are both continuous variables, a more comprehensive approach to modelling competitiveness cross-sectionally between bids, therefore, can be undertaken using multiple regression analysis. The effect of contract type, contract size and bidder size on competitiveness can be measured through building candidate models containing various combinations of predictor variables. These candidate models can then be examined systematically to find the model that best reflects competitiveness. Through the systematic building of candidate models in which the respective candidate model utilities are examined, the goal is to determine the best model that relates bidders' competitiveness (ie. the dependent variable) to the independent variables of bidder, contract type and contract size. By predicting the mean values and 95% prediction intervals the reliability of the best model can also be examined. The model's utility and reliability can then be used as a basis for testing future refinements.

The regression analysis in this research has followed the standard approach viz.

(1) data preparation and entry;
(2) development of models;
(3) selection of best model and predictor variables;
(4) transforming the model to satisfy regression assumptions;
(5) model verification, prediction and reliability.

5.3.1 Data preparation and entry

Data from tender reports were collected from the Architectural Services Department, Hong Kong Government on the basis of Flanagan and Norman's study (Flanagan and Norman 1982b) and split into 5 contract types, ie. fire stations, police stations, primary schools, secondary schools and hostels, according to CI/Sfb classification as described earlier.

5.3.1.1 Public sector data

Using data from the public sector instead of private sector has the advantage that the design and specification of construction work and contracts procedures are likely to be more standardised. Pressures of public accountability also give rise to bidding procedures, particularly prequalification and award of contract procedures, being more formalised and consistent.

In respect of the data source itself, the Architectural Services Department is one of Hong Kong's largest construction employers. This enables sufficient bidding data to be generated by one client instead of a variety of smaller clients, thus eliminating the 'noise' effects of contractors having varying degrees of preference towards different clients.

5.3.1.2 Data sample

Flanagan and Norman's study is based on a sample of 39 contracts let between 1973 and 1980 for a county council located in southern England. Data from 190 tender reports were collected in Hong Kong from the Architectural Services Department of the Hong Kong Government for the period 1981 to 1990 on the basis of Flanagan and Norman's study (ie. all projects were (a) for one sector, the public sector, (b) were of similar building type: mainly schools, fire and police stations and hostels, (c) were in the same geographical region).

The criterion for part (a) was straight forward to comply with as all the data collected came directly from the Architectural Services Department of the Hong Kong Government. As Hong Kong comprises only approximately 400 square miles, projects undertaken anywhere in Hong Kong have been interpreted as being in the same geographical region, thereby satisfying part (c) criterion.

5.3.1.3 Contract type definition

The terms used that make up similar building types as indicated in the part (b) criterion are interpreted for the purposes of this research as follows :

'School' is interpreted to exclude post secondary institutions, which are commonly given the title of colleges, polytechnics or universities, and pre-primary which are also known as kindergarten and nurseries. Schools therefore conveniently subdivide into primary and secondary.

'Fire and police stations' have been taken to exclude ambulance facilities. The collective term of protective services can be used to describe this set of data. Data were also collected on police recreation and training facilities but later rejected on the grounds that these fall outside the ambit of stations and therefore are excluded from the research.

In the classification of building type, the term 'hostel' appears vague in its meaning. It has been defined as 'house of residence for students or other special class' (Sykes 1978). Also as 'house or extra-collegiate hall for the residence of students; a place of residence not run commercially' (Hayward and Sparkes 1986). The Construction Index Samarbetskommitem for Byggnadsfrager (CI/Sfb) classifies hostels as embracing YMCA, youth hostels and halls of residence (Ray-Jones and Clegg 1976).

The term hostel could, therefore, be defined in the narrower sense and meaning of house/hall of residence for youth/students. Equally it could be interpreted in its broader sense to mean a place of 'residence for other special class; not run commercially'. As no data could be found on the narrower interpretation it was decided to define hostel for the purposes of this research in its widest sense.

Data on the following types of project have therefore been included in the hostel category:

(1) Girls' home;
(2) Sheltered home;
(3) Halfway house;
(4) Refugee camp;
(5) Holiday camp (non-profit making);

(6) Military married quarters;

(7) Civilian quarters (i.e. fire, police, ambulance, prison and railway).

5.4.1.4 Contract type classification

The contract title given in the tender report was used as the basis for classifying the building type. The contracts have been classified into contract types according to the CI/Sfb building type classification (Ray-Jones and Clegg 1976), except hostels which have been grouped as dwellings for special class of user. The contracts are therefore classified into five contract types (ie. fire stations, police stations, primary schools, secondary schools and hostels). Table 5.1 shows the contract type breakdown based on the CI/Sfb classification.

CI/Sfb code	Contract type	No. of Contracts	
		Sub-total	Total
	Protective Services Facilities		
372	Fire stations	29	
374	Police stations	43	72
	Educational Facilities		
712	Primary schools	29	
713	Secondary schools	39	68
	Residential Facilities		
848	Dwellings for special classes of user	50	50
		TOTAL	190

Table 5.1: Contract type breakdown based on CI/Sfb building type classification

It should be noted that some of the projects contain a mixture of more than one type. These hybrid projects were classified according to which type had the largest percentage of the bid value. For example for projects comprising both fire station and ambulance facilities, the fire station contained the greater percentage of bid value therefore these projects were classified under fire stations.

5.3.1.4.1 Further classification according to contract type and contract size

To obtain a better understanding of the data, mainly for purposes of interpreting the analysis, the data are further sub-divided according to the wording of the contract title in an attempt to account for the nature of work (ie. new and alteration work) and also to account for possible contract size differences.

An important aspect to consider under the contract type classification is the type of work, that is to say whether work is new work or alteration work such as extension, refurbishment or completion. If the project title contains the words 'construction of', this was classified as new work. Project titles containing the words 'extension of', 'alterations and extension of', 'addition of', 'restoration of', 'improvement of', 'refurbishment of', 'conversion of', 'alteration of' and 'reprovisioning of' were grouped under the title of alterations. Due to one bidder becoming insolvent there is also one completion contract. This contract has also been grouped under alterations.

It is also possible to use the contract title to break down the contracts in terms of contract size. For example, there were some multi-school contracts. These contracts have been sub-divided according to the number of schools included in the contract. Police stations comprised three distinct sizes viz, a police substation, police station and headquarters including police station. For the hostels category, it was not possible to divide the projects according to the number of dwelling units as this information was missing from the majority of project titles. However, these have been subdivided into military quarters, protective services quarters and miscellaneous. Table 5.2 gives a further contract breakdown according to nature of work and contract size as suggested by the title.

Contract type	No. of Contracts			
	New Work	Alteration	Sub-Total	Total
Fire Station				
Fire station and ambulance depot	5	0	5	
Fire station	22	2	24	29
Police				
Police substation	1	0	1	
Police station	17	18	35	
Police headquarters incl. police station	6	1	7	43
Primary				
One primary school	23	6		
Secondary			29	29
One secondary school	21	4	25	
Two secondary schools	11	0	11	
Four secondary schools	1	0	1	
Two secondary and one primary school	1	0	1	
One secondary and one primary school	1	0	1	39
Hostel				
Miscellaneous; girls home, sheltered home, halfway house, refugee and holiday	4	2	6	
camp	13	9	22	
Military, police and fire services residential quarters	20	2	22	50
TOTAL	146	44		190

Table 5.2: Further contract type breakdown according to new and alteration work

5.3.1.5 Bidder coding

The sample contained 2395 bids from a total of 192 bidders. Each bidder was assigned a code to preserve confidentiality. In the coding process it was found that one bidder was not eligible to tender for Government work and therefore was omitted from the sample. Also one bidder (bidder coded 13) had changed names to bidder coded 14. All bids for this bidder were, therefore, credited to bidder coded 14.

5.3.1.6 Bidder size classification

The size of bidder measure in Flanagan and Norman's study is determined according to area of operation, ie. small bidder is defined as working within approximately a 20 mile radius of the *county town*, medium bidder is defined as operating throughout the *county* and large bidder is defined as operating throughout the *country*.

Given that Hong Kong only comprises approximately 400 square miles, it is not really feasible to adopt these measures. Since Flanagan and Norman's rationale behind the bidder size measure is that 'in most instances they would be tendering in different project value ranges' the measure of bidder size adopted in this analysis is based on Hong Kong Government classification.

The Hong Kong Government maintains a list of approved bidders which are classified as Group A, B or C depending on their experience and financial status. The financial criterion for entry or promotion into a Group is according to the minimum employed capital. This varies from $1.1 million for Group A contractor to $4.7 million for Group C contractor (Walker and Rowlinson 1991). The maximum value of works for which approved contractors may tender is $6 million, $30 million and unlimited for Groups A, B and C respectively.

For analysing bidding performance according to bidder size, bidders are classified into these size groupings according to Government criteria (i.e. Group A: up to HK$6 million (small), Group B: up to HK$30 million (medium), Group C: unlimited (large)).

It should be noted that when classifying bidders according to this size, 18 bidders received reclassification changes during the period in which the data were collected. Eight bidders were promoted from Group A to Group B and eight from Group B to Group C. One bidder was promoted from Group A to Group B before moving into Group C. One bidder was demoted from Group C to Group A. The bidders for these cases have been split into the small, medium and large bidder size groupings according to when the bid was submitted. For example bidder 115 had 32 bidding attempts in the sample of which 30 were as a Group B contractor and 2 as a Group C contractor. The bids from this bidder have been split into the respective size groupings.

The number of bids breakdown in the sample based on this measure is 183 from Group A, 1144 from Group B and 1068 from Group C.

5.3.1.7 Alternative measures of bidder size

Apart from classifying the size of bidders according to the above Government criteria, there are a variety of potential measures that can and have been used to measure the size of a bidder. These can be classified into financial and non-financial measures.

Financial measures, based on definitions used by Hong Kong Government (1991), include:

(1) Fixed assets;

(2) Net assets ie. (Fixed assets + Investments + Current assets) less (Current liabilities + minority interests + long term liabilities);

(3) Working capital ie. Current assets - current liabilities;

(4) Turnover ie. Gross value of work performed;

(5) Gross profit ie. Total payments from clients or other sources less direct costs which include all project overheads.

A measure of bidder size can also be determined by considering the size of contracts recently undertaken by the bidders (eg. Russell and Skibneiwski 1990) such as:

(1) Average contract size;

(2) Largest contract performed in past five years (as main contractor);

(3) Smallest contract performed in past five years (as main contractor).

Non-financial measures (Hong Kong Government 1991) include:

(1) Number of active sites as main contractor;

(2) Number of persons directly engaged;

(3) Number of manual workers engaged excluding subcontractors;

(4) Number of manual workers engaged including subcontractors;

(5) Total annual completed floor area (m^2) for new work (as main contractor).

Data on alternative measures of bidder size were sought from Government sources. The data source (ie. Architectural Services Department, Hong Kong Government) was approached for this information. They stated that they did not have this information and suggested contacting two other Government departments, namely the Department of Census and Statistics and also Business Registration Department. Both Departments refused to disclose any information relating to an individual company on the grounds of confidentiality.

Although data on other bidder size classifications could have been collected, for example, by developing a questionnaire on bidder size measures directed at the bidders themselves, it was decided to base the analysis concerned with measuring the effect of bidder size solely on the bidder size classification according to Government criteria. The decision to do this was influenced by the work of Hillebrandt and Cannon (1990: 11) who, in describing changes in the construction industry (which includes the increasing use of subcontracting), comment 'one of the consequences of these changes is that there is no satisfactory measure of the size of firms in the construction industry since neither numbers employed nor turnover necessarily represent the amount of work actually carried out'.

5.3.1.8 Updating

The bids were updated to a common base date (September 1990) based on tender price indices published by the Architectural Services Department, Hong Kong Government.

5.3.2 Development of models

The development of candidate models and selection of the best model used here are based on a chunkwise approach[3]. Candidate models using different chunk combinations of predictor variables are built and the effect on competitiveness determined for each candidate model. The candidate models are then systematically compared using a forward chunkwise sequential variable selection algorithm based on the F test (see next section for detailed explanation) to find the best model (ie. chunk combination) that reflects competitiveness.

5.3.2.1 Rationale behind selecting the chunkwise approach

The rationale for selecting the chunkwise approach over other approaches is as follows:

(1) all subsets regression is too long winded, as to compare the 7 candidate variables could have produced up to $2^7 = 128$ models and up to 128! combinations to compare for each added bidder;

(2) the forward sequential technique is chosen as this approach begins with the simplest model to which additional candidate variables are progressively

---

[3]Detailed explanations of this approach can be found in most intermediate texts on regression analysis such as Klienbaum, Kupper and Muller (1988) or Kelting (1979).

added and tested to find the best predictor variables;

(3) the chosen technique allows a measure of control and rationale over the sequence of predictor variables so that the influence of each chunk of predictor variables can be measured rather than relying on a technique such as stepwise regression in which all theoretical considerations are removed;

(4) the chunkwise technique for selecting variables has substantial advantages over single variable selection techniques. The chunkwise method allows sets of variables for which there is prior scientific knowledge and preferences to be incorporated into the analysis. If a chunk test is not significant and the entire chunk of variables is deleted, then clearly no tests on individual variables in that chunk are carried out. Kleinbaum et al (1988: 328) state that 'in many situations such testing for chunk significance can be more effective and reliable than testing variables one at a time'.

5.3.2.2 Contract size

Contract size (S), a quantitative independent variable, has been expressed in terms of contract value. A quadratic term for this variable was added to allow the regression line to reflect possible economies of scale between contract size and bidder size. Relationships between competitiveness and contract size can be observed by plotting the value of bids entered in past competitions against the competitiveness measure (ie. Equation 5.1) with bidder's bid plotted at the lowest bid value[4]. Curvilinear regression analysis can be used to determine the line of

---

[4]The bid values that make up a bidding distribution, when plotted against competitiveness and contract size, will follow a straight line relative to the lowest bid. If the bids are plotted according to each bid value, the line will not be perpendicular. This is because smaller contracts will produce greater ratio differences between values (eg. a small contract which has a bid of $2 million and a lowest bid of $1 million will generate competitiveness of 0.5 for a contract size difference of $1 million; a large contract which has a bid of $110 million and the lowest bid of $100 million will generate competitiveness of 0.91 for a contract size difference of $10 million). The slopes of the bidding distributions will, therefore, become progressively oblique as the contract size increases. To eliminate this sloping effect and maintain perpendicularity all bidding attempts need to be and have been plotted at the point of the lowest bid.

best fit (eg. Figure 5.2).

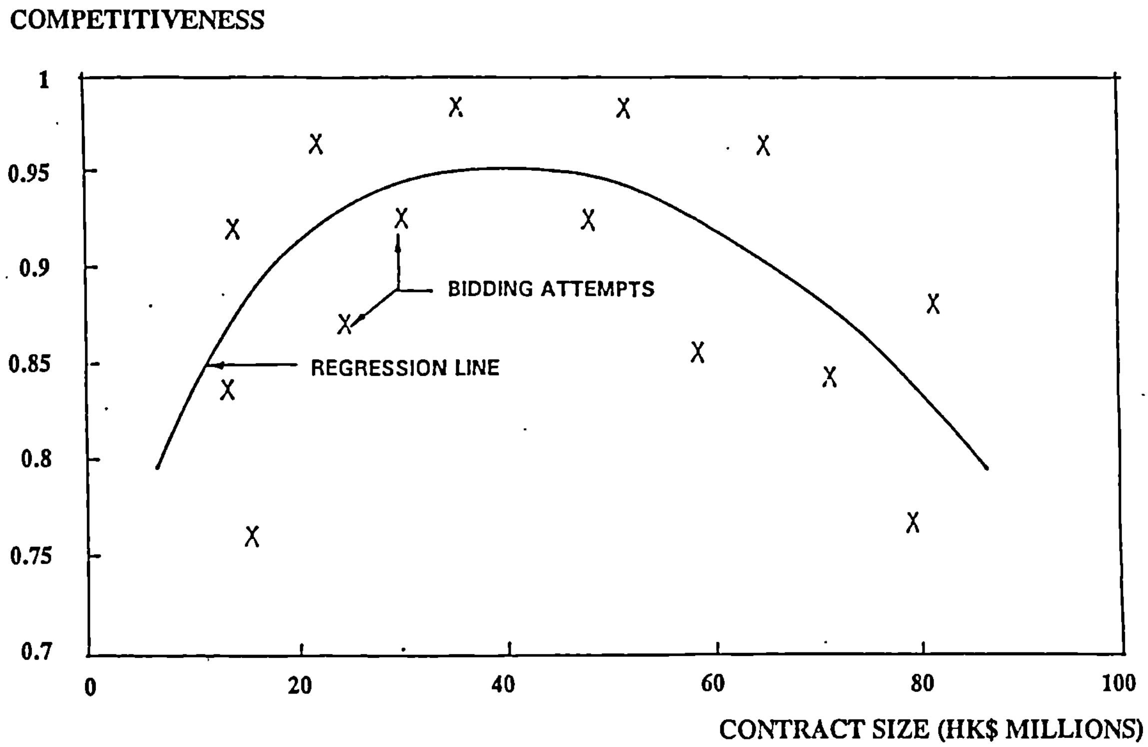


Figure 5.2: Competitiveness and contract size

Assuming the regression line represents a bidder's true competitiveness / contract size relationship, then the bidder is most competitive where the regression line is furthest from the X axis, ie. at the peak of the regression line. The corresponding contract value at this point represents the bidder's preferred contract size. Smaller bidders are expected to have smaller preferred contract sizes than large bidders.

A shallow mesokurtic regression curve indicates a wide preferred size range. Conversely, a leptokurtic regression curve indicates a narrow preferred range. Small bidders are expected to have a narrower preferred size range than large bidders due to obvious resource constraints. Thus it is anticipated that the regression curves of increasing size contractors will become more mesokurtic and shift to the right as illustrated in Figure 5.3.

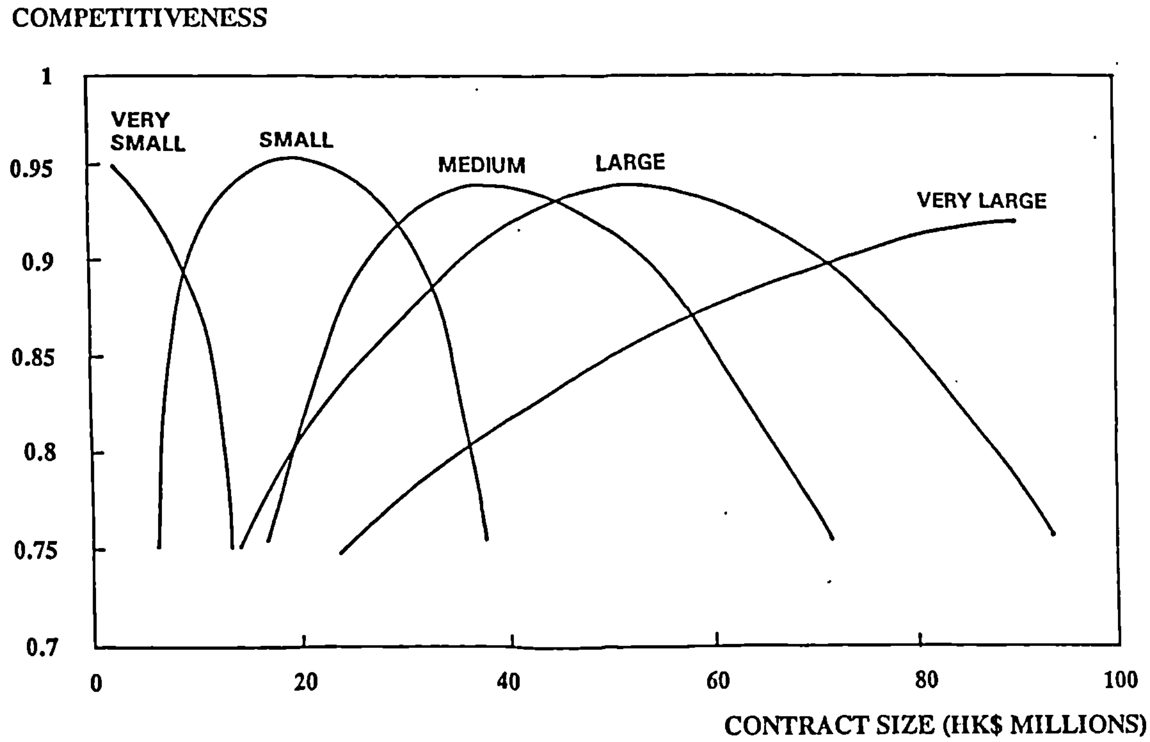


Figure 5.3: Competitiveness and bidder size

The notion that bidders have preferred size ranges implies that the shape of the regression line will be convex, for no matter how small or large the contractor is in size, in terms of contract size there will be upper and lower limits at which a bidder is competitive. At these limits a bidder's competitors should become relatively more competitive thereby increasing the slope of the regression line, suggesting the quadratic functions shown.

Although it is expected that the shape of the regression line will be convex, this may not always be the case and a concave curve may be due to the existence of any one or some combination of the following:

(1) two or more preferred size ranges;
(2) weak or no preferred size range;
(3) confounding effects of other preferences, eg. location;
(4) 'noise' effects caused by random fluctuations in bidding;
(5) sampling effects eg. lack of data, spurious data and outliers.

It should be noted that the inclusion of a quadratic term into the equation places an important limitation on the use of prediction equations. The model will only be valid over the range of x values that were used to fit the model (Mendenhall and McClave 1981).

One way of assessing the extent to which a contract size equates to the preferred size range is to measure the slope of the regression line at a given value. The shallower the slope, the closer the value is to the contractor's absolute preferred size (ie. the point where the regression line produces a horizontal tangent). The steeper the slope the further away the value is from the contractor's preferred size.

It also follows that the steeper the regression line the greater is the influence of contract size on bidding performance as the preferred size range will be smaller (see Figure 5.4)

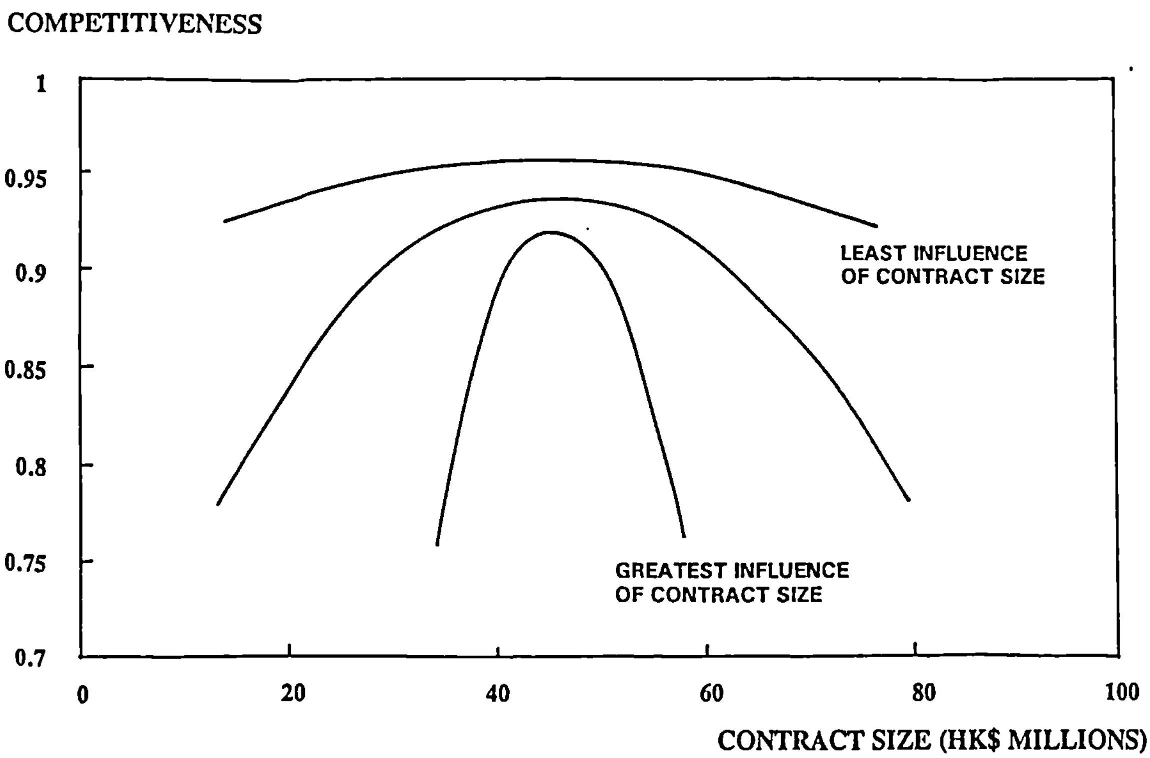


Figure 5.4: Degree of influence of contract size

The convex slope of the regression line is expressed by the equation:

$$Y = - ax^2 + bx + c$$

By differentiating the equation the slope of the line can be determined. Therefore the differential:

$- 2ax + b$

indicates the slope of $- 2a$.

The influence of contract size on bidding performance can be measured by considering the coefficient for the x squared term. The larger the coefficient the steeper the slope of the regression line and thus the greater the correlation between contract size and competitiveness.

In respect of size of contractor, due to the influence of resource constraints, smaller bidders should have smaller preferred size ranges than larger bidders and therefore larger coefficients for the x squared term.

5.3.2.3 Contract type and bidder

Contract type (T) and bidder (B) are both qualitative variables. A single prediction equation for each bidder and type can be found through the standard procedure of using dummy variables.

5.3.2.4 Building the candidate models

A chunk of predictor variables is required for each independent variable (ie. S, T, B). A chunk of predictor variables is also required for each of the corresponding two-way interactions (ie. ST, SB and TB) and three-way interaction (ie. STB). Candidate models comprising up to seven chunks of predictor variables are therefore considered. A total of 22 candidate models were developed according to different chunk combinations (see Figure 5.5). The candidate models vary from the simplest model (model 1) based on the sample mean to the seven chunk model (model 22) which is taken to be the saturated model.

Model No.	No. of Chunks in Model	Chunk Combination
1	0	$\bar{y}$
2	1	S
3	2	S + T
4	2	S + B
5	3	S + T + ST
6	3	S + B + SB
7	3	S + T + B
8	4	S + T + B + ST
9	4	S + T + B + SB
10	4	S + T + B + TB
11	4	S + T + B + STB
12	5	S + T + B + ST + SB
13	5	S + T + B + SB + TB
14	5	S + T + B + TB + ST
15	5	S + T + B + STB + ST
16	5	S + T + B + STB + SB
17	5	S + T + B + STB + TB
18	6	S + T + B + SB + ST + STB
19	6	S + T + B + SB + BT + STB
20	6	S + T + B + BT + ST + STB
21	6	S + T + B + BT + SB + ST
22	7	S + T + B + BT + SB + ST + STB

where :

$\bar{y}$ = sample mean   T = contract type
S = contract size   B = bidder

The regression coefficients contained within these chunks are as follows:

1. S : $b_1x + b_2x^2$
2. T : $b_3T_1 + b_4T_2 \ldots b_nT_n$
3. B : $b_5B_1 + b_6B_2 \ldots b_nB_n$
4. ST : $b_7T_1x + b_8T_1x^2 + b_9T_2x + b_{10}T_2x^2 \ldots b_nT_nx + b_nT_nx^2$
5. SB : $b_{11}B_1x + b_{12}B_1x^2 + b_{13}B_2x + b_{14}B_2x^2 \ldots b_nB_nx + b_nB_nx^2$
6. TB : $b_{15}B_1T_1 + b_{16}B_2T_1 + b_{17}B_1T_2 + b_{18}B_2T_2 \ldots b_nB_nT_n$
7. STB : $b_{19}B_1T_1x + b_{20}B_1T_1x^2 + b_{21}B_2T_1x + b_{22}B_2T_1x^2 + b_{23}B_1T_2x$
$b_{24}B_1T_2x^2 + b_{25}B_2T_2x + b_{26}B_2T_2x^2 + \ldots b_nB_nT_nx + b_nB_nT_nx^2$

where :

x = contract size T_1 = contract type 1 B_1 = bidder 1
T_2 = contract type 2 B_2 = bidder 2
T_n = contract type n B_n = bidder n

Figure 5.5: Proposed candidate models for individual bidders

5.3.2.4.1 Main effects

As can be seen in Figure 5.5 there are three main effects terms, one for each independent variable. The main effect for contract size will comprise two coefficients due to the inclusion of the quadratic term. There will also be one main effect term for every bidder and contract type included in the equation. The model containing the main effects for one bidder and one type is as follows:

	(Main effect for S)	(Main effect for T)	(Main effect for B)
$C(y) = B_0$	$+ B_1x_1 + B_2x_1^2$	$+ B_3x_2$	$+ B_4x_3$

5.3.2.4.2 Interaction effects

Since there are three main effects terms there will be three two-way interaction terms and one three-way interaction terms. For a 3 variable saturated model all possible two way and three way cross products of the variables need to be included. The two way and three way interaction terms which include contract size (S) will require two sets of coefficients due to the inclusion of the quadratic term. In addition there will also be one two-way interaction term for the qualitative variables of bidder and contract type. The main effects and interaction terms for a saturated model containing one bidder and one type is as follows:

	(Main effect for S)	(Main effect for T)	(Main effect for B)
$C(y) = B_0$	$+ B_1x_1 + B_2x_1^2$	$+ B_3x_2$	$+ B_4x_3$

(Interaction effect for ST)	(Interaction effect for SB)
$+ B_5x_1x_2 + B_6x_1^2x_2$	$+ B_7x_1x_3 + B_8x_1^2x_3$

(Interaction effect for TB

(Interaction effect for STB)

$+ B_9x_2x_3$ $\quad + B_{10}x_1x_2x_3 + B_{11}x_1^2x_2x_3$

For every new contract type or bidder introduced into the equation there will be one main effect term, two two-way interaction terms (ST and TB for contract type or SB and TB for bidder) and one three-way interaction term (STB) will be created and added to the equation making a total of six coefficients ie.

(Main effect for T or B)	(Interaction effect for SB or ST)	(Interaction effect for TB)
$+ B_4x_3$	$+ B_5x_1x_2 + B_6x_1^2x_2$	$+ B_9x_2x_3$

(Interaction effect for STB)

$+ B_{10}x_1x_2x_3 + B_{11}x_1^2x_2x_3$

Three further coefficients are needed for every subsequent contract type or bidder added to this new type or bidder ie.

(Interaction effect for TB)	(Interaction effect for STB)
$+ B_9x_2x_3$	$+ B_{10}x_1x_2x_3 + B_{11}x_1^2x_2x_3$

Figure 5.6 illustrates the SPSS-X codes that have been assigned to each of the independent variables.

5.3.2.5 Rationale behind the models

Each predictor variable therefore consists of a chunk of single variables. These sets of predictor variables are logically related and of equal importance (within a chunk) as candidate predictors.

Chunk	Variable	SPSS-X Code	Description
S	b_1x	BID	Contract size
	b_2x^2	BID2	Contract size x Contract size
T	b_3T_1	J1	Fire Stations
	b_4T_2	J2	Police Stations
	b_5T_3	J3	Primary Schools
	b_6T_4	J4	Secondary Schools
	b_7T_5	J5	Hostels
B	b_8B_1	B1	Bidder 18
	b_9B_2	B2	Bidder 142
	$b_{10}B_3$	B3	Bidder 119
	$b_{11}B_4$	B4	Bidder 127
	$b_{12}B_5$	B5	Bidder 122
	$b_{13}B_6$	B6	Bidder 148
	$b_{14}B_7$	B7	Bidder 45
	$b_{15}B_8$	B8	Bidder 52
	$b_{16}B_9$	B9	Bidder 96
	$b_{17}B_{10}$	B10	Bidder 71
	$b_{18}B_{11}$	B11	Bidder 109
	$b_{19}B_{12}$	B12	Bidder 69
	$b_{20}B_{13}$	B13	Bidder 20
	$b_{21}B_{14}$	B14	Bidder 24
	$b_{22}B_{15}$	B15	Bidder 9
ST	b_nT_nx	J_nBID	Contract type x Contract size
	$b_nT_nx^2$	J_nBID2	Contract type x Contract size x Contract size
SB	b_nB_nx	B_nBID	Bidder x Contract size
	$b_nB_nx^2$	B_nBID2	Bidder x Contract size x Contract size
TB	$b_nT_nB_n$	J_nB_n	Contract type x Bidder
STB	$b_nT_nB_nx$	J_nB_nID	Contract type x Bidder x Contract size
	$b_nT_nB_nx^2$	J_nB_nID2	Contract type x Bidder x Contract size x Contract size

Figure 5.6 : SPSS-X coding of independent variables

It should be noted that the models were constructed with the following rationale in mind:

(1) all models must contain the contract size variable as this is the independent quantitative variable;

(2) in accordance with normal procedures (eg. Glantz and Slinker 1990: 94) models containing interaction terms **without** main effect variables have been disregarded as they do not constitute a logical model build up and would not give a meaningful interpretation in further analysis;

(3) models containing more interaction effects, eg. four way interaction effects, could have been constructed. However, the literature (eg. Kerlinger 1986) suggests that interaction effects of more than three way are difficult to interpret in a meaningful way. Also there may be a data problem. It is recognised (eg. Skitmore 1991) that models containing a ratio of more than one third variables to data sample gives rise to the regression model becoming less reliable.

As can be seen from Figure 5.5, the models have been logically developed so that each candidate model includes and excludes different combinations of predictor variable chunks. If the chunk is included in the model then the model assumes that particular predictor variable chunk influences competitiveness. If it is excluded the model assumes that the predictor variable chunk has no influence on competitiveness. At one extreme there is model 1, the sample mean, which assumes none of the predictor variable chunks influence competitiveness. This is because model 1 is simply made up of the total SSE (which is the square of the standard deviation) divided by the number of degrees of freedom minus one. At the other extreme, model 22, the saturated model, assumes that each and every predictor variable chunk for both the main effects and interaction effects influences competitiveness.

5.3.2.6 Bids selected for analysis

Since bids submitted by contractors are likely to be made up of both serious and non-serious bids an important aspect to consider is whether to include all the bids submitted by contractors in the analysis. Some researchers have excluded non-serious bids from their analysis by different means eg. Franks (1970) excluded the upper 20% of bids, Morrison and Stevens (1980) excluded the highest two bids in each set. However, in undertaking analysis it has been suggested (Skitmore 1989) that all bids in the model should be retained because (1) some companies have been found to have quite distinct bidding behaviour, and what appears to be an unrealistic bid may be genuine in some cases (2) cover prices do not distort market prices, therefore non-serious bidders are not likely to have any great effect on low bid models (3) the non-serious bids are of great importance for determining skewness and possible correlation with industry workload.

5.3.2.7 Number of bidders

Ideally as many bidders as possible should be included in the analysis. However, there are data limitations, and for reasonably robust results Skitmore (1991a) recommends that the number of previous bidding attempts is three times the number of variables in the model. To overcome this problem a standard procedure for this type of analysis is to select bidders on the basis of most bidding attempts. Bidders are ranked in descending order of bidding attempts and a cumulative number of bidding attempts determined. Against this is compared the corresponding number of variables generated by the saturated model to find a reasonable minimum ratio cut off point. Table 5.3 shows the number of bidding attempts/number of variable ratios per incremental increase in bidders for models 22 (ie. the saturated model), 18 (ie. a representative high order model) and 12 (ie. a representative middle order model).

For this 5 contract type data set the cut off point is judged to be where 15 bidders are included in the analysis. Although the ratio at this point for model 22 (ie. the saturated model) is only 2.70 (ie. 776 bidding attempts / 287 variables), this is considered reasonable since this ratio is only just less than three. With the exception of two other models (ie. models 19 and 20), all other candidate models

No. of bidders	Total no. of bidding attempts	Model 22		Model 18		Model 12	
		No. of vari-ables	Ratio	No. of vari-ables	Ratio	No. of vari-ables	Ratio
1	72	35	2.05	30	2.40	20	3.60
2	135	53	2.54	43	3.14	23	5.87
3	193	71	2.72	56	3.45	26	7.42
4	251	89	2.82	69	3.64	29	8.66
5	306	107	2.85	82	3.73	32	9.56
6	360	125	2.88	95	3.79	35	10.29
7	412	143	2.88	108	3.82	38	10.84
8	464	161	2.88	121	3.84	41	11.32
9	513	179	2.86	134	3.83	44	11.66
10	562	197	2.85	147	3.82	47	11.96
11	608	215	2.83	160	3.80	50	12.16
12	652	233	2.80	173	3.77	53	12.30
13	695	251	2.77	186	3.74	56	12.41
14	736	269	2.74	199	3.70	59	12.47
15	776	287	2.70	212	3.66	62	12.52
16	812	305	2.66	225	3.61	65	12.49
17	848	323	2.63	238	3.56	68	12.47
18	883	341	2.59	251	3.52	71	12.44
19	917	359	2.55	264	3.47	74	12.39
20	951	377	2.52	277	3.43	77	12.35

Table 5.3: Bidding attempt / variable ratio per incremental increase in number of bidders for models 22, 18 and 12.

have a ratio greater than three. It is quite likely, therefore, that the eventual best candidate model will in fact have a ratio greater than three.

According to Mendenhall and McClave (1981: 222) the reasons for producing a single model to represent all the response curves is so that:

(1) 'we can test to determine whether the curves are different';

(2) 'we obtain a pooled estimate of variance, the variance of the random error component E'.

5.3.3 Selection of best model and predictor variables

The best model is found by determining the 'middle ground between an under-specified model, which yields biased estimates of the regression parameters and a high residual variance, and an over-specified model, which yields unbiased but imprecise estimates of the regression parameters'(Glantz and Slinker 1990: 245).

5.3.3.1 Forward chunkwise sequential variable selection algorithm

The approach used in determining the best model is by using a forward chunkwise sequential variable selection algorithm based on the F-test. The calculated F statistic expressed in terms of the sums of squares error as:

$$F_{(DA,DB,)} = [(SSE_A - SSE_B) / (da - db)] / MSE_B \qquad (5.2)$$

where

SSE_A = Sum of Square Error for model A

SSE_B = Sum of Square Error for model B

da = Explained degrees of freedom for model A

db = Explained degrees of freedom for model B

MSE = Mean square residual error for model B

is compared with the corresponding tabulated F distribution at the 5% significance level where

n_1 = da - db degrees of freedom

n_2 = residual degrees of freedom

When comparing models the null hypothesis is that the model with the explained degrees of freedom is the best model. If the resulting calculated value for the F statistic exceeds the tabulated F distribution at the 5% significance level the null hypothesis is rejected and the best model then becomes the model represented in the alternative hypothesis. In the case where the compared models contain an identical number of coefficients then the model with the smallest MSE (mean squared error) is automatically chosen as the best model. This algorithm is repeated until all the models have been compared.

The results from using this chunkwise algorithm are verified by checking the utility statistics of the best model against the other candidate models. The utility statistics referred to comprise adjusted R2, global F test and Mallows C_p

5.3.3.2 Ordering of the candidate models for testing

Although the candidate models are developed according to the number of chunks (as shown in Figure 5.5) the testing sequence to find the best model does not strictly follow this order. This is because the sequence of testing was undertaken according to the number of explained degrees of freedom contained in the models which vary according to the numbers of bidders (and contract types) in the model.

For determining the best model by using the algorithm, the 22 models are, therefore, ranked for comparison in ascending order of the number of explained degrees of freedom contained in the model. Starting with two bidders, individual bidders are added incrementally into the analysis up to the 15 bidder cut off point and the best candidate model determined for each incremental increase. Such an approach is taken so that the robustness of the best model can be observed.

A spreadsheet using Lotus 1-2-3 is developed to calculate the forward chunkwise sequential variable selection algorithm and thereby determine the best model.

5.3.3.3 Bidder size

The notion that different size bidders have different preferred size ranges (as shown in Figure 5.3) is tested by observing the bidding behaviour of contractors according to size. The preceding sections have set out the regression analysis methodology for determining the best model based on the bidding performance of

15 individual bidders. This methodology can be developed to measure the effect that bidder size has on the competitiveness.

The effect of bidder size can be measured using the same approach, except that contractors are grouped according to size (ie. small, medium and large) based on the Hong Kong Government classification system and the bidder size behaviour observed. Since bidder size is a qualitative variable, a single prediction equation for each bidder size can be found by creating a dummy variable for bidder size (see Figure 5.7). Since the bidder sizes are known for all bidders, the whole data set is included in this part of the analysis.

The best model according to bidder size is determined using the same forward chunkwise sequential variable selection algorithm based on the F-test as shown in Equation 5.2.

5.3.3.4 Comparison of best models based on individual and grouped bidder performance

So that a direct comparison can be made, the best model based on the bidding performance of 15 individual bidders and the best model based on the bidding performance of the same 15 bidders grouped according to size is compared by using the same forward chunkwise sequential variable selection algorithm based on the F-test as shown in Equation 5.2.

In making the comparison, the model with the least number of explained degrees of freedom (ie. the grouped bidder best model) will be treated as the null hypothesis ie. that it is the best model. The 15 individual bidder best model will be treated as the alternative hypothesis.

Therefore, if the resulting calculated value for the F statistic exceeds the tabulated F distribution at the 5% significance level then the null hypothesis is rejected and the best model then becomes the model represented in the alternative hypothesis.

Model No.	No. of Chunks in Model	Chunk Combination
1	0	$\bar{y}$
2	1	S
3	2	S + T
4	2	S + G
5	3	S + T + ST
6	3	S + G + SG
7	3	S + T + G
8	4	S + T + G + ST
9	4	S + T + G + SG
10	4	S + T + G + TG
11	4	S + T + G + STG
12	5	S + T + G + ST + SG
13	5	S + T + G + SG + TG
14	5	S + T + G + TG + ST
15	5	S + T + G + STG + ST
16	5	S + T + G + STG + SG
17	5	S + T + G + STG + TG
18	6	S + T + G + SG + ST + STG
19	6	S + T + B + SG + TG + STG
20	6	S + T + B + TG + ST + STG
21	6	S + T + B + TG + SG + ST
22	7	S + T + B + TG + SG + ST + STG

where :

$\bar{y}$ = sample mean T = contract type
S = contract size G = bidder size

The regression coefficients contained within these chunks are as follows:

1. S : $b_1x + b_2x^2$
2. T : $b_3T_1 + b_4T_2 \ldots b_nT_n$
3. G : $b_5G_1 + b_6G_2 + b_7G_3$
4. ST : $b_8T_1x + b_9T_1x^2 + b_{10}T_2x + b_{11}T_2x^2 \ldots b_nT_nx + b_nT_nx^2$
5. SG : $b_{12}G_1x + b_{13}G_1x^2 + b_{14}G_2x + b_{15}G_2x^2 + b_{16}G_3x + b_{17}G_3x^2$
6. TG : $b_{15}G_1T_1 + b_{16}G_2T_1 + b_{17}G_1T_2 + b_{18}G_2T_2 \ldots b_nG_nT_n$
7. STG : $b_{19}G_1T_1x + b_{20}G_1T_1x^2 + b_{21}G_2T_1x + b_{22}G_2T_1x^2 + b_{23}G_1T_2x + b_{24}G_1T_2x^2 + b_{25}G_2T_2x + b_{26}G_2T_2x^2 + \ldots b_nG_nT_nx + b_nG_nT_nx^2$

where :

x = contract size T_1 = contract type 1 G_1 = small bidder
T_2 = contract type 2 G_2 = medium bidder
T_n = contract type n G_3 = large bidder

Figure 5.7: Proposed candidate models for bidders grouped according to bidder size (ie. small, medium and large)

5.3.3.5 Testing the robustness of the best model

The best model's robustness will be examined by using this same approach but varying the combinations of contract types in the analysis. The robustness of the best model resulting from the above comparison of best models is further examined by:

(1) reanalysing the best model based on the forward chunkwise sequential variable selection algorithm with the approximate values for $F_{.01}$ being taken from the 1% points for the Distribution of F table (instead of 5% points);
(2) testing whether the second order terms contribute to the prediction of competitiveness;
(3) excluding alteration work from the analysis;
(4) comparing the robustness of the ratio measure of competitiveness as shown in Equation 5.1 with the ratio of bidder's bid to lowest bid ie.

$$C = x/x_{(1)} \tag{5.3}$$

where

C = measure of competitiveness

x = bid value entered by an individual bidder

$x_{(1)}$ = value of lowest bid entered for the contract

(Maximum and minimum competitiveness are respectively constrained between one and infinity)

The resulting model, whether it be the 15 individual bidder or grouped bidder best model, will then go forward to be tested and if necessary transform the model to satisfy regression assumptions.

5.3.3.6 Multivariate analysis of variance (MANOVA)

It should be noted that using regression analysis to obtain the necessary statistics for each candidate model on which to perform the forward chunkwise sequential variable selection algorithm is very expensive in terms of computer CPU time due to the matrix inversion that is required. This is particularly time consuming, especially for the higher order models which contain many variables. A minimum tolerance problem was also encountered in which some variables were left out of the equations of some higher order models thereby producing inaccurate statistics on which to apply the algorithm.

An alternative, more efficient and more accurate technique for supplying the necessary statistics on which to determine the best model can be accomplished by using the MANOVA technique which is based on the minimum variance approach rather than the least squares approach. As MANOVA also overcomes the regression analysis problem of minimum tolerance this technique is used to supply the statistics on which to apply the algorithm for models 3 - 22.

The statistics needed for model 1 are univariate summary statistics, therefore these have been derived from the descriptives procedure. As MANOVA needs two predictor variables and only one predictor variable is generated by model 2 the statistics for model 2 are based on the multiple regression.

5.3.4 Transforming the model to satisfy regression assumptions

Having determined the best model, the residuals of the best model are then examined to see if any of the standard least squares regression assumptions have been violated. Each assumption is examined in turn and where necessary the model is modified to accommodate the assumption to produce a final model which is not only closest to satisfying these assumptions but also the best predictor of the dependent variable, competitiveness. These assumptions are:

(1) Mean of the residuals equal to zero : It is impossible to violate the assumption of the mean of the residuals equals zero as the method of least squares guarantees that the mean of the residuals is equal to zero.

(2) Multicollinearity : For detecting multicollinearity, the variance inflation

factors (VIFs) for the individual B parameters are used as indicators. A severe multicollinearity problem can be assumed to exist if the largest variance inflation factors is greater than 10 (Neter et al, 1983).

(3) Autocorrelation : To test that the observations are independent the residuals are plotted against a sequence variable, the most usual being time. The Durbin-Watson test is commonly used to test this assumption. However, in bidding studies where more than one bidder is being analysed the potential problem of 'artificial' autocorrelation is likely to occur if the data set is arranged chronologically. The chronological order for contracts containing more than one bidding attempt will produce clusters of similar value bids. The clustering effect produces artificial dependency between succeeding bid values for the same contract within the data set. This is likely to result in a significant autocorrelation. To minimise this undesirable effect the ordering of the bid values within the data set was therefore randomised at the commencement of the analysis. By randomising the data, the data set can be regarded as being cross-sectional. As autocorrelation in cross-sectional studies is 'typically not an assumption of concern' (Dielman 1991: 135), the testing of this assumption has not been reported.

(4) Normality : The normality aspect is formally tested using the Kolmogorov-Smirnov test (see eg. Kenkel 1989). This tests the null hypothesis that the distribution of residuals is normal against the alternative hypothesis that the distribution is not normal. The normality aspect is verified by referring to a histogram and normal probability plot of the residuals.

(5) Homoscedasticity : The assumption of homoscedasticity is tested using a scatterplot of the studentised residuals against the predicted values. In addition each continuous and categorical variable in the model is respectively tested using Szroeter's test (see eg. Dielman 1991) and Bartlett Box F test. These both test the null hypothesis that variance of the residuals is constant against the alternative hypothesis that the variance of the residuals is not constant. Scatterplots of the residuals against each of the continuous and categorical variables have also been examined.

5.3.5 Model verification, prediction and reliability

The best model, transformed to satisfy the regression assumptions, was then retested against all other candidate models to verify whether it remains in its modified state as the best model.

Having satisfied this procedure, the best model prediction equations were then estimated and analysed. The best model prediction equations are estimated from the regression analysis coefficients. The predictions were back checked by estimating the predicted means obtained from MANOVA.

The reliability of the model is tested by checking the coefficients and by constructing 95% confidence limits around the prediction equations. The SPSS-X statistics software package is used to obtain all the statistics up to this point. Unfortunately SPSS-X does not have the capability to produce confidence intervals for prediction intervals for particular *y* values. As pointed out by Mendenhall and Sinich (Mendenhall and Sinich 1993: 193) 'this is a rather serious oversight, since the prediction intervals represent the culmination of model building efforts: using the model to make inferences about the dependent variable *y*'. To overcome this problem the SAS statistics software package is used to determine the prediction intervals.

A spreadsheet using Lotus 1-2-3 was developed to estimate the prediction equations and construct the 95% confidence limits around the prediction equations.

Summary

The methodology used to replicate and develop Flanagan and Norman's study is set out in this chapter and the approach is described in three sections. The first section compares the measures of competitiveness and variability in bidding used by Flanagan and Norman (1982b) in their study with a preferred alternative competitiveness measure which is used to develop the study. The second section describes the method taken to classify the bidding behaviour of bidders according to competitiveness and variability. The regression analysis methodology used to model the effect of contract type, contract size and bidder size on competitiveness is presented in the third section.

Chapter 6 sets out the analysis for replicating Flanagan and Norman's study and also analyses the relationship between competitiveness and variability. Chapters 7 to 11 are devoted to the regression analysis. Chapter 7 deals with the selection of the best model and predictor variables. Chapter 8 is concerned with transforming the best model to satisfy the regression assumptions. Chapter 9 describes the verification of the best model and model prediction and reliability. This model is refined in Chapter 10 by grouping together bidders whose competitiveness towards contract type and contract size are not significantly different. Chapter 11 examines the effect of adding new bidders to the model.

The data set together with the principal SPSS-X and SAS command files are shown in the appendices.

CHAPTER 6

Competitiveness and variability between bids

6 COMPETITIVENESS AND VARIABILITY BETWEEN BIDS

6.1 Introduction

This chapter is divided into two sections. The first section replicates Flanagan and Norman's study (Flanagan and Norman 1982b) and in so doing compares the bidding performances of three UK contractors with three Hong Kong contractors. The second section develops the study by introducing an alternative preferred measure of competitiveness (ie. Equation 5.1), and considers the variability in competitiveness arising from this measure. This is further developed by examining the relationship between competitiveness, C' and competitiveness variability, C". From this a matrix is produced which can be used to identify various classes of competitive bidding behaviour.

6.2 Replicating Flanagan and Norman's study

Three Hong Kong contractors (ie. bidders coded 64, 52 and 18) were selected for analysis in accordance with Flanagan and Norman's criteria ie. they have tendered consistently throughout the period in which the data are collected and 'in most instances ... be tendering in different size ranges' (Flanagan and Norman 1982b). To comply, as far as possible, with this latter criterion, the three classes of contractors that make up the Hong Kong Government's list of approved contractors are used as the basis for measuring contractor size (Hong Kong Government 1981). Class A, B and C contractors are taken to represent small, medium and large contractors respectively. One bidder has been selected from each class and is correspondingly labelled A, B and C.

Table 6.1 shows the number of bidding attempts, average bid values and variability of bid values for each of the three Hong Kong bidders (The bid values for the UK bidders is not reported by Flanagan and Norman). Since Government regulations specify that each class of contractor can bid only for contracts up to stipulated maximum contract values (Hong Kong Government 1981), it follows that small contractors will have the least number of bidding opportunities and large contractors the most bidding opportunities. It is not surprising, therefore, to see that the number of bidding attempts made by the three bidders A, B, and C following this trend. As expected bidder C, the large contractor, has the largest average bid value and bidder A, the small contractor the smallest average bid value. It is unexpected, however, to see that the coefficient of variation does not also follow this trend. It is bidder A, the small contractor, who attained the largest coefficient of variation. Upon further investigation it was found that this contractor has bid for a few contracts beyond the maximum value stipulated for this class of contractor.

Bidder label	Number of bidding attempts	Bid Values		
		Average contract bid (HK$ millions)	Standard Deviation	Coefficient of Variation
A	23	HK$ 5.84	6.80	116.44%
B	52	HK$ 12.19	8.53	69.98%
C	72	HK$ 21.54	17.88	83.01%

Table 6.1: Number of bidding attempts, average bid values and variability of bid values for Hong Kong contractors A, B and C

6.2.1 Comparison of bidding performances

Figure 6.1 illustrates the bidding performances of the three Hong Kong contractors and also Flanagan and Norman's three UK contractors. The bidding performance is based on a competitiveness measure adopted by Flanagan and Norman (ie. Equation 4.2) in which each competitor's bid is expressed as a percentage of the bidder's bid. The rationale behind the contract order, shown on the x-axis, is not stated by Flanagan and Norman. The contract order shown for Hong Kong contractors is chronological. When comparing the bidding performances of the Hong Kong and UK contractors overall, what is particularly striking is that the

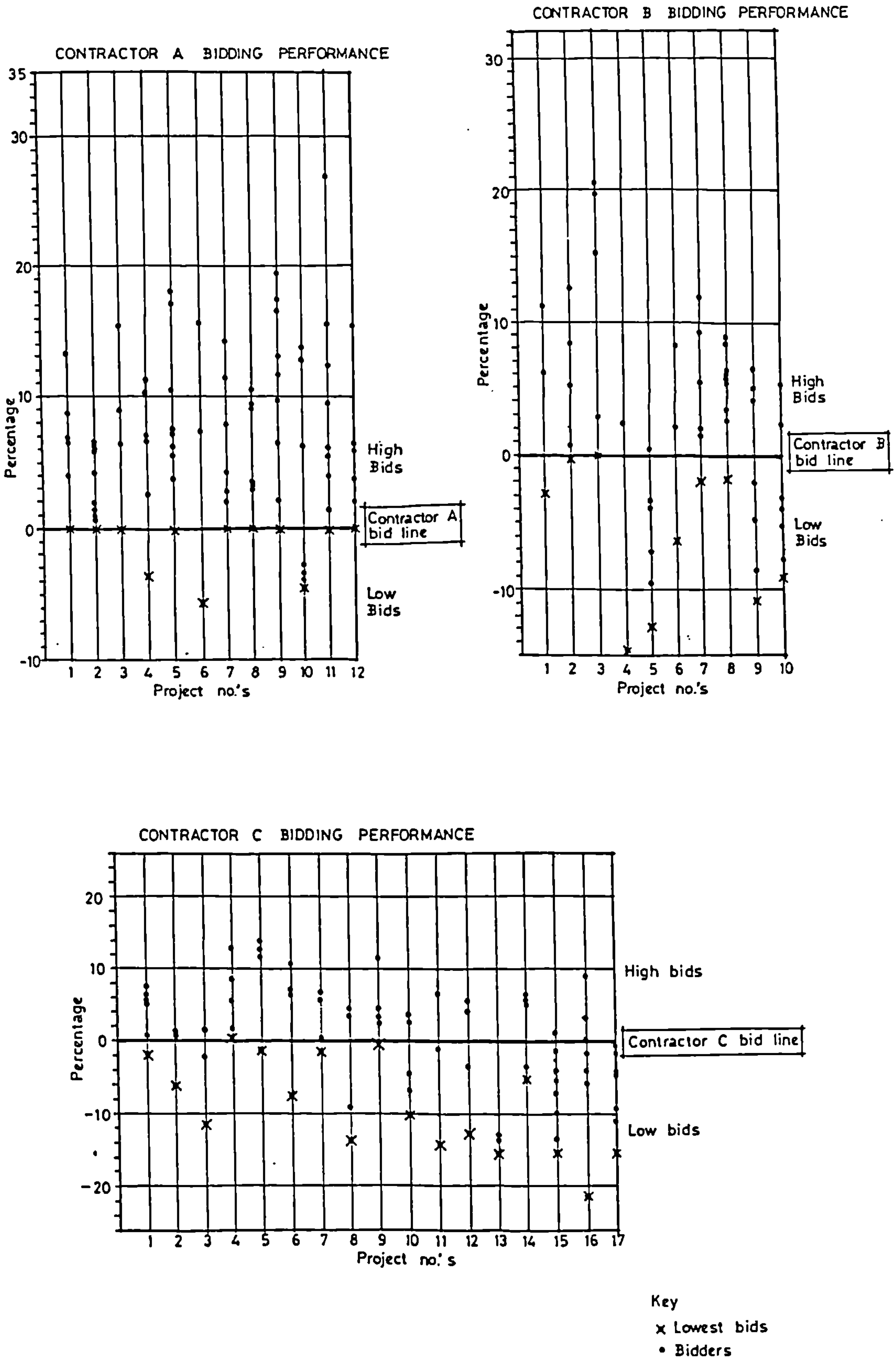


Figure 6.1 a-c: Bid lines of UK bidders in relation to competitor bids (Source Flanagan and Norman 1982b)

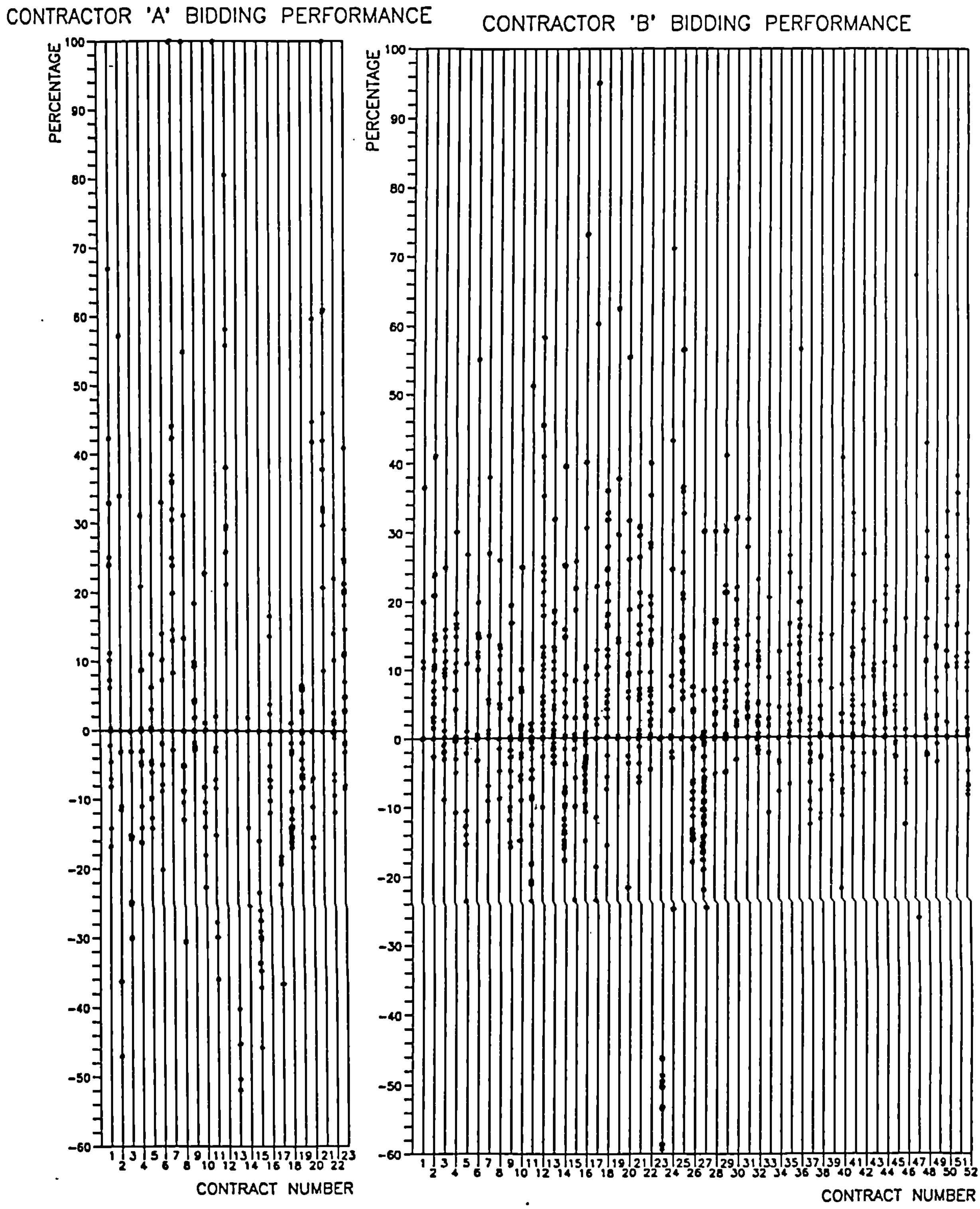


Figure 6.1 d-e: Bid lines of Hong Kong bidders 'A' and 'B' in relation to competitor bids

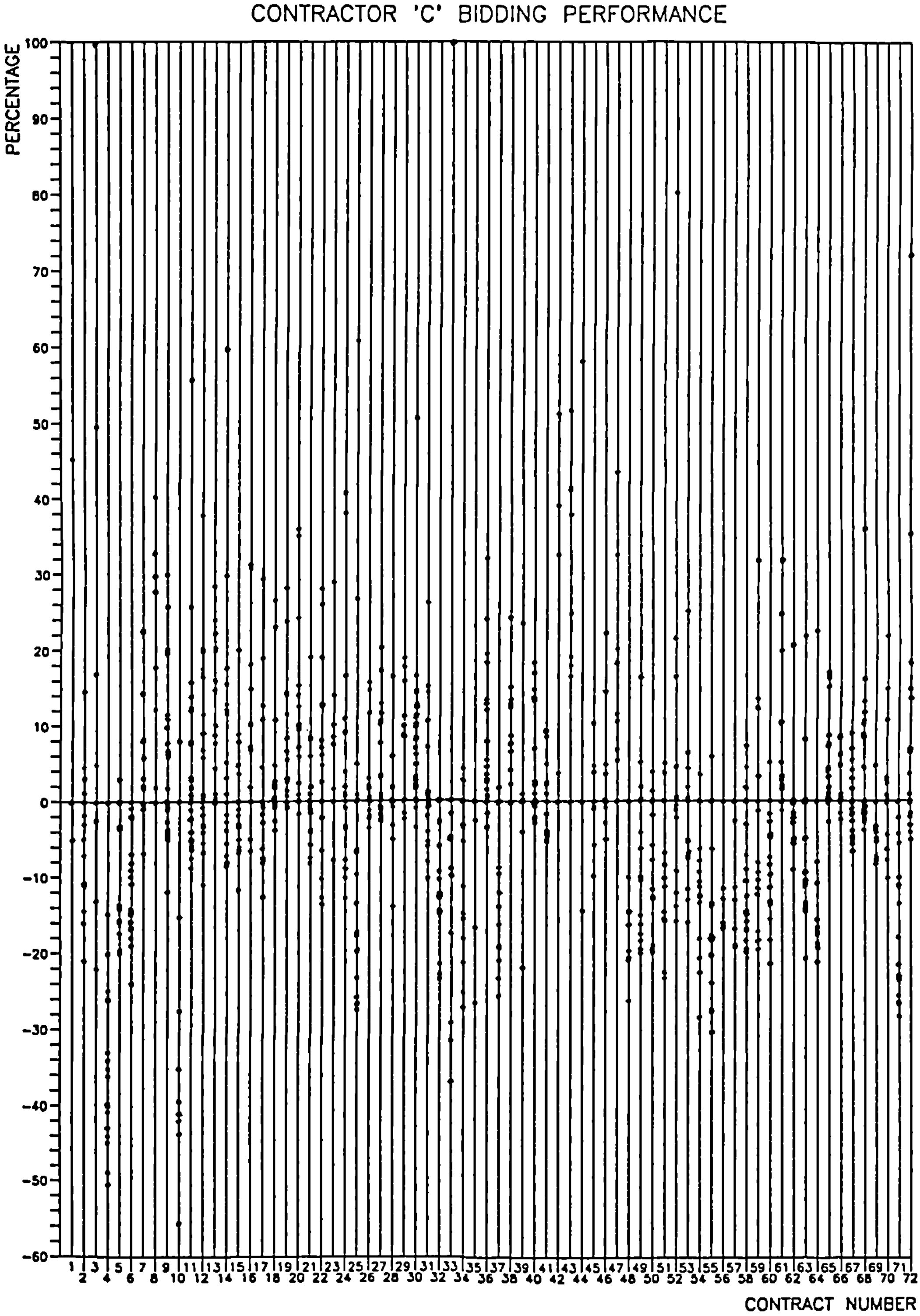


Figure 6.1 f: Bid lines of Hong Kong bidder 'C' in relation to competitor bids

Hong Kong contractors have had many more bidding attempts. The total number of bidding attempts for Hong Kong bidders A, B and C (shown in Figure 6.1 d-f) is 23, 52 and 72 respectively while the number of bidding attempts for the corresponding UK bidders is only 12, 10 and 17. Hong Kong contractors are also bidding, on average, against more competitors. The average number of bidders in competition with Hong Kong bidders A, B and C is 12, 16 and 14 respectively. The average numbers of bidders for the corresponding UK bidders is 8, 7 and 6. In addition, the percentage differences between the bidder's bid and competitor's bid, in many instances, are much larger than the UK counterparts. This can be seen in Table 6.2 which shows a comparison of the mean bidding percentages for contracts on which the three bidders made bidding attempts. It can be seen that the resulting coefficient of variations for the Hong Kong bidders are approximately double that of the UK bidders.

Bidder label	Hong Kong		UK	
	Mean percentage bidding range	Coefficient of variation	Mean percentage bidding range	Coefficient of variation
A	88.60%	81.03%	19.11%	40.92%
B	60.63%	79.58%	19.21%	36.42%
C	53.16%	87.70%	17.25%	45.67%

Table 6.2: Mean percentage bidding ranges for contracts on which the Hong Kong and UK contractors made bidding attempts

The principal reason for all of above differences is probably because the UK data are based on selective tendering, in which the contractor is invited to bid, whereas the Hong Kong data is based on a restricted open tendering system, in which the onus to bid lies with the contractor. The large percentage differences between some Hong Kong bids is probably exacerbated by some contractors being compelled to bid. There is a Government tendering regulation which stipulates that contractors 'who over a reasonable period of time appear to be disinterested in tendering for public works contracts ... may be removed from the approved list' (Hong Kong Government 1981).

In considering the individual bidding performances of the three Hong Kong contractors, it looks as though bidder B is the most competitive contractor overall.

6.2.2 Overall success rates

Bidder B being the most competitive contractor is also reflected in the success rates of the contractors as shown in Table 6.3. This shows this same contractor attaining the highest success percentage out of the three Hong Kong contractors. When compared against the UK contractors it can be seen that the resulting success percentages are generally lower. This is likely to be because the Hong Kong contractors are competing, on average, against more competitors. Competing in this level of competition would seem to make it more difficult for contractors to have control over the work they really want to undertake. This is likely to be one reason why the three Hong Kong contractors are unable to attain a high success percentage over all contracts.

Bidder label	Hong Kong		UK	
	Success Ratio	Percentage	Success Ratio	Percentage
A	2 / 23	8.7%	9 / 12	75.0%
B	8 / 52	15.4%	1 / 10	10.0%
C	5 / 72	6.9%	2 / 17	11.8%

Table 6.3: Success rates of obtaining contracts for the Hong Kong and UK contractors

6.2.3 Success rates according to type and nature of work

Having examined the overall differences, the success percentages for the three Hong Kong contractors were split into the 5 contract types according to the CI/Sfb classification and also according to nature of work (ie. new work and alteration work). This shown in Table 6.4. In respect of the contract type breakdown it can be seen that bidder B obtained a success percentage of 40% for primary schools. Although the success percentage is not as high as UK bidder A, who bid only for school contracts, it may be taken to be comparable given the larger number of

Hong Kong competitors per competition. This inclination toward schools may be due to the fact that schools may be very similar or identical in design. Another possibility is that some Hong Kong contractors at least, have to specialise in the work they undertake in order to compete successfully in this level of competition. It would seem, therefore, that experience is a key factor. Although the success percentage is lower, both of bidder A's only successes are also confined to one contract type, namely police stations. These two bidders' successes are in contrast to bidder C's successes which are spread over three types. This is also reflected in the nature of work. All of bidder B's successes are for new work contracts whereas both of bidder A's successes are for alteration work contracts. Bidder C's successes are split between alteration and new work. It can be seen that bidder C's success ratio is over three times higher for alteration work contracts.

Bidder label	Contract type										Nature of work			
	Fire stations		Police stations		Primary schools		Secondary Schools		Hostels		New work		Alteration work	
	Success ratio	%	Success ratio	%	Success ratio	%	Success ratio	%	Success ratio	%	Success ratio	%	Success ratio	%
A	0 / 3	0.0	2 / 9	22.2	0 / 8	0.0	0 / 1	0.0	0 / 2	0.0	0 / 6	0.0	2 / 17	11.8
B	0 / 8	0.0	1 / 8	12.5	6 / 15	40.0	0 / 7	0.0	1 / 14	7.1	8 / 40	20.0	0 / 12	0.0
C	2 / 15	13.3	1 / 14	7.1	0 / 19	0.0	0 / 13	0.0	2 / 11	18.2	3 / 60	5.0	2 / 12	16.7

Table 6.4 Success rates of obtaining contracts for Hong Kong contractors A, B and C according to contract type and nature of work

6.2.4 Success and contract size

The size of and range of contracts on which the UK contractors were successful is not fully reported by Flanagan and Norman for those UK contractors. They merely state that for bidder A 'no contract was over £500,000' and that bidder C 'was successful in obtaining contracts on the two occasions when the project value exceeded £1,500,000'. Details of the size and range of contracts on which the Hong Kong contractors are successful is given in Table 6.5. As expected the average size of contracts on which the bidders were successful corresponds to the size of bidder with the large bidder achieving the largest range of successes and the small contractor achieving the smallest range. The large contractor also achieved the largest coefficient of variation.

Bidder label	Average bid value (HK$ Millions)	Standard Deviation	Coefficient of variation	Contract Size Range	
				Minimum	Maximum
A	HK$ 1.84	1.11	60.33%	HK$ 0.73	HK$ 2.95
B	HK$ 8.98	3.40	37.84%	HK$ 1.93	HK$ 11.42
C	HK$ 13.73	11.44	83.33%	HK$ 1.07	HK$ 30.38

Table 6.5: Size and range of contracts on which Hong Kong contractors A, B and C are successful

6.2.5 Overall comparison

For the UK contractors, Flanagan and Norman concluded that bidder B, the medium bidder, showed no bidding trend while bidder A, the small bidder, works only within a well defined range and sticks to a well defined product, and bidder C, the large bidder, appears to bid more competitively on the large projects.

By comparison, none of the Hong Kong contractors appears to restrict their bidding to one type. However, bidder B, (the medium contractor) is successful on six contracts of the same type (ie. primary schools) and all eight contracts are new works contracts. Both of bidder A's (the small contractor) only successes are for the same type (ie. police stations) and both are for alteration works contracts. Bidder C (the large contractor) five successes are over a range of both new works and alteration works.

It would seem, therefore, that bidder C shows no particular bidding trend while both bidder A and B's successes, at least, are for a well defined product and within a well defined range. None of the three Hong Kong bidders appeared to be more competitive on the larger contracts.

6.3 Developing Flanagan and Norman's study

6.3.1 Competitiveness and bidding performance

Flanagan and Norman's conclusions on the bidding performance of bidders appear to rest largely on the relationship between the size of bidders and their success rates relative to type and size of project. The competitive bidding performances of the bidders is also measured by expressing each competitor's bid as a percentage of the bidder's bid and shown in Figure 6.1. Although this gives an overall picture of a contractor's bidding performance it is difficult to observe the relative degree of competitiveness of each of the bidders.

Although success and expressing each competitors bid as a percentage of the bidder's bid are both indicators of competitiveness, it is not possible to determine the relative degree of each bidder's competitiveness towards contract type and size. Since success is a discrete variable and success rates are based on a nominal scale, the distance between values, in terms of competitiveness, is not known. Using each bidder's bid as the baseline has a disadvantage when comparing the bidding performance between bidders in that each bidders baseline is likely to be different. Although this gives an overall picture of a contractors bidding performance it is difficult to observe and compare the relative degree of competitiveness between each bidder.

Bidding performance analysis is concerned with the *relationships between bids* entered by different contractors in competition. As bidding performance is the product of competitive tendering for projects of different types and sizes contracts a suitable measure is needed to reflect the competitiveness of bids for all contracts. The preferred measure offered is the ratio of the bidders bid to the lowest bid (ie. Equation 5.1). This is now used in developing Flanagan and Norman's study.

6.3.2 Overall competitiveness

Table 6.6 shows the average competitiveness for each of the three Hong Kong bidders over all projects together with the competitiveness variability. It can be seen that bidder B appears to be the most competitive and bidder overall with least competitiveness variability. In contrast bidder A is the least competitive, but the most variable in terms of competitiveness.

Bidder label	Competitiveness		
	Average competitiveness	Standard Deviation	Coefficient of Variation
A	0.7893	0.1512	19.16%
B	0.8875	0.1110	12.51%
C	0.8652	0.1163	13.58%

Table 6.6: Overall competitiveness vs variability for Hong Kong contractors A, B and C

6.3.3 Competitiveness according to contract type

Table 6.7 shows the competitiveness of these bidders according to type. It can be seen that bidder A appears to be the most competitive bidder towards fire stations, bidder B the most competitive toward primary schools and bidder C the most competitive towards the three remaining contract types. Bidder B's proclivity towards primary schools, referred to earlier in the analysis is borne out in the competitiveness value of 0.9539. This is considerably higher than any of the remaining competitiveness values. With the exception of fire stations, bidder B appears to be most consistent in competitiveness. (The relatively high variability for police stations is caused by one very poor bidding attempt which was 175% above the lowest bid).

Bidder according to contract type	Competitiveness		
	Average Competitiveness	Standard Deviation	Coefficient of Variation
Fire stations (372)			
A	0.9073	0.0625	0.89%
B	0.8937	0.0476	5.33%
C	0.8494	0.0961	11.31%
Police stations (374)			
A	0.7638	0.1866	24.43%
B	0.8206	0.2067	25.18%
C	0.8350	0.1589	19.02%
Primary schools (712)			
A	0.7590	0.1487	19.59%
B	0.9539	0.0644	6.75%
C	0.8325	0.1204	14.46%
Secondary schools (713)			
A	0.8595	-	-
B	0.8896	0.0868	9.76%
C	0.9011	0.0983	10.91%
Hostels (848)			
A	0.8129	0.0300	3.69%
B	0.8497	0.0820	9.65%
C	0.8804	0.0870	9.88%

Table 6.7: Competitiveness according to type for Hong Kong contractors A, B and C

6.3.4 Competitiveness and variability in bidding

There appears to be a correlation between competitiveness C' and the corresponding standard deviation C". Comparing the average competitiveness and standard deviation in Tables 6.6 and 6.7 it can be seen that in many instances a lower average competitiveness value attracts a higher standard deviation and vice versa. This appears to be a logical outcome as a bidder with a low average competitiveness ratio and low standard deviation would fail to get any work. Conversely, a bidder with a high average competitiveness ratio would eventually become bankrupt. This logic is developed in the methodology chapter from which a four way classification system is proposed (see Chapter 5). Bidders are classified, according to the client's perspective, as *Sensible* (high C' and low C" values), *Suicidal* (high C' and C" values), *Non-serious* (low C' and C" values) and *Silly* (low C' and high C" values).

6.3.4.1 All bidders

Using data for all the bidders in the sample, the overall mean competitiveness, C', was correlated with the standard deviation, C". This produced a negative correlation coefficient of - 0.2858 (n=149, p=0.000) for bidders having more than one bidding attempt.

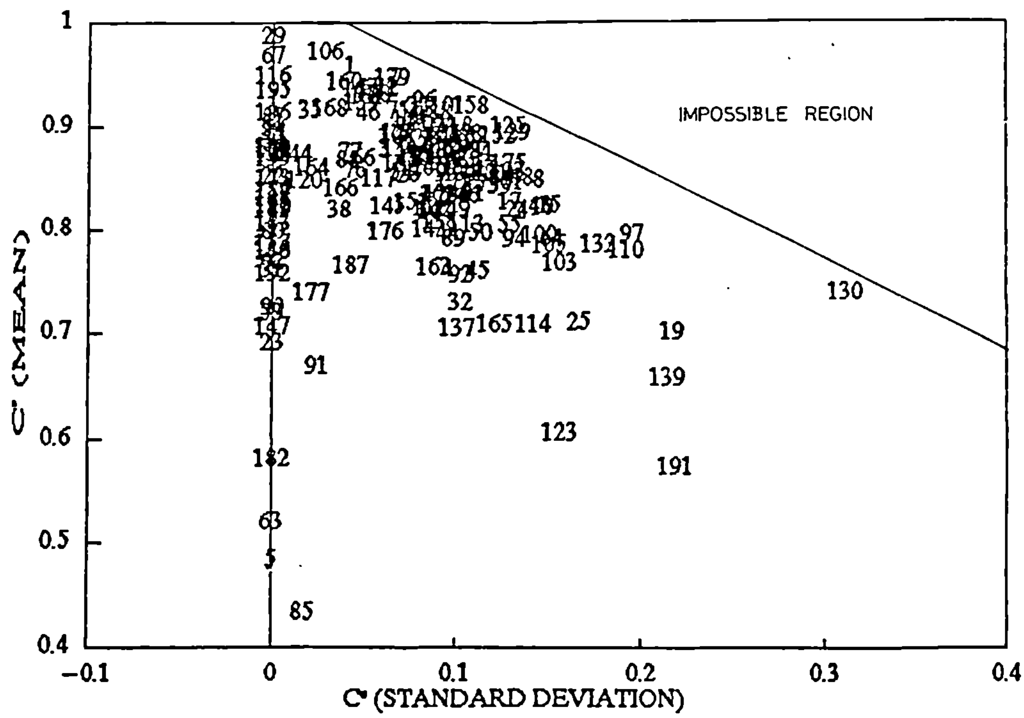


Figure 6.2: Scatterplot of competitiveness and variability for all the bidders in the sample

Figure 6.2 shows the scatterplot of all the coded bidders in the sample (bidders entering only one bid have been assigned a zero standard deviation). The central cluster of bidders represents the typical bidders performance in terms of C' and C". It is also interesting that no bidder has a high C' and high C". This has been denoted in Figure 6.2 as the 'impossible region'. Clearly this phenomenon is symptomatic of the measure used, for as competitiveness is constrained to be at a maximum value of one, large C" values are hardly possible for greater values of C'. It could also, however, be because there are few *Suicidal* bidders in the sample.

6.3.4.2 Most frequent bidders

The most frequent bidders (ie. those who bid ten times or more in the sample) were selected for analysis as it was considered that the results obtained would be more representative of their bidding behaviour. The C' and C" values of this subset of 75 bidders were found to have a much stronger correlation of -0.6290 ($n=75$, $p=0.000$).

Figure 6.3 shows the overall bidding performance broken down into the four competitiveness classification quadrants, the axes of the quadrants being determined according to the mean C' and C" of this grouping of bidders. Due to the strong negative correlation, most bidders fall in the *Sensible-Silly* quadrants, 37 being classified as *Sensible* and 16 as *Silly.* Of the 22 remaining, 16 were *Non-Serious* while 6 were *Suicidal.* There appears to be some evidence of a lengthy *Sensible-Silly* continuum, with several bidders reaching towards the extremities. The *Non-Serious-Suicidal* continuum, on the other hand is much shorter - indicating fewer extreme differences between the bidders on this scale.

The objective of submitting a *bona fide* competitive bid is to become the lowest bidder and thereby win the contract. The next part of the analysis therefore examines the question 'which of the four groups is most successful at becoming the lowest bidder and thereby securing the contract?' In terms of success at becoming the lowest bidder, the logical sequence should rank in descending order of *Suicidal, Sensible, Silly* and *Non-Serious*. To answer this question, therefore, the number of lowest bids was expressed as a proportion to the total number of bidding attempts to produce the success ratio for each quadrant. This yielded the following success ratios; *Suicidal* = 0.168, *Sensible* = 0.108, *Silly* = 0.047, *Non-Serious* = 0.038 against an overall average of 0.084. The result therefore concurs with the above stated proposition.

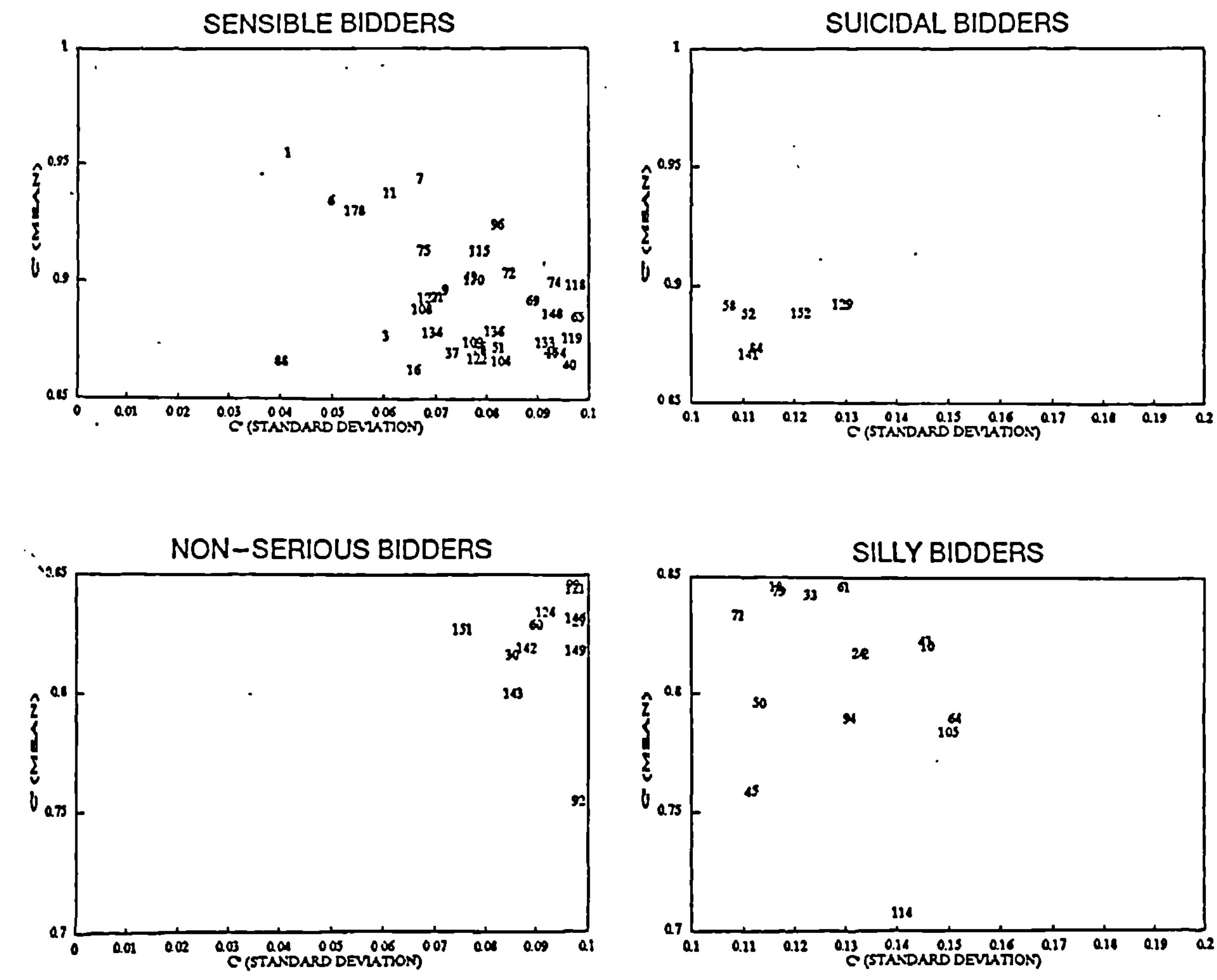


Figure 6.3: Scatterplot of competitiveness and variability for bidders with 10 or more bidding attempts

Bidders were then considered in terms of contract type groupings, within each classification, and tabulated according to their overall performance classification. Table 6.8 shows the classification for each bidder across contract types, single bidding attempts being shown separately.

Bidder code	Contract type code				
	372	374	712	713	848
	SENSIBLE BIDDERS				
1	SE	S	SE	SE	S
3	-	SE	-	NS	SE
6	S	S	SE	SE	SE
7	S	SE	N	-	SE
9	SE	SE	SE	SI	SE
11	S	SE	N	SE	S
16	SE	NS	N	SE	NS
21	SE	SE	SE	SE	S
26	SI	SE	N	SE	NS
36	-	SI	SE	NS	SE
37	SE	SE	NS	N	SE
40	SI	SE	SE	SI	SE
48	SE	SI	SE	SE	NS
49	SE	SI	SE	SE	SE
51	N	SE	-	SI	SE
65	_	SE	N	SU	SE
69	NS	SU	SE	SE	SE
72	SE	SE	S	S	S
74	SE	-	SE	SI	S
75	SE	SE	NS	SI	S
88	S	SE	-	N	SE
96	SE	SU	SE	SE	SE
104	S	SU	NS	NS	NS
108	SE	SE	N	N	SE
109	N	NS	S	SE	SE
115	SE	NS	SE	SE	SI
118	NS	SU	SE	SU	SE
119	S	NS	SI	SE	SE
122	SE	SE	SE	SE	NS
127	SE	NS	SE	NS	NS
133	SE	SE	NS	SE	NS
134	SE	NS	-	N	SE
136	NS	S	SE	SU	SE
148	NS	SE	S	SE	SE
150	SE	SE	SE	SE	SE
154	SE	-	SI	SE	SE
178	SU	SE	-	-	SE

Bidder code	Contract type code				
	372	374	712	713	848
	SUICIDAL BIDDERS				
52	SE	SI	SE	SE	SE
58	SE	SI	SE	-	SE
84	NS	-	SE	SE	N
129	SU	SE	SI	SE	S
141	NS	N	S	SE	SU
152	SE	NS	SI	SU	SE
	SILLY BIDDERS				
2	SI	SE	N	SI	SE
10	S	NS	-	NS	SI
18	SI	SI	SI	SU	SE
24	SE	NS	S	SI	SI
33	-	SE	N	NS	SI
43	SI	SI	SI	SI	SI
45	NS	SI	NS	NS	SI
50	SE	N	SI	SI	NS
61	NS	SE	NS	SI	SI
64	SE	SI	SI	N	NS
68	SE	N	SI	SI	SE
71	SI	SI	SI	NS	NS
79	SE	N	SE	SE	SI
94	NS	S	NS	SI	-
105	N	NS	-	S	SI
114	N	N	NS	-	SI
	NON-SERIOUS BIDDERS				
20	SE	SI	SE	NS	NS
27	NS	NS	SE	SI	NS
30	NS	SI	NS	N	NS
60	SI	NS	S	N	NS
92	NS	SI	SI	SI	NS
99	SI	SE	SE	SI	NS
121	NS	SE	SE	NS	SU
124	N	SE	-	NS	NS
126	N	NS	SE	NS	SE
135	NS	SE	-	N	SI
140	SI	SU	SI	NS	SE
142	NS	NS	NS	SI	NS
143	N	NS	N	SI	N
146	-	NS	N	SI	NS
149	NS	S	NS	SI	SI
151	NS	NS	NS	S	SE

Table 6.8: Bidder classification according to type

Consider first the *Sensible* group of bidders. Some bidders are clearly consistently *Sensible* over all contract types (eg. bidders 1, 6, 21, 72, and 150). It could be argued that this group of bidders is of unfocused cost leaders as they appear to be competitive over all contract types, and that clients can be assured of receiving a competitive bid irrespective of contract type. Those border line cases who just fall into the *Sensible* competitive quadrant (eg. bidders 16, 26, 40, 84, and 119) show a mixed classification over the various contract types. In this case it could be argued that these bidders are focused. In general then it seems that this *Sensible* group of bidders can be regarded as lying on an unfocused-focused continuum. This corresponds to a C'-C" diagonal line running from top left to bottom right through the *Sensible* quadrant in Figure 6.3. Based on this model, we would therefore consider bidders 11 and 75 for instance also to be unfocused cost leaders despite the lack of available direct evidence.

Of the few bidders classified as *Suicidal* over all five contract types, three are classed as *Suicidal* for individual contract types. Apart from three exceptions, these bidders are classed as either *Sensible* or *Silly* for each type. This suggests that they are focused but, as implied by the class, are rather more risky in their bidding than the bidders in the *Sensible* group. In the *Non-Serious* group, some of the bidders (eg. bidders 121 and 140) may be considered focused, whilst others in the group are clearly *Non-Serious* over all contract types. Similar but weaker traits to the *Sensible* bidders are reflected in the results for the *Silly* group of bidders. Bidder 43 is unique in that this bidder is classified as *Silly* over all contract types while bidders 30, 45, 71, 92, 114, 142 and 143 have shown themselves to be either *Silly* or *Non-Serious* over all contract types.

Table 6.9 gives a breakdown of the total number of bidding attempts and successes for the various contract types. As indicated in Table 6.9, the number of successes is not evenly distributed over the different contract types (eg. bidder 96 has a success ratio of 0.47 for contract type 848 compared a success ratio of 0.09 for the remaining contract types). Again, this appears to support the existence of focusing strategies.

Bidder code	All types		Contract type code									
			372		374		712		713		848	
			SENSIBLE BIDDERS									
1	25	4	6	3	1	-	9	1	8	-	1	-
3	12	-	-	-	6	-	-	-	3	-	3	-
6	14	2	1	1	1	-	6	1	3	-	3	-
7	16	6	1	1	4	-	-	-	-	-	11	5
9	40	1	4	-	8	1	9	-	11	-	8	-
11	12	2	1	-	2	1	1	-	7	1	1	-
16	21	1	8	-	2	-	1	-	5	1	5	-
21	27	2	7	1	4	-	7	1	8	-	1	-
26	22	-	4	-	-	-	4	-	9	-	3	-
36	22	1	-	-	3	-	6	-	3	-	10	1
37	16	1	2	-	6	1	3	-	1	-	4	-
40	36	1	6	-	4	1	9	-	11	-	6	-
48	34	3	7	-	5	1	8	2	10	-	4	-
49	25	3	9	3	1	-	6	-	5	-	3	-
51	16	2	1	-	4	2	-	-	2	-	9	-
69	44	5	4	-	8	2	6	-	10	-	16	3
72	10	1	4	-	3	-	1	-	1	1	1	-
74	30	3	9	1	-	-	11	-	9	1	1	1
75	15	3	6	2	3	1	2	-	3	-	1	-
88	10	-	1	-	6	-	-	-	1	-	2	-
96	50	11	16	2	4	1	2	-	9	-	17	8
99	33	2	6	1	5	-	9	1	6	-	7	-
104	17	-	1	-	3	-	3	-	8	-	2	-
108	16	1	3	-	9	-	1	-	1	-	2	-
109	44	3	1	-	12	-	1	-	14	1	16	2
115	32	4	8	2	6	-	6	2	9	-	2	-
118	32	7	3	-	7	2	3	1	5	1	14	3
119	58	11	3	1	15	2	5	-	12	3	23	5
122	54	2	9	-	8	-	7	-	17	1	13	1
127	58	1	16	-	4	-	20	1	14	-	4	-
133	31	1	4	-	7	-	4	-	7	1	9	-
134	15	1	3	-	3	-	-	-	1	-	8	1
136	31	2	8	-	1	-	9	-	9	2	4	-
148	54	9	5	-	19	5	1	-	16	3	13	1
150	36	7	3	-	7	1	2	-	9	1	15	5
154	19	1	3	-	-	-	2	-	5	0	9	1
178	10	2	2	1	5	1	-	-	-	-	3	-

Bidder code	All types		Contract type code									
			372		374		712		713		848	
			SUICIDAL BIDDERS									
52	52	8	8	-	8	1	15	6	7	-	14	1
58	20	3	7	1	4	-	6	2	-	-	3	-
84	10	3	2	-	-	-	4	1	3	2	1	-
129	18	3	5	1	2	1	5	-	5	1	1	-
141	13	2	2	-	1	-	1	-	2	-	7	2
152	30	5	4	1	5	-	6	-	13	4	2	-
			SILLY BIDDERS									
2	23	-	9	-	2	-	1	-	3	-	8	-
10	19	-	1	-	5	-	-	-	5	-	8	-
18	72	5	15	2	14	1	19	-	13	-	11	2
24	42	1	3	-	10	1	1	-	12	-	16	-
33	10	-	-	-	2	-	1	-	2	-	5	-
43	35	2	6	-	4	-	6	1	10	1	9	-
45	52	1	12	-	10	-	7	-	5	-	18	1
50	20	-	9	-	1	-	5	-	2	-	3	-
61	32	3	6	-	2	-	7	-	14	3	3	-
64	23	2	3	-	9	2	8	-	1	-	2	-
65	13	1	-	-	5	1	-	-	2	-	6	-
68	24	4	3	1	1	-	5	1	2	-	13	2
79	18	1	4	1	1	-	6	-	2	-	5	-
92	26	1	4	-	2	1	8	-	4	-	8	-
94	16	-	3	-	1	-	5	-	7	-	-	-
105	12	-	1	-	3	-	-	-	1	-	7	-
114	10	-	1	-	1	-	3	-	-	-	5	-
			NON-SERIOUS BIDDERS									
20	41	2	9	-	6	-	8	-	6	1	12	1
27	33	2	4	-	11	1	3	-	7	1	8	-
30	13	-	5	-	2	-	2	-	1	-	3	-
60	19	1	6	1	3	-	1	-	5	-	4	-
71	49	4	13	1	13	2	10	1	5	-	8	-
121	16	-	1	-	5	-	2	-	6	-	-	-
124	24	2	1	-	8	2	-	-	6	-	9	-
126	20	-	1	-	4	-	5	-	5	-	5	-
135	19	-	-	-	7	-	-	-	1	-	9	-
140	34	2	3	-	7	-	3	-	9	1	12	1
142	63	-	15	-	10	-	9	-	12	-	17	-
143	11	-	1	-	3	-	1	-	5	-	1	-
146	17	1	-	-	1	-	1	-	5	1	9	-
149	30	1	6	-	1	-	9	1	4	-	10	-
151	10	-	2	-	2	-	2	-	1	-	3	-

Table 6.9: Number of bidding attempts/successes overall and according to contract type

Tables 6.8 and 6.9 together show that all bidders who had 5 or more successes at a particular type were classified as *Sensible* for that particular type. Although those bidders who had between 1 and 4 successes at one particular type came from the different classification groupings, the dominant grouping in terms of success is the *Sensible* group of bidders. The most successful bidders from the *Sensible* group are bidders 7, 96, 118, 119, 148, and 150 who had a bid/success ratio of 0.38, 0.22, 0.22, 0.19, 0.17 and 0.19 respectively. The principal reason for the comparatively high success ratios may be that in all instances these bidders were more competitive on particular contract types. For example, bidders 7, 96, 119 and 150 had success ratios of 0.45, 0.47, 0.22 and 0.33 respectively for contract type 848. Bidder 148 had a success ratio of 0.26 for contract type 374. Of the *Suicidal* bidders, bidder 52 with a success ratio of 0.15 in total, was classified as *Sensible* for contract type 712 with a success ratio of 0.40.

Apart from bidder 61, who had three successes (ie. a success ratio of 0.21) on contract type 713, those classified as *Silly* on individual types were restricted to 1 or 2 successes on each type. All the *Non-Serious* bidders were restricted to either 1 or 2 successes on each contract type. The least successful *Non-Serious* bidder was bidder 142 who did not win a single contract in 63 bidding attempts. Bidders who were successful more than once were found in all five contract types.

6.4 Summary

In replicating Flanagan and Norman's study (Flanagan and Norman 1982b), some similarities are found when comparing the bidding performance of three Hong Kong and UK contractors. UK bidder A, a small contractor only bid for one particular contract type, namely schools, and was found to be very successful. By comparison none of the three Hong Kong contractors restricted their bidding to just one type, although in terms of successes, Hong Kong bidder A's only two successes are restricted to one type (ie. police station alteration contracts) while all eight of Hong Kong bidder B's (a medium contractor) successes are for new works. Six of these are for primary school contracts. This inclination towards schools may be due to the fact that Government schools are very similar in design. It would seem therefore, that experience is a key factor. In contrast, Hong Kong bidder C's (a large contractor) five successes are spread over three contract types and are for contracts of varying sizes. Three successes are for new works contracts and the remaining two for alteration contracts. This bidder, similar to UK bidder B, appears to show no particular bidding trend as far as contract size and type is concerned. Unlike UK bidder C, a large contractor, none of the Hong Kong contractors appear to be more competitive on larger contracts.

Flanagan and Norman's conclusions on the bidding performance of bidders appear to rest largely on the relationship between the size of bidders and their successes rates relative to type and size of contract. Since success is a discrete variable and success rates are based on a nominal scale, the distance between values, in terms of competitiveness, is not known. The bidding performances of the bidders is also measured by expressing each competitor's bid as a percentage of the bidders bid. Although this gives an overall picture of a contractor's bidding performance it is difficult to observe and compare the relative degree of competitiveness between each bidder.

In using the competitiveness measure of bidder's bid to lowest bid (ie. Equation 5.1), it is found that of the three Hong Kong contractors, bidder B appears to be the most competitive and bidder with least competitiveness variability. In contrast bidder A is the least competitive, but the most variable in terms of competitiveness.

There appears to be a correlation between competitiveness C' and the corresponding standard deviation C". This appears to be a logical outcome as a bidder with a low average competitiveness ratio and low standard deviation would fail to get any work. Conversely, a bidder with a high average competitiveness ratio and high standard deviation would eventually become bankrupt. This logic is developed in the methodology chapter and a four way bidder classification system is proposed. Bidders are classified as *Sensible* (high C' and low C" values), *Suicidal* (high C' and C" values), *Non-serious* (low C' and C" values) and *Silly* (low C' and high C" values).

The most frequent bidders, ie. those who bid ten times or more in the sample, were selected for analysis as it was considered that the results obtained would be more representative of the bidders' bidding behaviour. The C' and C" values of this subset of 75 bidders were found to have a strong negative correlation of -0.6290 (n=75, p=0.000). The significant negative correlation between competitiveness and consistency resulted in most bidders being classified as *Sensible* or *Silly*. More extreme cases of *Sensible* and *Silly* bidders were found than in the *Suicidal* and *Non-Serious* categories, where bidders were much less differentiated. In terms of success at becoming the lowest bidder, the success rates ranked in descending order of *Suicidal*, *Sensible*, *Silly* and *Non-Serious*.

A major disadvantage of using this particular approach is that it does not account for different size contractors bidding for different sizes of contract. Since this measure of competitiveness will produce greater ratio differences for smaller contracts, it is likely to show smaller contractors to be less competitive than the larger contractors and also more variable in their bidding simply because they are more likely to have bid over a narrower range of smaller contracts. One approach in reducing this problem may be to divide the contracts into different bands of contract sizes and recalculating the competitiveness of bidders according to each contract size band. This, however, requires more data. Eliminating this problem may be accomplished by modelling the competitiveness of bidders using regression analysis. One of the assumptions in using this technique is that the independent variables have a constant variance. If this assumption is violated the competitiveness model is required to be transformed in order to satisfy the assumption.

CHAPTER 7

Determining the best model

7 DETERMINING THE BEST MODEL

7.1 Introduction

The approach taken in selecting the best model was first to determine the best candidate model according to the individual bidding performance of bidders. Starting with two bidders, individual bidders were added incrementally into the analysis up to the 15 bidder cut off point and the best candidate model determined (using the forward chunkwise sequential variable selection algorithm as previously described in Chapter 5) for each incremental increase.

The bidders were then grouped, using the Hong Kong Government classification system according to bidder size (ie. small, medium and large) and the best model determined using the same algorithm. Since bidder sizes are known for all bidders, the whole data set was used.

Sensitivity tests were undertaken for both the individual and grouped bidder analysis by varying the combination of contract types.

The best model for the individual bidding performance of 15 bidders was then compared with the grouped bidding performance to determine whether bidders modelled individually or grouped is the best predictor of competitiveness. In making the comparison, the model with the least number of explained degrees of freedom (ie. the grouped bidder best model) was treated as the null hypothesis (ie. that it is the best model). The 15 individual bidder best model was treated as the alternative hypothesis. The robustness of the best model resulting from this comparison was then further examined.

Development of the candidate models, details of the rationale behind this approach and examining robustness of the best model is described in Chapter 5.

7.2 Individual bidder analysis

The individual bidding behaviour was analysed by incrementally adding bidders into the sample up to the predetermined 15 bidder cut off point and the best model determined for each incremental increase.

7.2.1 Utility of the candidate models

Table 7.1 shows a summary of the values (rounded) of SSE, MSE, df, global F values and adjusted R2 for the candidate models. For the sake of brevity starting with six bidders these are shown in incremental stages of three bidders.

As can be seen in Table 7.1 the model order is based on the number of explained degrees of freedom. As expected, in most cases, the MSE (Mean square error) gradually decreases as the number of explained degrees of freedom increases. Significant global F values for each of the candidate models indicate that at least one of the coefficients in the model differs from zero and therefore the model is of some use in predicting competitiveness.

The adjusted R2 statistics, as shown in Table 7.1 are small, and therefore indicate that the data do not fit the candidate models very well. When comparing the incremental analysis of the models overall, for 6, 9, 12 and 15 bidder data sets, it can be seen that the adjusted R2 statistics show an improvement up to the 9 bidder data set, after which there is a slight deterioration in this statistic for both the 12 bidder and 15 bidder data sets.

Turning to the utility of the individual models themselves, in terms of adjusted R2 and global F-values, it would appear that models 8, 12, 21, 18 and 22 out perform the other models in the 3, 6 and 9 bidder data sets. For the 12 and 15 bidder data sets, with the exception of model 8, the same set of models appear to be the better models together with models 19 and 20.

6 BIDDERS 5 TYPES						
Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2
1	0	360	3.25	0.009028	0.00	0.00
2	3	357	3.07	0.008599	10.47	0.05
3	7	353	2.97	0.008414	5.55	0.07
4	8	352	2.83	0.008040	7.46	0.11
7	12	348	2.76	0.007931	5.62	0.12
5	15	345	2.76	0.008000	4.38	0.11
6	18	342	2.71	0.007924	4.01	0.12
8	20	340	2.53	0.007441	5.09	0.18
9	22	338	2.63	0.007781	3.79	0.14
12	30	330	2.45	0.007424	3.72	0.18
10	32	328	2.51	0.007652	3.12	0.15
13	40	320	2.36	0.007375	3.09	0.18
14	42	318	2.40	0.007547	2.75	0.16
21	50	310	2.27	0.007323	2.73	0.19
11	52	308	2.44	0.007922	2.00	0.12
15	60	300	2.17	0.007233	2.53	0.20
16	62	298	2.25	0.007550	2.17	0.16
18	70	290	2.08	0.007172	2.36	0.21
17	72	288	2.07	0.007188	2.31	0.20
20	80	280	2.00	0.007143	2.22	0.21
19	82	278	1.97	0.007086	2.23	0.22
22	90	270	1.92	0.007111	2.10	0.21

9 BIDDERS 5 TYPES						
Mod No.	Exp df	Res	SSE	M S Error	F Value	Adj R2
1	0	513	5.62	0.010955	0.00	0.00
2	3	510	5.37	0.010529	11.87	0.04
3	7	506	5.23	0.010336	6.29	0.06
4	11	502	4.42	0.008805	13.63	0.20
5	15	498	4.98	0.010000	4.57	0.09
7	15	498	4.31	0.008655	10.81	0.21
8	23	490	4.03	0.008224	8.79	0.25
6	27	486	4.15	0.008539	6.62	0.22
9	31	482	4.05	0.008402	6.23	0.23
12	39	474	3.82	0.008059	5.88	0.26
10	47	466	3.96	0.008498	4.25	0.22
13	55	458	3.73	0.008144	4.30	0.26
14	63	450	3.75	0.008333	3.62	0.24
21	71	442	3.56	0.008054	3.65	0.26
11	79	434	3.73	0.008594	2.82	0.22
15	87	426	3.38	0.007934	3.28	0.28
16	95	418	3.45	0.008254	2.80	0.25
18	103	410	3.22	0.007854	3.00	0.28
17	111	402	3.28	0.008159	2.61	0.26
20	119	394	3.12	0.007919	2.68	0.28
19	127	386	3.10	0.008031	2.49	0.27
22	135	378	3.00	0.007937	2.46	0.28

12 BIDDERS 5 TYPES						
Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2
1	0	652	6.89	0.010567	0.00	0.00
2	3	649	6.58	0.010139	15.29	0.04
3	7	645	6.46	0.010016	7.16	0.05
4	14	638	5.59	0.008762	11.41	0.17
5	15	637	6.17	0.009686	5.31	0.08
7	18	634	5.22	0.008233	11.93	0.22
8	26	626	5.50	0.008786	6.33	0.17
6	36	616	5.21	0.008458	5.68	0.20
9	40	612	5.13	0.008382	5.38	0.21
12	48	604	4.84	0.008013	5.44	0.24
10	62	590	5.04	0.008542	3.55	0.19
13	70	582	4.82	0.008282	3.62	0.22
14	84	568	4.72	0.008310	3.15	0.21
21	92	560	4.51	0.008054	3.25	0.24
11	106	546	4.76	0.008718	2.33	0.18
15	114	538	4.42	0.008216	2.66	0.22
16	128	524	4.39	0.008378	2.35	0.21
18	136	516	4.09	0.007926	2.62	0.25
17	150	502	4.07	0.008108	2.33	0.23
20	158	494	3.96	0.008016	2.33	0.24
19	172	480	3.90	0.008125	2.15	0.23
22	180	472	3.81	0.008072	2.13	0.24

15 BIDDERS 5 TYPES						
Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2
1	0	776	8.38	0.010799	0.00	0.00
2	3	773	8.01	0.010362	17.85	0.04
3	7	769	7.79	0.010130	9.71	0.06
5	15	761	7.53	0.009895	6.14	0.08
4	17	759	6.80	0.008959	11.02	0.17
7	21	755	6.64	0.008795	9.89	0.19
8	29	747	6.39	0.008554	8.31	0.21
6	45	731	6.20	0.008482	5.84	0.21
9	49	727	6.06	0.008336	5.80	0.23
12	57	719	5.80	0.008067	5.71	0.25
10	77	699	6.03	0.008627	3.58	0.20
13	85	691	5.83	0.008437	3.60	0.22
14	105	671	5.50	0.008197	3.38	0 24
21	113	663	5.29	0.007979	3.46	0.26
11	133	643	5.67	0.008818	2.33	0.18
15	141	635	5.30	0.008346	2.64	0.23
16	161	615	5.13	0.008341	2.44	0.23
18	169	607	4.78	0.007875	2.72	0.27
17	189	587	4.73	0.008058	2.41	0.25
20	197	579	4.63	0.007997	2.39	0.26
19	217	559	4.52	0.008086	2.21	0.25
22	225	551	4.43	0.008040	2.19	0.26

Table 7.1: Summary of candidate model statistics for bidders modelled individually (for 6, 9, 12 and 15 bidders based on 5 contract types)

Since the basic objective of the best model selection is to find the best model which has a combination of the least number of variables and smallest MSE, overall it would appear that models 8 and 12 are good contenders for the best candidate model.

7.2.2 Results of the forward chunkwise sequential variable selection algorithm

The calculated F-test value for the candidate models was derived from applying the forward chunkwise sequential variable selection algorithm as shown in Chapter 5, Equation 5.2. This algorithm is based on the explained and residual degrees of freedom, SSE statistics and MSE. The F-test value has been calculated for each of the 22 candidate models in the 6, 9, 12 and 15 model data sets. Each model was tested in order of explained df (see Table 7.1). The model with the least number degrees of freedom was regarded as the null hypothesis and tested against the model with the next highest number of degrees of freedom which was regarded as the alternative hypothesis.

The chunkwise algorithm as applied to the 15 bidder analysis is shown here as an example of how the best model is determined. Starting with the model with the least number of explained df (ie. model 1) the models are tested. Compare model 1 with model 2. The F-statistic based on 3 and 773 df is :

$$F = [(8.38 - 8.01) / (3)] / 0.010362$$

$$F = 11.90$$

The approximate tabulated value for $F_{.05}$ based on 3 and 773 df obtained from the F-distribution is 2.61. Since the calculated F-value exceeds the tabulated F-value the null hypothesis is rejected. The conclusion is therefore that the variables in model 2 (ie. contract size) contribute to the prediction of competitiveness. Model 2, therefore, goes forward to be tested against the next model with the least number of explained degrees of freedom. This algorithm is repeated for all the candidate models.

Table 7.2 shows the resulting tabulated and calculated F values for the 15 bidder data set after applying the chunkwise algorithm to the Table 7.1 statistics. It appears that model 12 is the best model. Table 7.2 also shows the resulting tabulated and calculated F values together with the best model for the 6, 9 and 12 bidder data sets.

It should be noted that the vast majority of cases appear to follow the expected trend whereby models with more explained degrees of freedom have a lower MSE, thereby necessitating the use of the chunkwise algorithm to find the best model. There are, however, instances where models with more explained degrees of freedom also have a higher MSE than models with fewer degrees of freedom. For example, in respect of the 15 bidder data set, compare model 12 with model 10. With 57 explained degrees of freedom model 12 has a MSE of 0.008067, yet model 10 with 77 degrees of freedom has a MSE of 0.008627. Since the goal of the best model analysis is to find the model that produces the best combination of least number of explained variables coupled with a low MSE, a model with less explained degrees of freedom and a lower MSE must be better than a model with more explained variables and a larger MSE. In such cases the model with the least number of variables and lower MSE automatically qualifies as the best model.

It should be further noted that there are instances in which the number of explained degrees of freedom are identical for both the null and alternative hypotheses. Although there is not an example of this in the 15 bidder data set, an example can be seen in the 9 bidder data set with models 5 and 7. Both models have 15 explained degrees of freedom. In these instances due to the difference of number of degrees of freedom equalling zero it is not possible to compute the calculated F value. The best model for cases such as these can be found simply by comparing the MSE. The model with the smaller MSE is taken to be the best model. Model 5 has an MSE of 0.01000 as compared with model 7's MSE of 0.008655. Therefore in the comparison of these two models, model 7 goes forward as the best model and is then compared with the model with the next highest degrees of freedom.

6 BIDDERS 5 TYPES				9 BIDDERS 5 TYPES			
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.	Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	6.98	2.63	2	1 / 2	7.91	2.62	2
2 / 3	2.97	2.40	3	2 / 3	3.39	2.39	3
3 / 4	17.41	3.88	4	3 / 4	23.00	2.39	4
4 / 7	2.21	2.40	4	4 / 5	-	2.39	4
4 / 5	1.25	1.97	4	4 / 7	3.18	2.39	7
4 / 6	1.51	1.97	4	7 / 8	4.26	1.96	8
4 / 8	3.36	1.75	8	8 / 6	-	1.51	8
8 / 9	-	-	8	8 / 9	-	1.96	8
8 / 12	1.08	1.50	8	8 / 12	1.63	1.67	8
8 / 10	0.22	1.47	8	8 / 10	0.34	1.54	8
8 / 13	1.15	1.44	8	8 / 13	1.15	1.45	8
8 / 14	0.78	1.43	8	8 / 14	0.84	1.41	8
8 / 21	1.18	1.40	8	8 / 21	1.22	1.38	8
8 / 11	0.36	1.40	8	8 / 11	0.62	1.37	8
8 / 15	0.59	1.37	8	8 / 15	1.28	1.35	8
8 / 16	0.88	1.37	8	8 / 16	0.98	1.32	8
8 / 18	1.26	1.36	8	8 / 18	1.29	1.30	8
8 / 17	1.23	1.34	8	8 / 17	1.04	1.30	8
8 / 20	1.24	1.33	8	8 / 20	1.20	1.28	8
8 / 19	1.28	1.33	8	8 / 19	1.11	1.28	8
8 / 22	0.86	1.32	8	8 / 22	1.16	1.26	8

12 BIDDERS 5 TYPES				15 BIDDERS 5 TYPES			
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.	Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	10.19	2.61	2	1 / 2	11.90	2.61	2
2 / 3	3.00	2.38	3	2 / 3	5.43	2.38	3
3 / 4	14.19	2.03	4	3 / 5	3.28	1.95	5
4 / 5	-	-	4	5 / 4	40.74	3.01	4
4 / 7	11.23	2.39	7	4 / 7	4.55	2.38	7
7 / 8	-	-	7	7 / 8	3.65	1.96	8
7 / 6	0.07	1.44	7	8 / 6	1.40	1.48	8
7 / 9	0.49	1.59	7	8 / 9	1.98	1.59	9
7 / 12	1.58	1.48	12	9 / 12	4.03	1.96	12
12 / 10	-	-	12	12 / 10	-	1.59	12
12 / 13	0.11	1.58	12	12 / 13	-	1.48	12
12 / 14	0.40	1.35	12	12 / 14	0.76	1.37	12
12 / 21	0.93	1.40	12	12 / 21	1.14	1.35	12
12 / 11	0.16	1.36	12	12 / 11	0.19	1.31	12
12 / 15	0.77	1.34	12	12 / 15	0.71	1.29	12
12 / 16	0.67	1.31	12	12 / 16	0.77	1.27	12
12 / 18	1.08	1.30	12	12 / 18	1.16	1.26	12
12 / 17	0.93	1.28	12	12 / 17	1.01	1.25	12
12 / 20	1.00	1.27	12	12 / 20	1.05	1.24	12
12 / 19	0.93	1.26	12	12 / 19	0.99	1.23	12
12 / 22	0.97	1.26	12	12 / 22	1.01	1.23	12

Table 7.2: Summary of candidate model calculated and tabulated F values for bidders modelled individually (for 6, 9, 12 and 15 bidders based on 5 contract types)

As expected, Table 7.2 also shows the eventual best model varying more where there are fewer bidders in the data sample (ie. 9 or less bidders) before settling down to be more constant in the best model prediction. The reason for this is that the impact of adding more bidding attempts to the analysed data set decreases as the numbers of bidders are added to the analysis.

Depending on the number of bidders, models 8 and 12 are shown in Table 7.2 to be the best models. Model 8 comprises the three main effects (ie. S,T and B) with the contract type-contract size two-way interaction (ie. ST). Model 12 is closely related to this model in that it is made up of the same chunks as model 8, but with the addition of the contract size-bidder 2-way interaction (ie. SB). The results indicate that model 8 is the best model where the data sample contains fewer bidders. However, model 12 quite clearly becomes the dominant model when more bidders are added.

It is interesting to note that when comparing the calculated and tabulated F-values for model 8 and 12 in the 9 bidder data set it can be seen that the respective values are 1.63 and 1.67. The closeness of these values reflects that the significance is only marginal.

Turning to the 15 bidder data set, it can be seen that when comparing the calculated and tabulated F-values, the two models closest to model 12 in being the best model are models 21 and 18. These are closely related to the 12 bidder model in that they are made up of terms but also include one extra term. Model 21 includes the remaining 2-way interaction of bidder contract type (ie. BT). Model 18 include the 3-way interaction of bidder-contract type-contract size (ie. STB).

Model 12 appears to be the overall best model. The two principal contract type-bidder interaction chunks (ie. ST and STB) are eliminated. This indicates that competitiveness differences between contract types is not so influential as the contract size differences which are retained in the equation.

7.2.3 Mallow's Cp

To verify the F-test results, Mallow's Cp was computed and plotted for each of the subset regression models against the line Cp = p + 1 (see Figure 7.1). When comparing the 6, 9, 12 and 15 bidder models, it can be that the Cp scores fit more tightly around the line Cp = p + 1 as more bidders are included in the model. The closeness to the line implies that the models have a small total mean square and a negligible bias. It appears, therefore, that the best predicted models for the 6 bidder data set are somewhat bias since they are not close to the line Cp = p + 1.

The global F-values, adjusted R2 and chunkwise algorithm results and Mallow's Cp scores all provide supporting evidence that model 12 is the best overall candidate model. This is particularly so where 12 or more bidders included in the data set.

7.2.4 Sensitivity tests

Sensitivity tests were carried out by varying the contract type combination. The data was reanalysed first with the omission of fire stations and second with the omission of hostels. Fire stations were left out because this contract type has the least amount of data. Hostels were also omitted because, *prima facie,* this type appears to be most dissimilar. It is the only 'residential' contract type and the contract size appears to be more variable because the size of contract is largely dependent on the number of dwelling units contained within the contract.

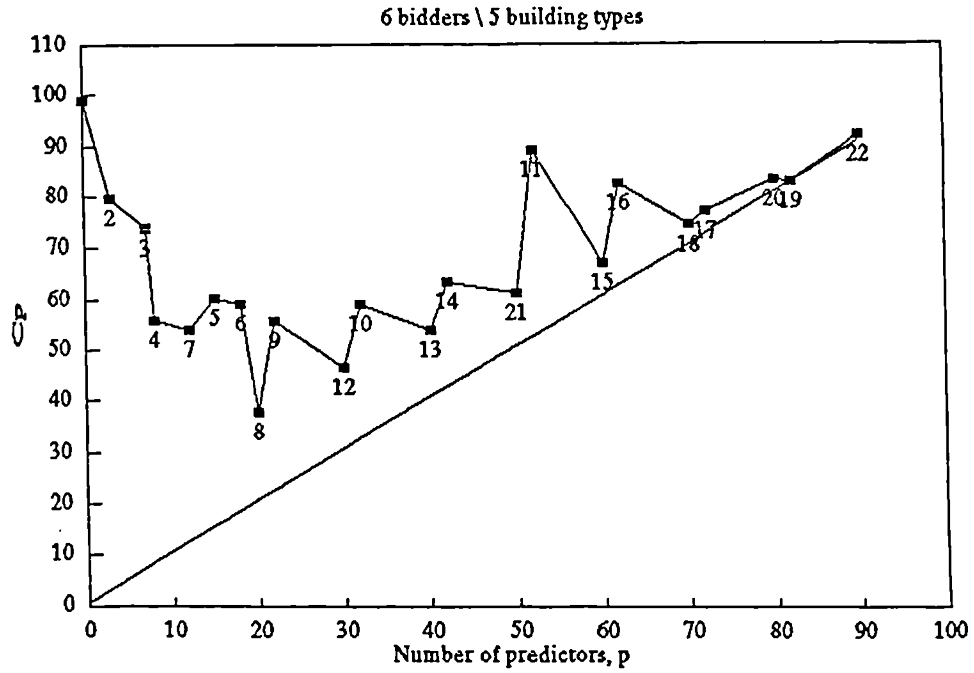
The analysis with fire stations omitted produced a similar set results as the five contract data set. However, there are some interesting differences. The global F-values and adjusted R2 statistics are slightly lower than the 5 contract type analysis (see Table 7.3). The F-test results show the best model to be model 12 (see Table 7.4). Mallows Cp results appear to verify the F-test results and also show the models having a better overall fit around the line Cp = p + 1 when compared to the 5 contract data set (compare Figure 7.1 with Figure 7.2).

4 CONTRACT TYPES (EXCLUDING FIRE STATIONS)							4 CONTRACT TYPES (EXCLUDING HOSTELS)						
Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2	Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2
1	0	634	6.66	0.010505	0.00	0.00	1	0	576	5.57	0.009670	0.00	0.00
2	3	631	6.30	0.009984	18.03	0.05	2	3	573	5.40	0.009424	9.02	0.03
3	6	628	6.19	0.009857	9.54	0.06	3	6	570	5.31	0.009316	5.58	0.04
5	12	622	5.97	0.009598	6.54	0.09	5	12	564	5.10	0.009043	4.73	0.06
4	17	617	5.54	0.008979	7.80	0.15	4	17	559	4.52	0.008086	8.12	0.16
7	20	614	5.44	0.008860	7.25	0.16	7	20	556	4.46	0.008022	7.28	0.17
8	26	608	5.22	0.008586	6.71	0.18	8	26	550	4.25	0.007727	6.83	0.20
6	45	589	5.13	0.008710	3.99	0.17	6	45	531	4.14	0.007797	4.17	0.19
9	48	586	5.03	0.008584	4.04	0.18	9	48	528	4.09	0.007746	4.07	0.20
12	54	580	4.82	0.008310	4.18	0.21	12	54	522	3.90	0.007471	4.22	0.23
10	62	572	5.01	0.008759	3.09	0.17	10	62	514	4.01	0.007802	3.28	0.19
13	68	566	4.83	0.008534	3.20	0.19	11	68	508	3.86	0.007598	3.36	0.21
14	90	544	4.62	0.008493	2.70	0.19	14	90	486	3.66	0.007531	2.85	0.22
21	96	538	4.45	0.008271	2.81	0.21	21	96	480	3.50	0.007292	2.99	0.25
11	104	530	4.68	0.008830	2.18	0.16	11	104	472	3.72	0.007881	2.28	0.18
15	110	524	4.41	0.008416	2.45	0.20	15	110	466	3.52	0.007554	2.49	0.22
16	132	502	4.30	0.008566	2.10	0.18	16	132	444	3.30	0.007432	2.33	0.23
18	138	496	4.08	0.008226	2.29	0.22	18	136	438	3.03	0.007032	2.58	0.27
17	146	488	4.10	0.008402	2.10	0.20	17	146	430	3.11	0.007233	2.35	0.25
20	152	482	3.98	0.008257	2.15	0.21	20	152	424	3.03	0.007146	2.35	0.26
19	174	460	3.84	0.008348	1.95	0.21	19	174	402	2.89	0.007189	2.15	0.26
22	180	454	3.81	0.008392	1.90	0.20	22	180	396	2.85	0.007197	2.11	0.26

Table 7.3: Summary of candidate model statistics for bidders modelled individually (for 15 bidders based on 4 contract types)

4 CONTRACT TYPES (EXCLUDING FIRE STATIONS)				4 CONTRACT TYPES (EXCLUDING HOSTELS)			
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.	Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	12.02	2.61	2	1 / 2	6.01	2.62	2
2 / 3	3.72	2.61	3	2 / 3	3.22	2.62	3
3 / 5	3.82	2.10	5	3 / 5	3.87	2.12	5
5 / 4	9.58	2.23	4	5 / 4	14.35	2.23	4
4 / 7	3.76	2.62	7	4 / 7	2.49	2.62	4
7 / 8	4.27	2.12	8	4 / 8	3.88	1.90	8
8 / 6	0.54	1.40	8	8 / 6	0.74	1.40	8
8 / 9	1.01	1.57	8	8 / 9	0.94	1.57	8
8 / 12	1.72	1.51	12	8 / 12	1.67	1.51	12
12 / 10	-	-	12	12 / 10	-	-	12
12 / 13	-	-	12	12 / 13	0.38	1.72	12
12 / 14	0.65	1.45	12	12 / 14	0.89	1.45	12
12 / 21	1.07	1.41	12	12 / 21	1.31	1.41	12
12 / 11	0.32	1.38	12	12 / 11	0.46	1.38	12
12 / 15	0.87	1.36	12	12 / 15	0.90	1.36	12
12 / 16	0.78	1.32	12	12 / 16	1.03	1.32	12
12 / 18	1.07	1.30	12	12 / 18	1.39	1.30	18
12 / 17	0.93	1.30	12	18 / 17	-	-	18
12 / 20	1.04	1.28	12	18 / 20	0.50	1.72	18
12 / 19	0.98	1.25	12	18 / 19	0.73	1.45	18
12 / 22	0.96	1.25	12	18 / 22	0.76	1.41	18

Table 7.4: Summary of candidate model calculated and tabulated F values for bidders modelled individually (for 15 bidders based on 4 contract types)



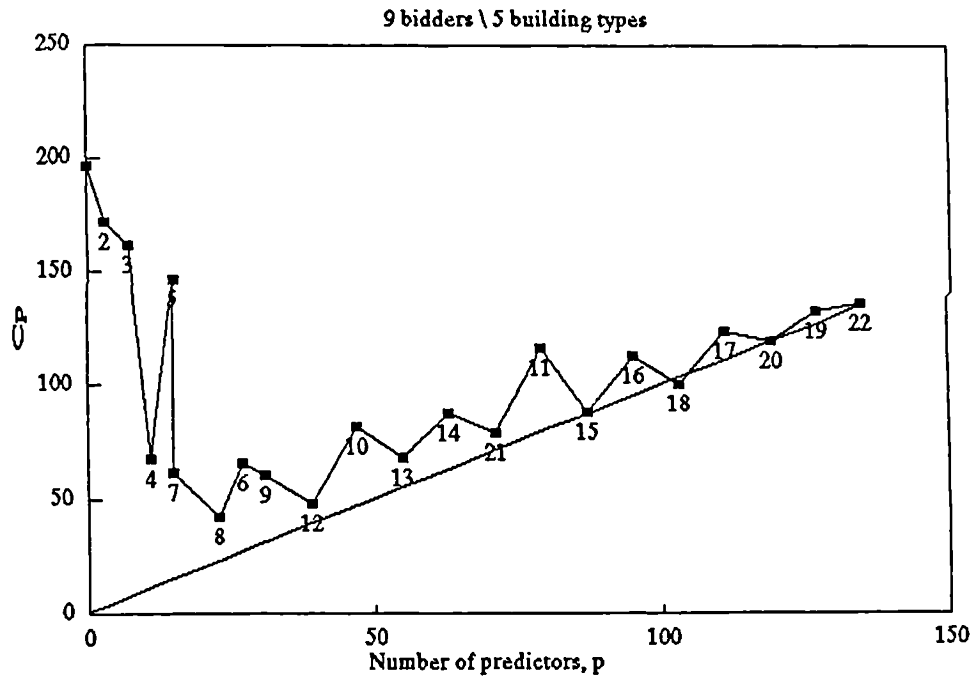
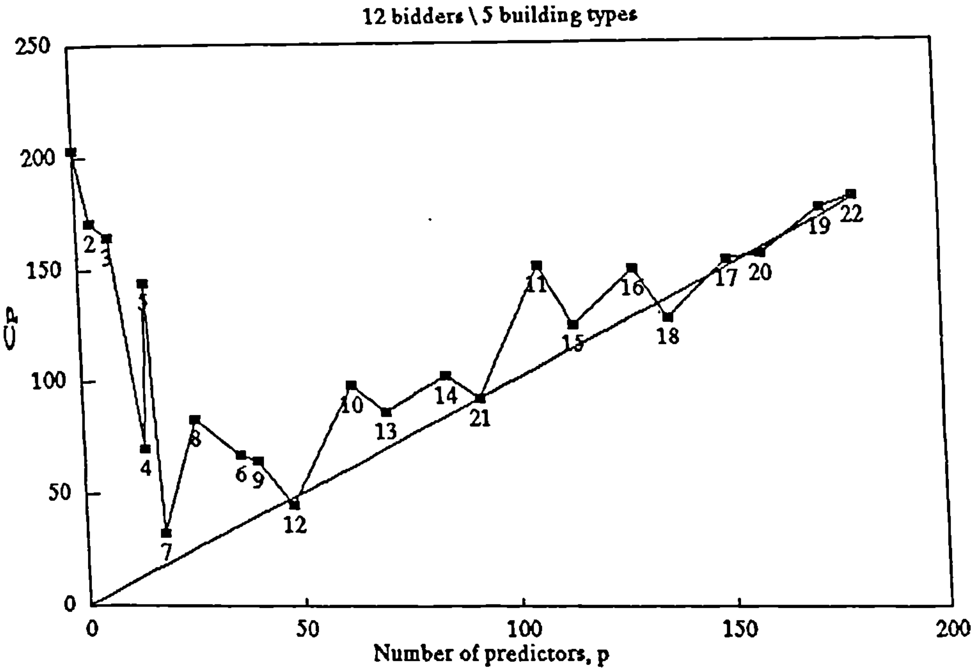


Figure 7.1 a: Candidate model plot of Mallow's Cp scores for bidders modelled individually (for 6 and 9 bidders based on 5 contract types)



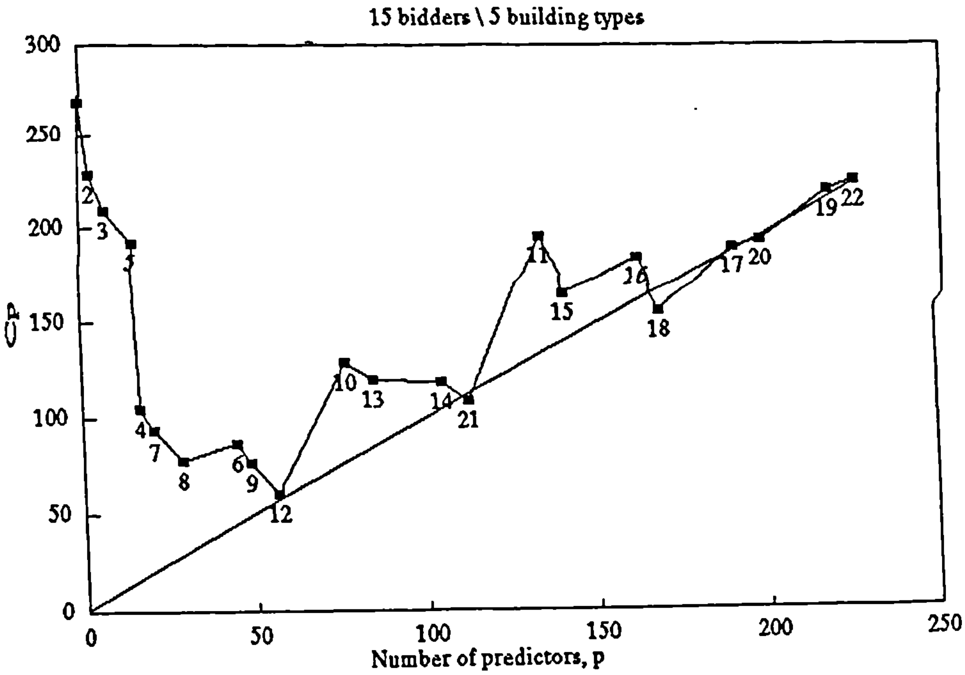
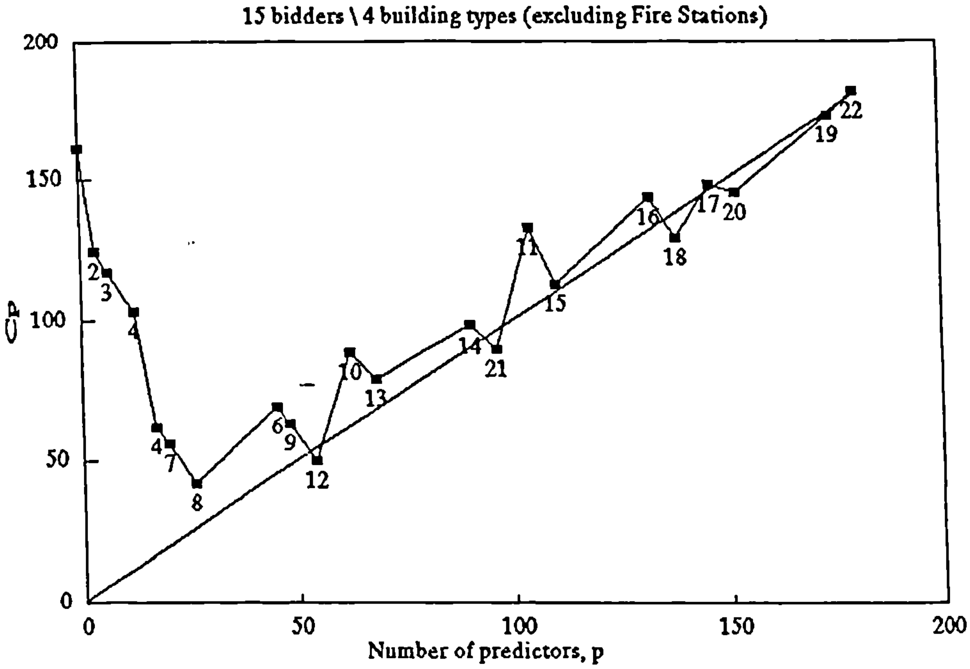


Figure 7.1 b: Candidate model plot of Mallow's Cp scores for bidders modelled individually (for 12 and 15 bidders based on 5 contract types)



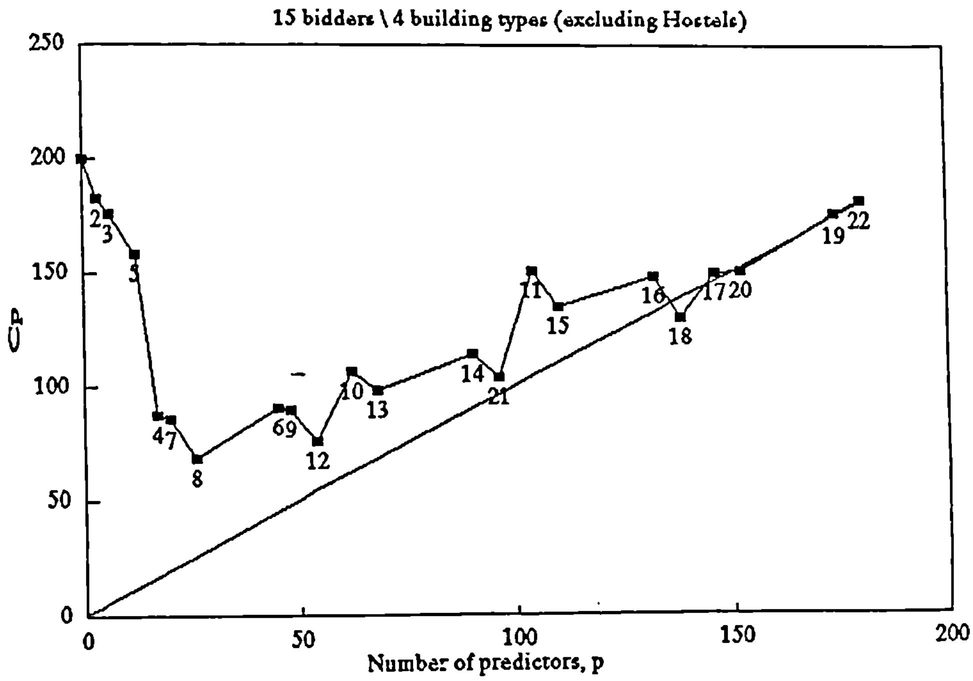


Figure 7.2: Candidate model plot of Mallow's Cp scores for bidders modelled individually (for 15 bidders based on 4 contract types)

The analysis with the hostels omitted produced a better set of results in terms of the global F-values. The adjusted R2 statistics are similar when compared to the 5 contract type bidder analysis (compare Table 7.1 with Table 7.3). In applying the F-test model 18 is adjudged to be the best model (see Table 7.4) and not model 12. However, the calculated and tabulated F-values for model 12 and 17 are close (1.39 and 1.30) which indicates that the significance is marginal. Mallows Cp results appear to concur with the F-test results and also show the models having a better overall fit around the line Cp = p + 1 when compared to the 5 contract data set (compare Figure 7.1 with Figure 7.2).

With fire stations omitted, the best model concurs with that in the five contract data set. However, with hostels omitted the best model is shown to be model 18. An explanation for model 18 and not model 12 being the best model may be that with hostels being left out of the data set the distribution of bidding attempts is less dispersed thereby making the differences between bidders for the remaining contract types more marked. The difference is enough for the three way interaction to be important thereby making model 18 the best model. The results are consistent in so far that the significance difference is only marginal and that model 18 is closely related to model 12. On balance the results support the evidence shown in the five contract type data set and, therefore, model 12, based on the bidding performance of 15 bidders, will go forward to the next stage of the analysis as the best model for the individual bidders.

7.3 Grouped bidder analysis

Using the Hong Kong Government classification system bidders were grouped into large, medium and small and the best model determined.

7.3.1 Utility of the candidate models

Table 7.5 shows the summary of the values (rounded) of SSE, MSE, df, global F values and adjusted R2 for the 22 candidate models.

Model no.	Explain df	Residual df	SSE	M S Error	F Value	Adj R2
1	0	2395	28.72	0.011992	0.00	0.00
2	3	2392	27.21	0.011375	66.37	0.05
4	5	2390	27.00	0.011297	38.06	0.06
3	7	2388	26.59	0.011135	31.88	0.07
6	9	2386	28.13	0.011790	6.26	0.02
7	9	2386	26.14	0.010956	29.44	0.09
9	13	2382	25.96	0.010898	21.10	0.09
5	15	2380	25.95	0.010903	18.15	0.09
8	17	2378	25.68	0.010799	17.59	0.10
10	17	2378	25.89	0.010887	16.25	0.09
12	21	2374	25.63	0.010796	14.31	0.10
14	21	2374	25.78	0.010859	13.54	0.09
13	25	2370	25.53	0.010772	12.34	0.10
11	25	2370	25.69	0.010840	11.65	0.10
21	29	2366	25.47	0.010765	10.78	0.10
16	29	2366	25.48	0.010769	10.74	0.10
15	33	2362	25.40	0.010754	9.65	0.10
17	33	2362	25.42	0.010762	9.58	0.10
18	37	2358	25.34	0.010746	8.74	0.10
19	37	2358	25.58	0.010848	8.94	0.10
20	41	2354	25.15	0.010684	8.35	0.11
22	45	2350	25.14	0.010698	7.61	0.11

Table 7.5: Summary of candidate model statistics for bidders modelled according to size (for all bidders based on 5 contract types)

As expected MSE shows the same characteristics as that in the individual bidder models. The adjusted R2 samples are poorer in comparison to the models based on individual bidders. The poor fit indicates that different size bidders appear not to behave in a similar way competitively as previously hypothesised - see Chapter 5, Figure 5.3. A possible alternative reason to explain the poor results is that Government criteria is a poor measure of bidder size. However, it is interesting to note that all the global F-values are significant and that the F-values are higher than the individual bidder model. The likely reason for this is that the individual bidder analysis is only based on a sub-set of the whole data set and, therefore, the number of degrees of freedom and corresponding F-values are smaller.

In respect of comparing the adjusted R2 values for the individual models it can be seen that there is a trend in which the adjusted R2 statistic slightly improves with the higher order models. From models 7 through to 22 the improvement is in fact very slight. Taking account the small differences in terms of numbers of variables and SSE between models, indications are that a higher order model is likely to be the eventual best model.

7.3.2 Results of the forward chunkwise sequential variable selection algorithm

The calculated F-test values for the candidate models, derived from applying the forward chunkwise sequential variable selection algorithm, are shown in Table 7.5. The same procedural approach was used in determining the best model as that shown in the individual bidder analysis.

Table 7.6 shows a summary of the F-test calculated and tabulated values resulting from the compared models together with the best model which is model 20. Only the contract size-bidder two-way interaction (ie. SB) is excluded. As all but one of the interaction variables remain in the best model, this would tend to suggest that different size bidders do not behave competitively in a similar way, at least according to this measure of bidder size, for each of the five contract types.

Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	44.25	2.60	2
2 / 4	9.29	2.99	4
4 / 3	18.41	2.99	3
3 / 6	-	-	3
3 / 7	20.54	2.99	7
7 / 9	4.13	2.37	9
9 / 5	0.92	1.69	9
9 / 8	6.48	2.37	8
8 / 10	-	-	8
8 / 12	1.16	2.37	8
8 / 14	-	-	8
8 / 13	1.74	1.94	8
8 / 11	0.00	0.00	8
8 / 21	1.63	1.75	8
8 / 16	1.55	1.75	8
8 / 15	1.63	1.64	8
8 / 17	1.51	1.64	8
8 / 18	1.58	1.57	18
18 / 19	-	-	18
18 / 20	4.45	2.37	20
20 / 22	0.23	2.37	20

Table 7.6: Summary of candidate model calculated and tabulated F values for bidders modelled according to size (for all bidders based on 5 contract types)

7.3.3 Mallow's Cp

To verify the chunkwise algorithm results, Mallow's Cp was computed and plotted for each of the subset regression models against the line Cp = p + 1 (see Figure 7.3). As can be seen the chunkwise algorithm results appear to concur with Mallow's Cp as the variables up to model 20 for the lowest bid combinations fall consistently above the line. This suggests that all of the preceding models are biased.

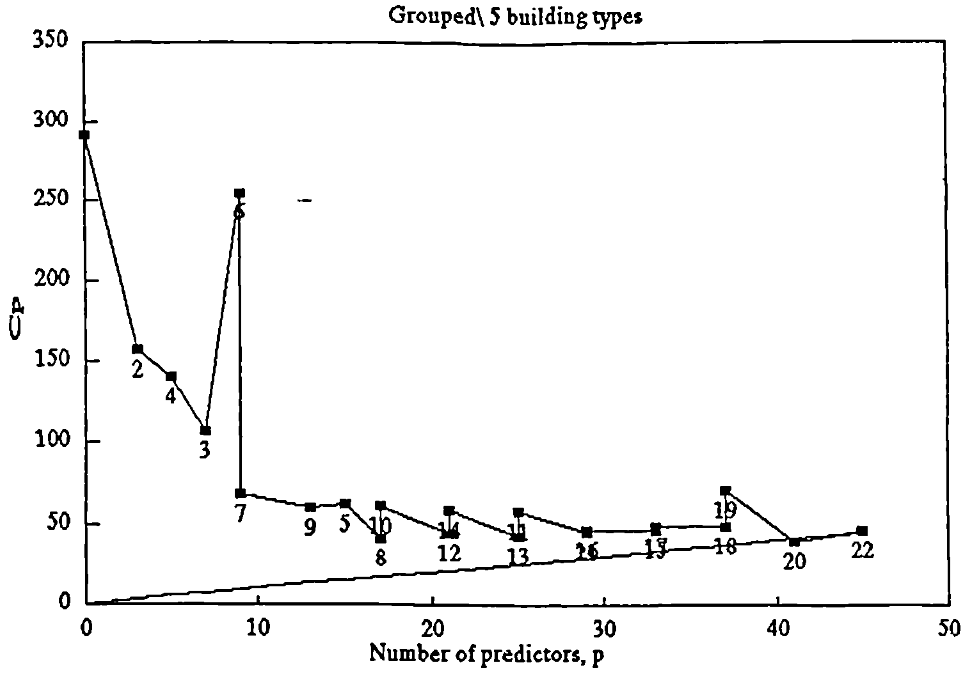


Figure 7.3: Candidate model plot of Mallow's Cp scores for bidders modelled according to size (for all bidders based on 5 contract types)

The results indicate that bidders do not behave competitively in a similar way according to contract type and size when the bidder sizes are grouped as small, medium and large. Evidence of this can be seen from observing the low adjusted R2 and also because a high order model is shown to be the best model.

7.3.4 Sensitivity tests

Sensitivity tests are also carried out for the bidders grouped according to size by omitting fire stations and hostels. This produced much the same results as the five contract type data set in that the global F-values are significant and the adjusted R2 statistics are of approximately the same magnitude (see Table 7.7). The chunkwise algorithm results also follow a similar pattern. Model 19 is shown to be the best predicted model where fire stations are omitted and model 20 where hostels are omitted (see Table 7.8). Mallow's Cp results are also consistent in that all the preceding models to these best predicted models are shown to be biased (see Figure 7.4).

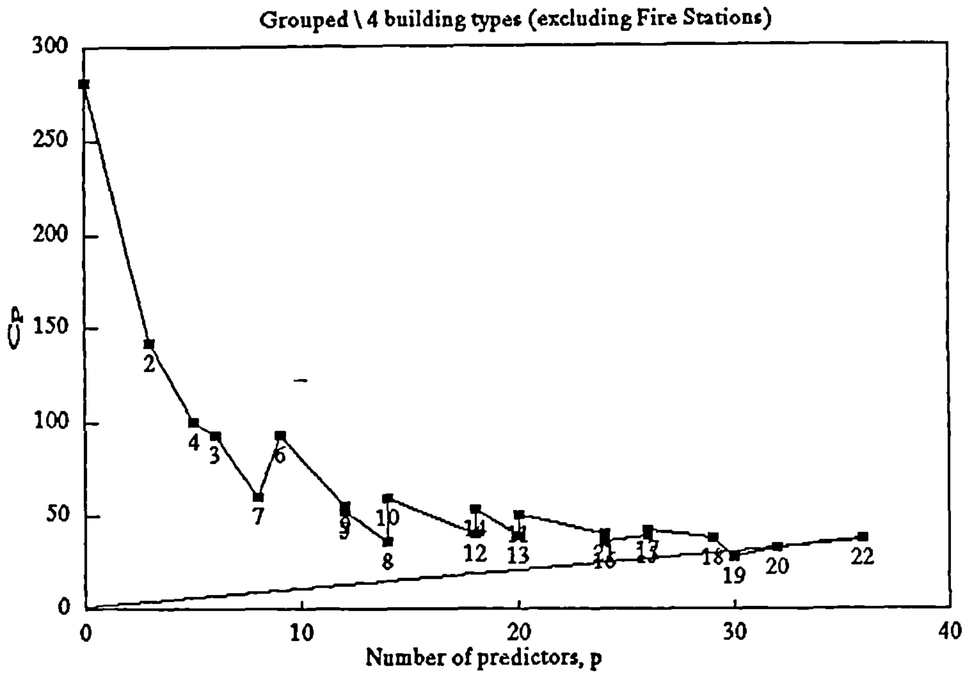
4 CONTRACT TYPES (EXCLUDING FIRE STATIONS)							4 CONTRACT TYPES (EXCLUDING HOSTELS)						
Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2	Mod No.	Exp df	Res	SSE	M S Error	F Value	Adj R2
1	0	1994	24.78	0.012427	0.00	0.00	1	0	1798	19.83	0.011029	0.00	0.00
2	3	1991	23.21	0.011657	67.34	0.06	2	3	1795	18.82	0.010485	48.17	0.05
4	5	1989	22.71	0.011418	45.32	0.08	4	5	1793	18.34	0.010229	36.42	0.07
3	6	1988	22.61	0.011373	38.16	0.08	3	6	1792	18.63	0.010396	23.09	0.06
7	8	1986	22.20	0.011178	32.97	0.10	7	8	1790	18.22	0.010179	22.60	0.08
6	9	1985	22.54	0.011355	24.66	0.09	6	9	1789	18.19	0.010168	20.16	0.08
9	12	1982	22.06	0.011130	22.22	0.10	9	12	1786	18.07	0.010118	15.81	0.08
5	12	1982	22.03	0.011115	22.49	0.11	5	12	1786	18.00	0.010078	16.51	0.09
8	14	1980	21.81	0.011015	20.74	0.11	8	14	1784	17.76	0.009955	15.99	0.10
10	14	1980	22.06	0.011141	18.78	0.10	10	14	1784	17.98	0.010078	14.12	0.09
12	18	1976	21.77	0.011017	16.07	0.11	12	18	1780	17.73	0.009961	12.40	0.10
14	18	1976	21.91	0.011088	15.23	0.11	14	18	1780	17.88	0.010045	11.42	0.09
13	20	1974	21.71	0.010998	14.69	0.12	13	20	1778	17.62	0.009910	11.74	0.10
11	20	1974	21.83	0.011059	14.04	0.11	11	20	1778	17.76	0.009989	10.91	0.09
21	24	1970	21.64	0.010985	12.43	0.12	21	24	1774	17.55	0.009893	10.02	0.10
16	24	1970	21.59	0.010959	12.66	0.12	16	24	1774	17.59	0.009915	9.82	0.10
15	26	1968	21.58	0.010965	11.67	0.12	15	26	1772	17.52	0.009887	9.35	0.10
17	26	1968	21.62	0.010986	11.51	0.12	17	26	1772	17.52	0.009887	9.35	0.10
18	29	1965	21.51	0.010947	10.67	0.12	18	30	1768	17.47	0.009881	8.24	0.10
19	30	1964	21.38	0.010886	10.77	0.12	19	30	1768	17.45	0.009870	8.32	0.11
20	32	1962	21.39	0.010902	10.03	0.12	20	32	1766	17.29	0.009790	8.37	0.11
22	36	1958	21.35	0.010904	8.99	0.12	22	36	1762	17.28	0.009807	7.43	0.11

Table 7.7: Summary of candidate model statistics for bidders modelled according to size (for all bidders based on 4 contract types)

4 CONTRACT TYPES (EXCLUDING FIRE STATIONS)				4 CONTRACT TYPES (EXCLUDING HOSTELS)			
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.	Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	44.89	2.60	2	1 / 2	32.11	2.60	2
2 / 4	21.90	2.99	4	2 / 4	23.46	2.99	4
4 / 3	8.79	3.84	3	4 / 3	-	-	4
3 / 7	18.34	2.60	7	4 / 7	3.93	2.60	7
7 / 6	-	-	7	7 / 6	2.95	3.84	7
7 / 9	3.14	2.37	9	7 / 9	3.71	2.37	9
9 / 5	-	-	5	9 / 5	-	-	5
5 / 8	9.99	1.69	8	5 / 8	12.05	1.69	8
8 / 10	-	-	8	8 / 10	-	-	8
8 / 12	0.91	2.37	8	8 / 12	0.75	2.37	8
8 / 14	-	-	8	8 / 14	-	-	8
8 / 13	1.52	2.09	8	8 / 13	2.35	2.09	13
8 / 11	-	-	8	13 / 11	-	-	13
8 / 21	1.55	1.83	8	13 / 21	1.77	2.37	13
8 / 16	2.01	1.83	16	13 / 16	0.76	2.37	13
16 / 15	0.46	1.94	16	13 / 15	1.69	2.09	13
16 / 17	-	-	16	13 / 17	0.00	2.09	13
16 / 18	1.46	2.21	16	13 / 18	1.52	1.83	13
16 / 19	3.22	2.09	19	13 / 19	0.00	1.83	13
19 / 20	-	-	19	13 / 20	2.81	1.75	20
19 / 22	0.46	2.09	19	20 / 22	0.25	2.37	20

Table 7.8: Summary of candidate model calculated and tabulated F values for bidders modelled according to size (for all bidders based on 4 contract types)

With hostels omitted, the best model concurs with that in the five contract data set. However, with fire stations omitted the best model is shown to be model 19. The likely reason for the inconsistency in best model prediction is due to the poor fit of the data to the models. It seems that there is very little difference in terms of predictive capability between the higher order models. The results are consistent with the five contract type data set in so far that they show a higher order model of at least six chunks to be the best model.



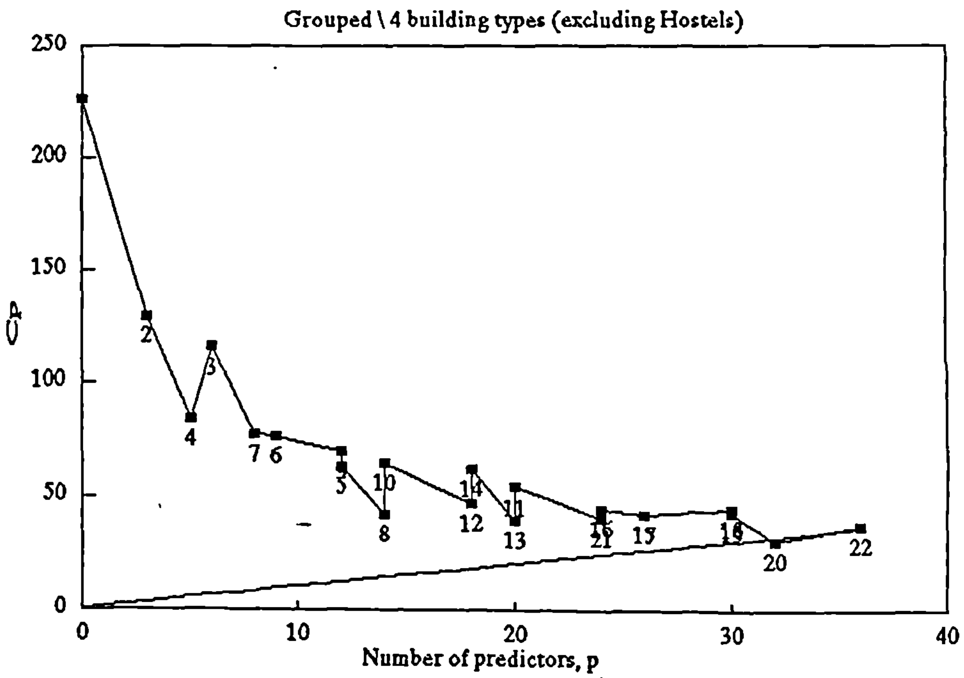


Figure 7.4 Candidate model plot of Mallow's Cp scores for bidders modelled according to size (for all bidders based on 4 contract types)

7.4 Comparison of grouped and individual bidder behaviour

The next stage of the analysis was to compare the results of the grouped and individual bidders to find which of the two models is the best predictor of competitiveness. This is accomplished by comparing the grouped bidder best model with the individual best model, based on the 15 bidder data set, using the same F-test methodology as previously described.

To make the data sets identical for comparative purposes, the same 15 bidders were grouped into large, medium and small according to the same criteria as previously described and the best model found. As can be seen from Table 7.9 the model utility statistics are poor. This is consistent with the group bidder analysis based on the whole data set (compare Table 7.5 with Table 7.9). Table 7.10, which displays the F-test results after applying the chunkwise algorithm, shows model 17 to be the eventual best model. The Cp results also indicate that all preceding models are biased (see Figure 7.5).

Model no.	Explain df	Residual df	SSE	M S Error	F Value	Adj R2
1	0	776	8.38	0.010799	0.00	0.00
2	3	773	8.01	0.010362	17.85	0.04
4	5	771	7.84	0.010169	13.28	0.06
3	7	769	7.79	0.010130	9.71	0.06
6	9	767	7.77	0.010130	7.53	0.06
7	9	767	7.65	0.009974	9.15	0.08
9	13	763	7.58	0.009934	6.71	0.08
5	15	761	7.53	0.009895	6.14	0.08
10	16	760	7.49	0.009855	6.02	0.09
8	17	759	7.40	0.009750	6.28	0.10
12	21	755	7.33	0.009709	5.41	0.10
14	21	755	7.45	0.009868	4.71	0.09
13	24	752	7.27	0.009668	4.99	0.10
11	25	751	7.28	0.009694	4.73	0.10
21	28	748	7.24	0.009679	4.36	0.10
16	29	747	7.25	0.009705	4.16	0.10
17	32	744	7.12	0.009570	4.25	0.11
15	33	743	7.18	0.009664	3.88	0.11
18	35	741	7.15	0.009649	3.75	0.11
19	37	739	7.08	0.009581	3.77	0.11
20	41	735	6.99	0.009510	3.65	0.12
22	45	731	6.98	0.009549	3.33	0.12

Table 7.9: Summary of candidate model statistics for bidders modelled according to size (for 15 bidders based on 5 contract types)

Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	11.90	2.61	2
2 / 4	8.36	3.00	4
4 / 3	2.47	2.61	4
4 / 6	1.73	2.38	4
4 / 7	4.76	2.38	7
7 / 9	1.76	2.38	7
7 / 5	1.83	1.69	5
5 / 10	4.06	1.64	10
10 / 8	9.23	3.85	8
8 / 12	1.80	2.38	8
8 / 14	-	-	8
8 / 13	1.92	2.02	8
8 / 11	1.55	1.95	8
8 / 21	1.50	1.80	8
8 / 16	1.29	1.76	8
8 / 17	1.95	1.67	17
17 / 15	-	-	17
17 / 18	-	-	17
17 / 19	0.84	2.22	17
17 / 20	1.52	1.89	17
17 / 22	1.13	1.73	17

Table 7.10: Summary of candidate model calculated and tabulated F values for bidders modelled according to size (for 15 bidders based on 5 contract types)

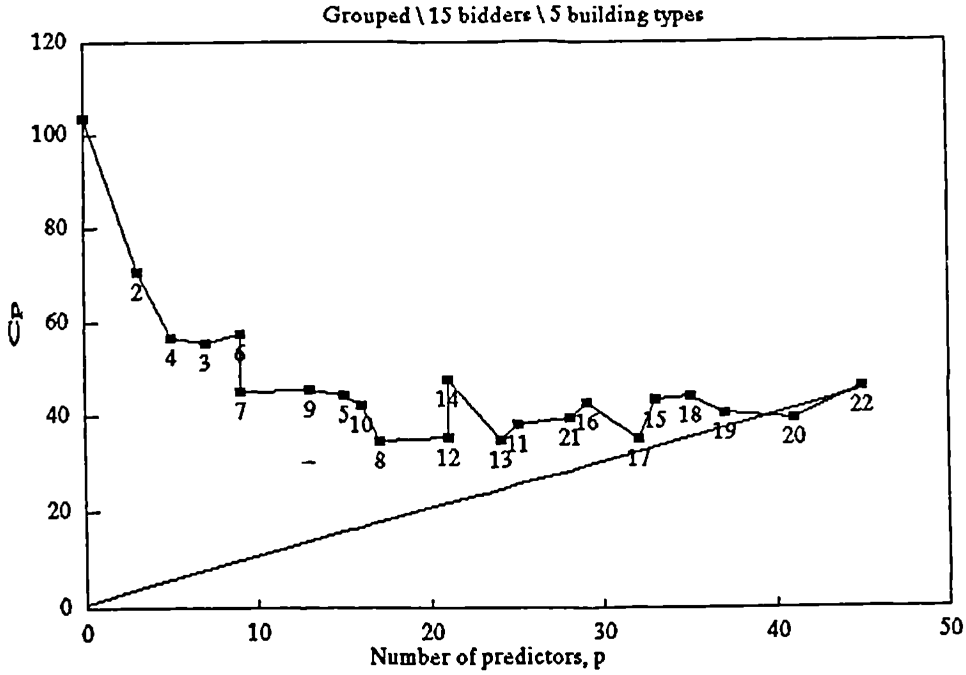


Figure 7.5: Candidate model plot of Mallow's Cp scores for bidders modelled according to size (for 15 bidders based on 5 contract types)

When viewing the best and individual model comparison summary, as shown in Table 7.11, it is perhaps no surprise to find that the individual best model is substantially better than the grouped best model.

MODEL ORDER BASED ON EXPLAINED DF					
Model No.	Explain df	Residual df	SSE	MS Error	
17 12	32 57	744 719	7.12 5.80	0.009570 0.008067	GROUPED INDIVIDUAL

SUMMARY OF MODEL COMPARISON TO DETERMINE THE BEST MODEL				
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.	
17 / 12	6.55	1.52	12	INDIVIDUAL

Table 7.11: Summary of best model statistics for bidders modelled individually and according to size, and corresponding best model summary of calculated and tabulated F values (for 15 bidders based on 5 contract types)

The likely reason for the poor results of the grouped bidder model is that the individual bidders contained within each bidder size group have different competitive performance patterns. Evidence of this can be seen by referring to Figure 9.4 (see Chapter 9), which illustrates the extent to which contract type and contract size affects the competitive performance of each of the 15 bidders.

Another possible reason for the poor results may be that the data set comprised contracts that were nearly all small to medium in size. A data sample with a greater diversity of contract sizes may have produced a different set of results. A set of larger contracts included in the sample is only likely to have a minimal effect on the small and medium bidders, as according to their definition, it is unlikely they would have enough resources to bid for these larger contracts. (In this instance they would in fact not be permitted to bid for the larger projects due to Government regulations). However, the impact of including larger contracts into the sample is likely to have an effect on the large bidders as it would produce a wider range of bidding attempts. If these bidders are more competitive on the larger contracts this would most likely influence the results. It would seem therefore that these results are inconclusive at providing evidence that large contractors are more competitive on larger contracts and vice versa.

The poor grouped bidder model utility statistics coupled with a high order 6 term model indicates that, in terms of competitiveness, there is little difference between large, medium and small bidders bidding for different sizes of contract types such as that contained in the data set. The results also show that a better competitiveness model is obtained by analyzing competitiveness according to individual bidding behaviour rather than that of grouped behaviour.

7.5 Testing the robustness of the individual best model

Up to this point in the analysis the robustness of the best model based on the individual behaviour of bidders has been tested by:

(1) adding bidders incrementally into the analysis up to and including the 15 bidder cut off point and determining the best model for each incremental increase;

(2) applying sensitivity tests by varying the combinations of contract types;

(3) comparing the best model based on individual bidding behaviour with the best model based on grouped bidding behaviour.

The robustness of the individual best model 12 was further tested by:

(1) recalculating the F-test results at 1% significance level;

(2) testing to see if the second order terms contribute to the prediction of competitiveness;

(3) determining the best model by excluding the alteration work contracts;

(4) comparing the measure of competitiveness shown in Equation 5.3 with another competitiveness measure.

7.5.1 F-test results at 1% significance level

The 5 contract type 15 bidder data set modelling individual bidders was reanalysed with the approximate values for $F_{.01}$ being taken from the 1% Points for the Distribution of F table to further test the robustness of model 12. As can be seen from Table 7.12, the best model still appears to be the best model thereby providing further support for using this model 12.

Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	2.03	3.80	1
1 / 3	5.32	3.34	3
3 / 5	4.54	2.53	5
5 / 4	23.55	4.62	4
4 / 7	4.30	3.34	7
7 / 8	4.75	2.53	8
8 / 6	1.40	1.72	8
8 / 9	0.87	1.89	8
8 / 12	2.23	1.73	12
12 / 10	-	-	12
12 / 13	0.08	1.73	12
12 / 14	0.49	1.56	12
12 / 21	0.94	1.52	12
12 / 11	-	-	12
12 / 15	0.55	1.44	12
12 / 16	0.61	1.41	12
12 / 18	1.09	1.41	12
12 / 17	0.81	1.37	12
12 / 20	0.95	1.35	12
12 / 19	0.95	1.34	12
12 / 22	1.03	1.34	12

Table 7.12: Summary of candidate model calculated and tabulated F values at 1% significance level for bidders modelled individually (for 15 bidders based on 5 contract types)

7.5.2 Testing whether second order terms contribute to the prediction of competitiveness

The best model based on the 5 contract type 15 bidder data set was found for the straight line interaction model by omitting all the squared terms and using the same F-test methodology as previously described. The linear and quadratic best model summary shown in Table 7.13 shows the calculated F-value exceeding the tabulated model in both cases. It can be concluded, therefore, that quadratic terms do contribute to the prediction of competitiveness and therefore should be retained in the best model.

MODEL ORDER BASED ON EXPLAINED DF					
Model No.	Explain df	Residual df	SSE	MS Error	
9 12	34 57	742 719	6.36 5.80	0.008571 0.008067	LINEAR QUADRATIC
SUMMARY OF MODEL COMPARISON TO DETERMINE THE BEST MODEL					
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.		
9 / 12	3.02	1.53	12		QUADRATIC

Table 7.13: Summary of best linear and quadratic model statistics for bidders modelled individually, and corresponding summary of calculated and tabulated F values (for 15 bidders based on 5 contract types)

7.5.3 New work only

The hypothesis that the best model, based on individual bidding behaviour, could be improved by omitting the alteration work from the analysis is tested using the 15 bidder 5 contract type data set. As can be seen from looking at model 1 in Table 7.14 the data set is reduced from 776 df to 640 df (approximately 20%). However, the SSE is more almost halved when compared to the analysis that includes alteration work (compare Table 7.14 with Table 7.1). Since contracts for alteration work are likely to be more smaller in terms of average contract size than that for new work this, perhaps, is not surprising. The likely reason for this outcome is that there are greater differences in the competitiveness measure for smaller contracts than that for larger contracts (see Chapter 5, Footnote 5 for explanation). What, however, is surprising is that the adjusted R2 is lower for the new work only sample of data when compared to the data that compares both new work and alteration work. The reason for this, can clearly be seen by viewing the estimated prediction equations shown later in the analysis (see Chapter 9, Figures 9.3 and 9.4). By comprising mainly smaller contracts of greater competitiveness differences, the bidding attempts for alteration work is actually supporting a better fit of the quadratic regression line to the data.

Model no.	Explain df	Residual df	SSE	M S Error	F Value	Adj R2
1	0	640	4.91	0.007672	0.00	0.00
2	3	637	4.82	0.007567	5.95	0.01
3	7	633	4.58	0.007235	7.60	0.06
5	15	625	4.53	0.007248	3.74	0.06
4	17	623	4.13	0.006629	7.35	0.14
7	21	619	3.91	0.006317	7.92	0.18
8	29	611	3.85	0.006301	6.01	0.18
6	45	595	3.86	0.006487	3.68	0.15
9	49	591	3.62	0.006125	4.39	0.20
12	57	583	3.55	0.006089	3.99	0.21
10	77	563	3.53	0.006270	2.90	0.18
13	85	555	3.47	0.006252	2.74	0.19
14	105	535	3.23	0.006037	2.68	0.21
21	113	527	3.16	0.005996	2.61	0.22
11	133	507	3.10	0.006114	2.24	0.20
15	141	499	3.05	0.006112	2.17	0.20
16	161	479	2.84	0.005929	2.18	0.23
18	169	471	2.78	0.005902	2.15	0.23
17	189	451	2.61	0.005787	2.11	0.25
20	197	443	2.55	0.005756	2.09	0.25
19	217	423	2.48	0.005863	1.92	0.24
22	225	415	2.46	0.005928	1.85	0.23

Table 7.14: Summary of candidate model statistics with bidders modelled individually for new work only (for 15 bidders based on 5 contract types)

Table 7.15 shows the eventual best predicted model based on the F-test as model 20. However, the difference between this and model 9 in terms of significance is only very marginal. It can be seen that the respective tabulated and calculated values are 1.25 and 1.26 respectively.

Mallow's Cp for the subset regression models (see Figure 7.6) shows a poorer fit than to that of the data set which contains both new work and alteration work (compare Figure 7.6 with Figure 7.4). One of the purposes of analyses of this kind is to attempt and find a good model which can be fitted to similar sets of data. It is only to be expected that by dividing the data up different best models will prevail because of different data set characteristics. There is no apparent evidence that dividing the data set up in this way improves the likely predictive ability of the model. It is for these reasons that the data set containing both new and alteration work will be continue to be further analysed rather than using a data set that contains new work only.

It should be noted that due to the data limitations, it is not possible to undertake a study of solely alteration work.

Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	3.96	2.62	2
2 / 3	8.29	2.39	3
3 / 5	0.86	1.95	3
3 / 4	6.79	1.84	4
4 / 7	8.71	2.39	7
7 / 8	1.19	1.95	7
7 / 6	0.91	1.40	7
7 / 9	1.69	1.51	9
9 / 12	1.44	1.95	9
9 / 10	0.51	1.49	9
9 / 13	0.67	1.45	9
9 / 14	1.15	1.35	9
9 / 21	1.20	1.34	9
9 / 11	1.01	1.30	9
9 / 15	1.01	1.29	9
9 / 16	1.17	1.27	9
9 / 18	1.19	1.26	9
9 / 17	1.25	1.25	9
9 / 20	1.26	1.25	20
20 / 19	0.60	1.60	20
20 / 22	0.54	1.52	20

Table 7.15: Summary of candidate model calculated and tabulated F values with bidders modelled individually for new work only (for 15 bidders based on 5 contract types)

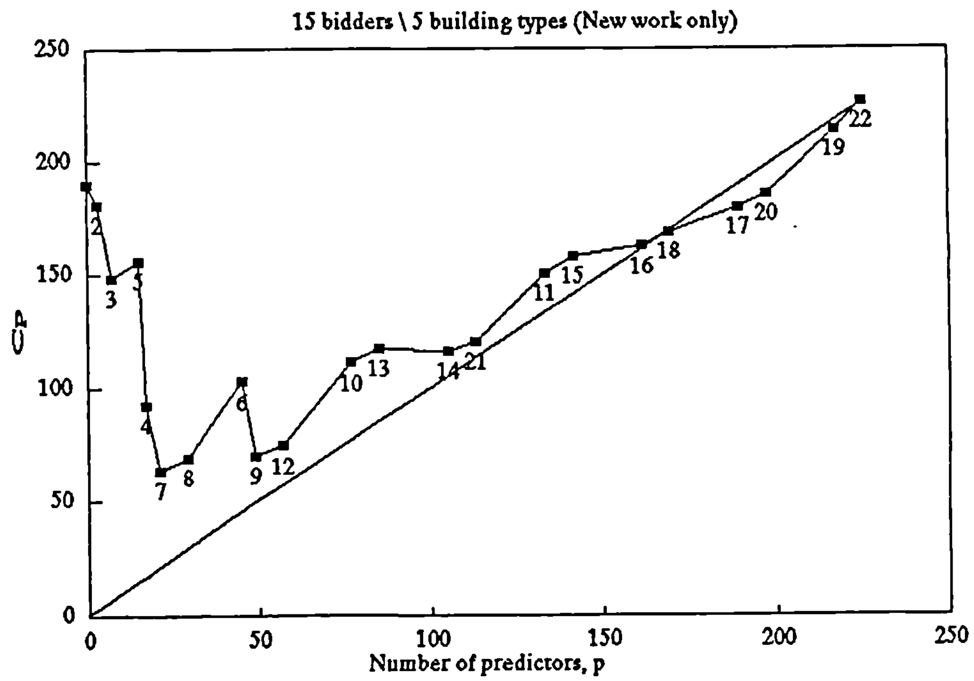


Figure 7.6: Candidate model plot of Mallow's Cp scores with bidders modelled individually for new work only (for 15 bidders based on 5 contract types)

7.5.4 Comparison of competitiveness measures

The measure of competitiveness used in this analysis, based on the ratio of lowest bid to bidder's bid (see Equation 5.1), was compared with the ratio of bidder's bid to lowest bid (see Equation 5.3) to determine measure which is the better predictor of competitiveness.

The model utility statistics resulting from this measure are presented in Table 7.16. The statistics are slightly inferior to those based on the original competitiveness measure (compare Table 7.1 to 7.16). This indicates a poorer fit to the data.

Table 7.17 shows a comparison of the calculated and tabulated F-values from comparing the chunkwise algorithm and shows model 12 to be the eventual best model thereby supporting the previous findings. Mallow's Cp results, shown in Figure 7.7 support this finding.

Model no.	Explain df	Residual df	SSE	M S Error	F Value	Adj R2
1	0	776	24.33	0.031353	0.00	0.00
2	3	773	23.27	0.030103	17.61	0.04
3	7	769	22.63	0.029428	9.63	0.06
5	15	761	21.75	0.028581	6.45	0.09
4	17	759	20.28	0.026719	9.47	0.15
7	21	755	19.83	0.026265	8.57	0.16
8	29	747	18.97	0.025395	7.54	0.19
6	45	731	18.35	0.025103	5.41	0.20
9	49	727	17.98	0.024732	5.35	0.21
12	57	719	17.10	0.023783	5.43	0.24
10	77	699	18.04	0.025808	5.21	0.18
13	85	691	17.40	0.025181	3.28	0.20
14	105	671	16.31	0.024307	3.17	0.22
21	113	663	15.66	0.023620	3.28	0.25
11	133	643	17.46	0.027154	1.92	0.13
15	141	635	16.15	0.025433	2.30	0.19
16	161	615	15.49	0.025187	2.19	0.20
18	169	607	14.35	0.023641	2.51	0.25
17	189	587	14.03	0.023901	2.29	0.24
20	197	579	13.77	0.023782	2.27	0.24
19	217	559	13.56	0.024258	2.06	0.23
22	225	551	13.34	0.024211	2.03	0.23

Table 7.16: Summary of candidate model statistics for bidders modelled individually using competitiveness measure of bidder's bid to lowest bid (for 15 bidders based on 5 contract types)

Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	11.74	3.01	2
2 / 3	5.44	2.22	3
3 / 5	3.85	1.95	5
5 / 4	27.51	3.01	4
4 / 7	4.28	2.38	7
7 / 8	4.23	1.96	8
8 / 6	1.54	1.40	6
6 / 9	3.74	1.40	9
9 / 12	4.63	1.96	12
12 / 10	-	-	12
12 / 13	-	-	12
12 / 14	0.68	1.37	12
12 / 21	1.09	1.37	12
12 / 11	-	-	12
12 / 15	0.44	1.29	12
12 / 16	0.61	1.27	12
12 / 18	1.04	1.26	12
12 / 17	0.97	1.25	12
12 / 20	1.00	1.24	12
12 / 19	0.91	1.23	12
12 / 22	0.92	1.23	12

Table 7.17: Summary of candidate model calculated and tabulated F values for bidders modelled individually using competitiveness measure of bidder's bid to lowest bid (for 15 bidders based on 5 contract types)

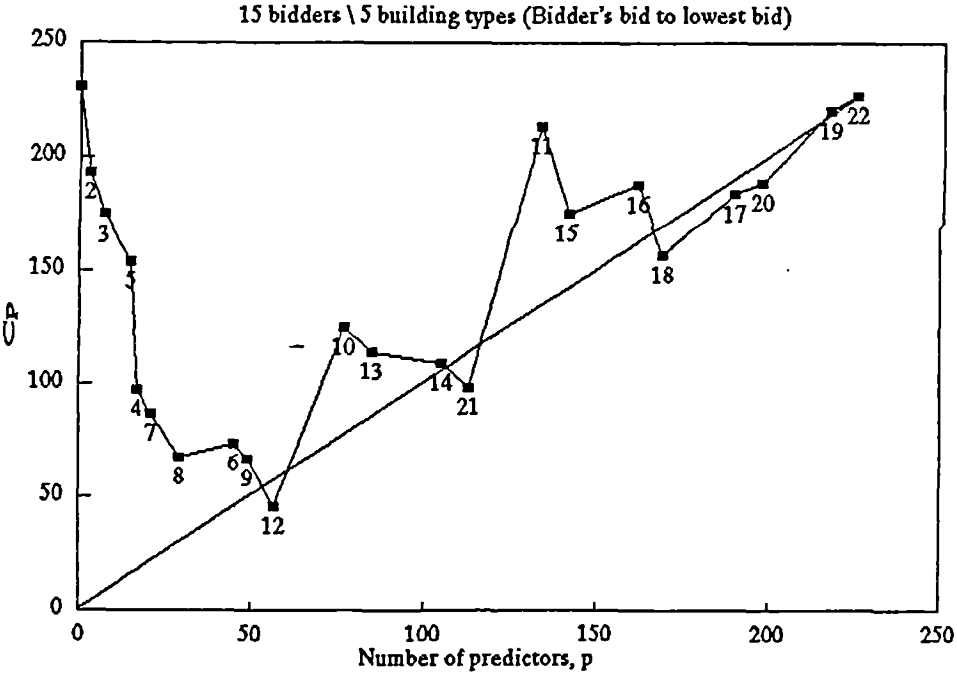


Figure 7.7: Candidate model plot of Mallow's Cp scores for bidders modelled individually using competitiveness measure of bidder's bid to lowest bid (for 15 bidders based on 5 contract types)

7.6 Summary

The foregoing analysis provides evidence that the candidate models based on individual bidder behaviour fits the data considerably better than those based on grouped bidder behaviour. This can be seen by referring to the candidate model utility statistics and best model analysis based on the F-test.

With regard to grouped bidder behaviour, in both the five contract data set and sensitivity analysis, based on four contract data sets, a high order 6 term model was selected as the best model. This, together with the poor model utility statistics, indicates that small, medium and large bidders do not behave in the manner that was originally hypothesised ie. smaller bidders are more competitive on smaller contracts and vice versa. Bidder size, therefore, appears to have little influence, in terms of competitiveness, on contract size. The suspected reason for the poor results of the grouped bidder model is that the individual bidders contained within each bidder size group have different performance patterns. However, this may be due to a possible data sampling error in that the sample contains almost exclusively small and medium contracts, thereby constraining the range of bidding attempts made by large bidders.

In respect of the candidate model based on individual bidder behaviour, model 12 is shown to be the best candidate model overall and is reasonably robust when bidders are added incrementally into the analysis. In addition to performing well in the 4 contract type sensitivity analysis, it out performed the grouped behaviour model.

When the 5 contract type 15 bidder data sample is reanalysed at 1% significance level model 12 is also found to be the best model.

However, when the data set was reduced to new work only it was found that the overall candidate model utilities were poorer than that contained in the data set which comprised both new work and alteration work and that model 17 prevailed as the best model. It is only to be expected that when subdividing the data set other best models will prevail because of different data set characteristics. As there is no apparent evidence that dividing the data set up in this manner improves the predictive ability of the model and since one of the main purposes of analyses this kind is to attempt to find a reasonably robust model to fit similar sets of data, on the evidence shown it seems that model 12 is the best model and also to work with the data set which comprises both new and alteration work.

The second order terms in the model appear to contribute to the prediction of competitiveness. The measure of competitiveness used in this analysis, based on the ratio of lowest bid to bidder's bid (ie. Equation 5.1), when compared with the ratio of bidder's bid to lowest bid (ie. Equation 5.3) is found to be a better predictor of competitiveness.

The candidate models based on the lowest bid to bidder's bid (ie. Equation 5.1) appear to fit slightly better than those based the ratio of bidder's bid to lowest bid (ie. Equation 5.3). This is probably due to the logarithmic nature of the former scale in which outliers have less of an adverse influence on the model prediction.

CHAPTER 8

Satisfying the regression assumptions

8 SATISFYING THE REGRESSION ASSUMPTIONS

8.1 Introduction

The best candidate model was determined in the previous chapter by using a forward chunkwise sequential variable selection algorithm based on the F-test. The results were verified by using Mallow's Cp and also by referring to the model utility statistics (ie. global F-value and adjusted R2 statistics). It was concluded that the best model to be selected for further analysis is model 12. This model is based on the individual bidding performance of 15 bidders towards 5 contract types using an inverse ratio measure of competitiveness. The robustness of this best model was also tested according to a variety of different procedures.

Having selected the best model, this chapter considers the reliability of this model by examining the residuals to see if one or more of the standard least squares assumptions is violated. Each assumption is examined in turn and where necessary the model is modified to accommodate the assumption to produce a final model which is not only closest to satisfying these assumptions but also the best predictor of the dependent variable, competitiveness.

Although the reliability of other candidate models could have been tested, examining the residuals of best model was considered sufficient. As demonstrated in the previous chapter, this model appears to be a reasonably robust. Another consideration for not testing the other candidate models was because of time constraints. Examining the residuals of every candidate model and adjusting it so as to satisfy all of the regression assumptions would be a very time-consuming and labourious process.

8.2 Regression assumptions

8.2.1 Multicollinearity

Multicollinearity (ie. excessive interdependency between independent variables) can be detected in several ways. An obvious approach is to examine the large coefficients in a pairwise correlation matrix - values of over 0.9 usually signalling the presence of multicollinearity (Glantz and Slinker 1990: 531). One of the most frequently used indicators of interdependency is the tolerance (ie., the proportion of variability in an independent variable not explained by other independent variables) between independent variables. It is possible for a variable not in the equation to have an acceptable tolerance level but when entered to cause the tolerance of other variables already in the equation to become unacceptably small. Thus, as a matter of routine, the tolerances of all the variables in the equation are recomputed at each step. A popular approach is to check out the situation more carefully if either the tolerance of the variable or the tolerance of any variable already in the equation is less than 0.0001 (Norusis 1988: 176).

One reason why the t-tests on the individual B parameters are non-significant is because the standard errors of the estimates are inflated in the presence of multicollinearity. Thus a more formal method for detecting multicollinearity involves the calculation of variance inflation factors (VIFs) for the individual B parameters. In practice, a severe multicollinearity problem can be assumed to exist if the largest of the VIFs is greater than 10 (Neter et al, 1983).

A pairwise correlation matrix was produced for all 56 variables. For the vast majority of cases the sample correlation coefficients between variables were small. It is the high correlations that are of interest and for the sake of brevity only those correlations that exceed 0.70 have been reported in Table 8.1. As can be seen the correlations exceeding 0.70 were found either in the pairwise correlations between the corresponding interactions with and without the squared term or between the categorical variables and their corresponding interactions with the continuous independent variable, bid. The one exception was the correlation between BID2 and J2BID2. The highest pairwise correlation was 0.942 for B14BID and B14BID2. Those with pairwise correlations over 0.90 are particularly indicative of severe multicollinearity in the model.

Variables	Correlation	Variables	Correlation
BID v BID2	0.884	B1BID v B1BID2	0.919
B1 v B1BID	0.756	B2BID v B2BID2	0.921
B2 v B2BID	0.798	B3BID v B3BID2	0.886
B3 v B3BID	0.732	B4BID v B4BID2	0.861
B4 v B4BID	0.815	B5BID v B5BID2	0.926
B5 v B5BID	0.755	B6BID v B6BID2	0.873
B6 v B6BID	0.801	B7BID v B7BID2	0.937
B7 v B7BID	0.853	B8BID v B8BID2	0.876
B8 v B8BID	0.812	B9BID v B9BID2	0.881
B9 v B9BID	0.810	B10BID v B10BID2	0.931
B11 v B11BID	0.773	B11BID v B11BID2	0.873
B12 v B12BID	0.806	B12BID v B12BID2	0.914
B13 v B13BID	0.860	B13BID v B13BID2	0.928
B14 v B14BID	0.881	B14BID v B14BID2	0.942
J1 v J1BID	0.815	J1BID v J1BID2	0.890
J3 v J3BID	0.892	J2BID v J2BID2	0.842
J4 v J4BID	0.826	J3BID v J3BID2	0.901
BID2 v J2BID2	0.769	J4BID v J4BID2	0.924

Table 8.1 : Pairwise correlation matrix between variables with correlations over 0.70

Mendenhall and Sinich (1993: 276) point out that when fitting a polynomial regression model, such as the model being analyzed, the independent variables will often be correlated due the relationship between the variables with a squared term and those corresponding first order variables. Evidence of this can clearly be seen in the pairwise correlation matrix. It can be seen from Figure 8.1 that all of the variables have been successfully entered into the regression equation indicating that the analyzed model does not have any excessive computational problems caused by variables having extremely small tolerances of less than 0.0001. However, the tolerance values for most of the independent variables do still tend to be rather small. This indicates that a potentially troublesome situation exists and may cause the variances of the estimators to be inflated.

**** MULTIPLE REGRESSION ****

Equation Number 1 Dependent Variable .. DEP

Multiple R	.55509
R Square	.30812
Adjusted R Square	.25024
Standard Error	.08981

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	56	2.58284	.04162
Residual	719	5.79967	.00807

F = 5.71789 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF
J4BID2	1.97596E-05	2.1964E-05	.180359	.023941	41.770
B2	.122896	.066453	.322950	.031555	31.690
B8BID2	2.84589E-04	1.6296E-04	.241125	.050476	19.811
B3BID2	1.01748E-04	1.1706E-04	.409633	.004332	230.820
B13BID2	3.19022E-04	2.5621E-04	.193852	.039702	25.187
B7BID2	-6.88147E-05	3.9164E-04	- .026678	.041743	23.956
B9BID2	2.66231E-04	1.4750E-04	.281263	.039630	25.234
J1BID2	-8.44920E-05	9.3640E-05	- .135819	.042470	23.546
J2BID2	2.86203E-05	1.6224E-05	.390135	.019673	50.830
B12	.142977	.072009	.318148	.037480	26.681
B4BID	- .005745	.006718	- .260190	.010396	96.191
B14	.340967	.079591	.750552	.031350	31.898
B10	.035682	.063778	.083503	.043198	23.149
B5BID2	7.99980E-05	1.2539E-04	.209884	.008891	112.476
J3	.105935	.038144	.374687	.052867	18.215
B1BID2	1.48761E-04	1.2011E-04	.484592	.006286	159.093
B11	.041340	.067313	.093928	.041139	24.308
B6	.071123	.067415	.175607	.034732	28.792
J2	.027759	.018858	.105199	.188396	5.308
B10BID2	-4.25291E-05	1.2209E-04	- .119673	.008153	122.658
B3	.100655	.063550	.254679	.037218	26.868
B8	.115400	.067625	.277624	.036356	27.506
B5	.065898	.066879	.161331	.035894	27.860
B12BID2	1.00811E-04	1.1786E-04	.539985	.002415	414.143
B2BID2	3.27209E-05	1.2144E-04	.102179	.006691	149.450
B9	.051427	.068081	.120347	.037910	26.378
J1	- .059039	.034517	- .214068	.061435	16.277
J3BID2	7.28725E-04	1.5721E-04	.612274	.055151	18.132
B1	.143786	.063813	.401376	.030326	32.975
J4	- .002080	.031148	- .008153	.064571	15.487
B14BID2	1.60167E-04	1.2335E-04	.579094	.004838	206.683
B13	.173122	.074958	.372623	.036968	27.050
B11BID2	4.77197E-05	1.1594E-04	.491686	6.743E-04	1482.956
B7	.115672	.071584	.278278	.032446	30.820
B4	.060978	.067416	.154287	.033071	30.238
B6BID2	6.21594E-05	1.1595E-04	.667166	6.213E-04	1609.417
B4BID2	9.96254E-05	1.2795E-04	.165799	.021221	47.123
B10	.004244	.005916	.745886	8.903E-04	1123.180
B3BID	- .007934	.006143	- .539722	.005510	181.492
J2BID	- .002988	.001286	- .422618	.029106	34.358
B8BID	- .014005	.007426	- .452407	.016722	59.802
B9BID	- .011493	.007157	- .411352	.014663	68.199
B10BID	.003294	.006504	.173403	.008209	121.823
B11BID	- .002243	.006097	- .235132	.002355	424.612
B1BID	- .010086	.006312	- .696392	.005067	197.368
B5BID	- .004318	.006657	- .248571	.006552	152.630
B2BID	- .003198	.006424	- .218412	.004998	200.065
B13BID	- .016672	.009166	- .489116	.013308	75.141
B12BID	- .008904	.006370	- .720649	.003620	276.216
B7BID	.003563	.010303	.089064	.014511	68.913
B6BID	- .004334	.006091	- .499845	.001950	512.767
J3BID	- .023121	.005128	-1.028039	.018510	54.026
J1BID	.004822	.004170	.266023	.018177	55.016
B14BID	- .014993	.006777	-1.124853	.003722	268.661
J4BID	- .001719	.001880	- .256712	.012205	81.936
BID2	-7.30274E-05	1.1501E-04	-1.218821	2.612E-04	3829.179
(Constant)	.086010	.059658			

Figure 8.1 Tolerance values and variance inflation factors of variables entered into the equation

Evidence of severe multicollinearity being present in the model can be found when referring to the VIF column in Figure 8.1 which shows all but one of the 56 variables attaining a VIF greater than 10. Thus there would appear to be severe multicollinearity present and this needs to be rectified before proceeding to test the model against the other regression assumptions.

8.2.1.1 Correcting multicollinearity

To correct multicollinearity Glantz and Slinker (1990) suggest that, if the multicollinearity is structural, it can often be dealt with by centring the measured independent variables on their mean values before computing the power (ie squared) terms and interaction (ie. cross-product) terms specified by the regression equation).

Another approach to overcoming the multicollinearity problem is to drop one or more of the independent variables. This can be done by using a sequential variable selection technique such as backward, forward or stepwise regression. These techniques 'often avoid producing a model with serious multicollinearity among the independent variables by sequentially selecting candidate independent variables based on how much independent information each one contains about the dependent variable, allowing for the information contained in the variables already in the regression equation' (Glantz and Slinker 1990: 262). Backward stepwise regression is considered a more conservative approach in variable selection than forward stepwise regression because by starting off with all the variables in the equation it avoids the problem of occasionally stopping too soon.

To correct multicollinearity in polynomial regression models Mendenhall and Sinich (1993: 277) recommend transforming the x variable in such a way that the correlation between the x- and x^2 is substantially reduced.

It will be seen in the subsequent analysis that a combination of all three approaches is used to bring multicollinearity down to an acceptable level.

To reduce the severity of the multicollinearity the measured independent variable bid was centred to zero by deducting the sample mean bid value of HK$19.910 million. Figure 8.2 shows that there is a definite improvement in that all the VIF values have been reduced. However, severe multicollinearity still prevails as 21 of the 56 variables have a VIF above the critical value of 10.

To diminish the effect of multicollinearity further, backwards stepwise regression was used to delete all of the insignificant independent variables from the equation. As can be seen from Figure 8.3 the number of independent variables was reduced from 56 to 29. Once again this produced a reduction in multicollinearity. Now only three of the remaining 29 variables have a VIF greater than 10. Aside from reducing multicollinearity it should be noted that when comparing the adjusted R2 values of 0.25424 (with 56 variables) and 0.26267 (with 29 variables) there is a marginal improvement in the predictive power of the model.

To further reduce multicollinearity to an acceptable level the x-variable was transformed by applying various exponential functions ranging from 0.1 to 0.9. Transforming the x-variable by the natural log was also used. In order that the equations remain centred at zero, the sample mean bid value of the exponential or natural log value was deducted for each transformation.

Table 8.2 shows the largest VIF obtained by a variable in the equation, the number of variables left in the equation together with their respective R2 and adjusted R2 values according to each x-variable transformation. As can be seen the x-variable transformations to which all variables in the equation have acceptable VIF in which all the variables are below 10 are the exponentials of 0.90, 0.75, 2/3, 1/3, 0.25, 0.1 and the natural log.

Of these, the transformation with the best predictive capability as judged by the adjusted R2 is where the x-variable has been transformed using the exponential function of 2/3. Figure 8.4 shows the improved VIF and tolerance levels for all of the remaining variables using this x-variable transformation.

**** MULTIPLE REGRESSION ****

Equation Number 1	Dependent Variable ..	DEP	
Multiple R	.55509		
R Square	.30812		
Adjusted R Square	.25424		
Standard Error	.08981		
Analysis of Variance			
	DF	Sum of Squares	Mean Square
Regression	56	2.58284	.04162
Residual	719	5.79967	.00807
F = 5.71789	Signif F = .0000		

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF
J4BID2	1.97596E-05	2.1964E-05	.092673	.090680	11.028
B5	.011638	.028993	.028493	.190997	5.236
B3BID	-.003882	.001987	-.179906	.113503	8.810
B9BID2	2.66231E-04	1.4750E-04	.121028	.214031	4.672
B13BID2	3.19022E-04	2.5621E-04	.102039	.143294	6.979
J2BID2	2.86203E-05	1.6224E-05	.276352	.039209	25.505
B8BID2	2.84589E-04	1.6296E-04	.123424	.192651	5.191
J1BID	.001457	.001156	.061142	.408751	2.446
B4BID2	9.96254E-05	1.2795E-04	.070289	.118076	8.469
B7BID2	-6.88147E-05	3.9164E-04	-.030295	.032371	30.892
B12	.005658	.026844	.012591	.269703	3.708
B14BID	-.008615	.002398	-.361145	.095244	14.499
B10	.084402	.031865	.197515	.173051	5.779
B2BID	-.001895	.002063	-.078046	.133236	7.505
B1BID	-.004163	.001991	-.188803	.117983	8.476
B5BID	-.001132	.002133	-.043183	.145446	6.875
B3	-.016974	.026215	-.042948	.218716	4.572
J3BID	.005897	.002343	.216560	.129970	7.694
B2	.072203	.026483	.189737	.198687	5.033
B11	.015604	.027285	.035454	.250376	3.994
B4BID	-.001778	.002222	-.052384	.224594	4.452
B10BID	.001600	.002127	.067319	.120180	8.321
J2	-.020397	.011610	-.077298	.497040	2.012
B1	.001939	.026765	.005414	.172388	5.801
B9BID	-8.91352E-04	.002287	-.024408	.245405	4.075
J1BID2	-8.44920E-05	9.3640E-05	-.047680	.344611	2.902
B12BID	-.004890	.002241	-.255634	.070112	14.263
B6	.009467	.026905	.023374	.218058	4.586
J4	-.028470	.011696	-.111580	.457958	2.184
B14	.105946	.027690	.233213	.259019	3.861
B11BID	-3.42526E-04	.001990	-.025874	.042603	23.473
B8BID	-.002673	.002419	-.076736	.199426	5.014
B3BID2	1.01748E-04	1.1706E-04	.222516	.014682	68.109
B4	-.013920	.028579	-.035221	.184025	5.434
B6BID	-.001859	.001973	-.151413	.037262	26.837
B13	-.032354	.032213	-.069637	.200171	4.996
B1BID2	1.48761E-04	1.2011E-04	.208374	.033995	29.416
B2BID2	3.27209E-05	1.2144E-04	.042095	.039424	25.365
B9	-.071856	.030924	-.168156	.183741	5.442
B5BID2	7.99980E-05	1.2539E-04	.085325	.053796	18.589
B10BID2	-4.25291E-05	1.2209E-04	-.056940	.036013	27.768
B7	.159338	.041568	.383330	.096222	10.393
J2BID	-.001849	7.5581E-04	-.196077	.149770	6.677
J3	-.065525	.019290	-.231759	.206716	4.838
B8	-.050626	.032053	-.121794	.161832	6.179
J1	.003465	.018867	.012565	.205629	4.863
B14BID2	1.60167E-04	1.2335E-04	.238465	.028533	35.048
J3BID2	7.28725E-04	1.5721E-04	.336200	.182914	5.467
B13BID	-.003969	.003657	-.091674	.134807	7.418
B12BID2	1.00811E-04	1.1786E-04	.299314	.007859	127.245
B11BID2	4.77197E-05	1.1594E-04	.343999	.001378	725.882
J4BID	-9.32026E-04	.001100	-.089067	.087078	11.484
B6BID2	6.21594E-05	1.1595E-04	.458007	.001318	758.481
B7BID	8.23095E-04	.007418	.024365	.019957	50.197
BID	.001336	.001783	.234860	.009805	101.998
BID2	-7.30274E-05	1.1501E-04	-.803075	6.015E-04	1662.498
(Constant)	.141567	.023217			

Figure 8.2 Tolerance values and variance inflation factors of variables entered into the equation after centring the independent continuous variable

**** MULTIPLE REGRESSION ****

Equation Number 1 Dependent Variable .. DEP

Variable(s) Removed on Step Number
83.. B4BID2

Multiple R	.53875
R Square	.29026
Adjusted R Square	.26267
Standard Error	.08930

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	29	2.43308	.08390
Residual	746	5.94944	.00798

F = 10.52011 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF
B3BID	-.002476	9.4868E-04	-.114723	.492255	2.031
B9BID2	2.50096E-04	9.4418E-05	.113693	.516419	1.936
B13BID2	3.35149E-04	1.0022E-04	.107197	.925841	1.080
B8BID2	3.06837E-04	1.1374E-04	.133073	.391030	2.557
J1BID	.001626	7.8889E-04	.068237	.868225	1.152
B14BID	- .007944	.001654	-.332988	.197871	5.054
B10	.062571	.016163	.146428	.665043	1.504
B1BID	- .003202	9.0046E-04	-.145244	.570350	1.753
J3BID	.005504	.002096	.202125	.160554	6.228
B2	.075829	.012814	.199264	.839055	1.192
B10BID	.001547	9.0390E-04	.065074	.657985	1.520
B12BID	- .003976	.001440	-.207879	.167976	5.953
J4	- .022922	.008724	-.089839	.813745	1.229
B14	.104700	.017119	.230470	.670011	1.493
B3BID2	8.46878E-05	2.7257E-05	.185207	.267746	3.735
B6BID	- .001610	7.5848E-04	-.131091	.249329	4.011
B1BID2	1.43813E-04	3.3514E-05	.201443	.431731	2.316
B9	- .071845	.018371	-.168131	.514749	1.943
B5BID2	8.16311E-05	3.4663E-05	.087067	.696063	1.437
B7	.126965	.013682	.305448	.878175	1.139
J2BID	-9.12454E-04	4.2897E-04	-.096770	.449671	2.175
J3	- .059731	.016962	-.211267	.264319	3.783
B8	- .040277	.020471	-.096896	.392265	2.549
B14BID2	1.62341E-04	4.9776E-05	.241702	.173226	5.773
J3BID2	6.73716E-04	1.5126E-04	.310821	.195354	5.119
B12BID2	1.01323E-04	3.1755E-05	.300832	.107030	9.343
B11BID2	6.38962E-05	1.9995E-05	.460611	.045793	21.837
B6BID2	7.85980E-05	2.1372E-05	.579131	.038364	26.066
BID2	-6.09158E-05	1.9522E-05	-.669885	.020644	48.440
(Constant)	.135391	.005852			

Figure 8.3 Tolerence values and variance inflation factors of variables entered into the equation after (1) centring the independent continous variable, bid and (2) backwards stepwise regression

**** MULTIPLE REGRESSION ****

Equation Number 1 Dependent Variable .. DEP

Variable(s) Removed on Step Number
86.. B11

Multiple R	.55923
R Square	.31274
Adjusted R Square	.28888
Standard Error	.08770

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	26	2.62155	.10083
Residual	749	5.76096	.00769

F = 13.10908 Signif F = .0000

--- Variables in the Equation ---------------------------------------

Variable	B	SE B	Beta	Tolerance	VIF
B10	.079240	.020111	.185434	.414263	2.414
B3BID	- .006187	.002564	-.076284	.918248	1.089
B13BID2	.003481	.001103	.097574	.960211	1.041
B9BID2	.002822	.001276	.093099	.518205	1.930
J2BID2	3.34026E-04	1.2969E-04	.112955	.477218	2.095
B8BID2	.002713	.001147	.101766	.495860	2.017
B14BID	- .021166	.003908	-.207052	.627920	1.593
B1BID	- .009256	.003062	-.101074	.820818	1.218
B2	.081119	.014740	.213167	.611556	1.635
B1BID2	.001431	4.9804E-04	.093387	.868558	1.151
J3	- .042175	.015849	-.149172	.291983	3.425
B10BID	.007231	.003516	.075467	.681520	1.467
J2	- .018464	.009681	-.069973	.681743	1.467
B14	.123084	.017513	.270939	.617441	1.620
J3BID2	.007191	.001576	.319058	.187584	5.331
J4	- .031613	.009104	-.123900	.720659	1.388
B10BID2	- .001882	6.8199E-04	-.122605	.464704	2.152
B8	- .039205	.017893	-.094317	.495204	2.019
B9	- .076932	.018222	-.180033	.504629	1.982
B2BID2	- .001420	6.9720E-04	-.077442	.634949	1.575
J1BID2	- .002013	9.4793E-04	-.071654	.806257	1.240
J2BID	- .007550	.001948	-.177164	.439237	2.277
B7	.148705	.020704	.357749	.369861	2.704
B12BID	- .007917	.002552	-.095750	.963181	1.038
J3BID	.022575	.009320	.217630	.113657	8.798
B7BID	.012649	.005964	.105610	.369981	2.703
(Constant)	.140395	.006474			

Figure 8.4 Tolerence values and variance inflation factors of variables entered into the equation after (1) centring the independent continuous variable, bid and (2) backwards stepwise regression (3) transforming the x-variable according to the exponential function of 2/3

	**0.90	**0.75	**2/3	**0.5	**1/3	**0.25	**0.1	Natural Log
R Square	0.29688	0.30821	0.31274	0.31611	0.30164	0.28719	0.24310	0.31085
Adjusted R Square	0.27248	0.28420	0.28888	0.29048	0.27740	0.25784	0.21787	0.28791
Number of variables in equation	26	26	26	28	26	25	25	25
Largest variance inflation factor	6.377	7.441	8.798	15.726	6.956	6.510	3.648	4.166

Table 8.2 : Regression summary statistics and largest variance inflation factor in the equation after (1) centring the independent continuous variable (2) using backwards stepwise regression and (3) transforming the x-variable according to expotential functions of 0.9, 0.75, 2/3, 0.5, 1/3, 0.25, 0.1 and natural log

Variables	Correlation	Variables	Correlation
BID v BID2	-	B1BID v B1BID2	0.203
B1 v B1BID	-	B2BID v B2BID2	-
B2 v B2BID	0.092	B3BID v B3BID2	-
B3 v B3BID	-	B4BID v B4BID2	-
B4 v B4BID	-	B5BID v B5BID2	-
B5 v B5BID	-	B6BID v B6BID2	-
B6 v B6BID	-	B7BID v B7BID2	-
B7 v B7BID	-0.789	B8BID v B8BID2	-
B8 v B8BID	-	B9BID v B9BID2	-
B9 v B9BID	-	B10BID v B10BID2	-0.117
B11 v B11BID	-	B11BID v B11BID2	-
B12 v B12BID	-	B12BID v B12BID2	-
B13 v B13BID	-	B13BID v B13BID2	-
B14 v B14BID	-0.600	B14BID v B14BID2	-
J1 v J1BID	-	J1BID v J1BID2	-
J3 v J3BID	-	J2BID v J2BID2	0.644
J4 v J4BID	-	J3BID v J3BID2	-0.870
BID2 v J2BID2	-	J4BID v J4BID2	-

Table 8.3: Pairwise correlation matrix between variables left in the equation

Further evidence of improvement in multicollinearity can also be seen when comparing the pairwise correlation matrix in Table 8.3 with that of Table 8.1. Observe that all of the remaining pairwise correlations have been reduced. It can be seen that the highest pairwise correlation is -0.870 which is for J3BID and J3BID2. As this amended model appeared to be reasonably satisfactory, it was next checked against the remaining regression assumptions.

8.2.2 Normality

A further assumption of regression analysis is that the members of the underlying population are normally distributed about the regression plane. This assumption can be tested by examining the distribution of the residuals. The simplest procedure is to plot the frequency distribution of the residuals to see if the distribution looks normal. However, according to Glantz and Slinker (1990) it is difficult for the inexperienced eye to determine visually whether the distribution of the residuals significantly deviates from normality and a better graphical test may be undertaken by constructing a normal probability plot of the residuals, as normal probability plots are regarded as a more sensitive qualitative indicator of deviations from normality than a frequency distribution.

Although it is suggested that looking at the normal probability plot is probably more informative than testing (Glantz and Slinker 1990: 130), the normality aspect can be formally tested by using the Kolmogorov-Smirnov test (Kenkel 1989: 932). This tests the null hypothesis that the distribution of residuals is normal against the alternative hypothesis that the distribution is not normal.

Figure 8.5 shows a histogram of the standardised residuals with a superimposed outline of the normal distribution. The distribution of the residuals appears to be fairly normal, though it is a bit more 'peaked' than would be expected. Also, there are five outliers (residuals with standardized residual values greater than 3), appearing on the negative side, suggesting that the distribution is slightly skewed.

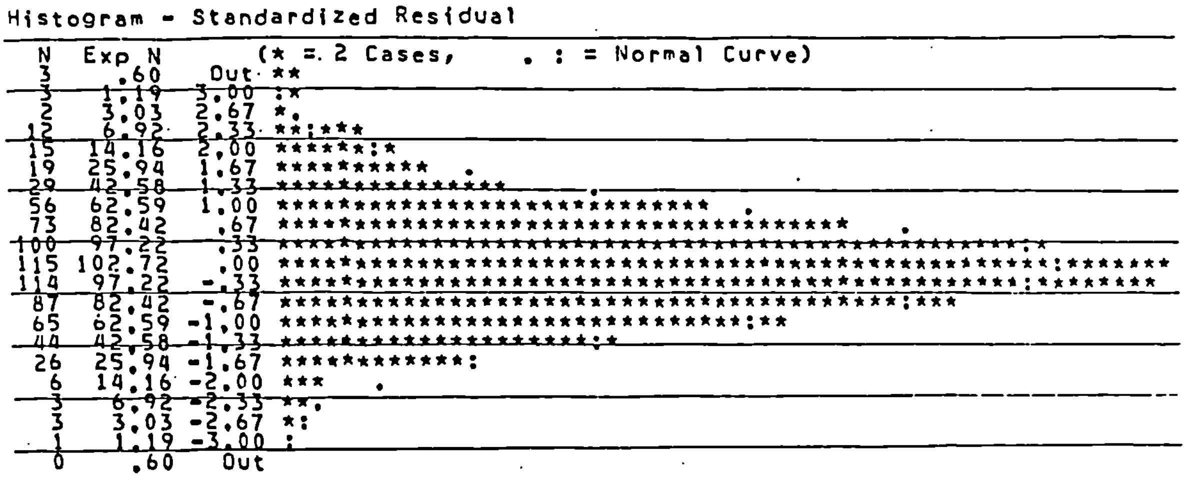


Figure 8.5: Histogram of standardised residuals

The degree of skewness can be seen with more clearly with the aid of the normal probability plot (Figure 8.6) which shows the residuals displaying very light tailed errors, so light in fact that the errors may, in this instance, be interpreted as normal.

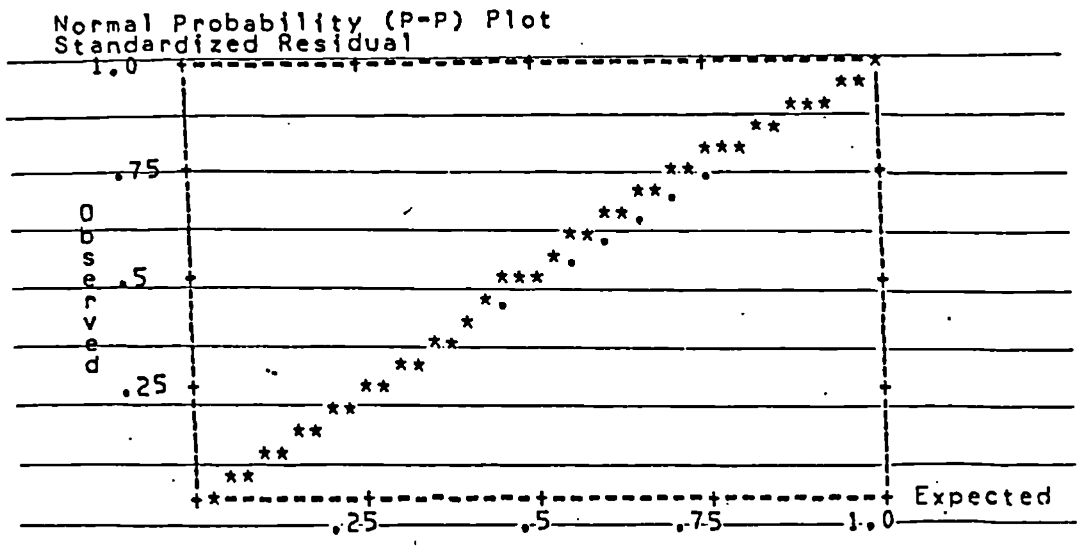


Figure 8.6: Normal probability plot

The Kolmogorov-Smirnov test (Figure 8.7) shows the sample mean of the residuals to be zero with a sample standard deviation of 0.0862177. The maximum distance between the observed cumulative distribution and the theoretical normal distribution having a mean equal to 0 and standard deviation equal to 0.0862177 is D = 0.03832. The two tailed probability value associated with D = 0.03832 is 0.205. Thus, using a 5% level of significance the null hypothesis would not be rejected because this probability value exceeds the level of significance. Although the probability value is close to the 5% critical value, as it exceeds 5% the distribution can be regarded as being normal, thereby satisfying this assumption.

---

* * * * KOLMOGOROV - SMIRNOV GOODNESS OF FIT TEST * * * *

RES Residual

Test Distribution -	Normal	Mean:	.0000000
		Standard Deviation:	.0862177

Cases: 776

Most extreme differences

Absolute	Positive	Negative	K-S Z	2-Tailed P
.03832	.03832	-.02540	1.067	.205

Figure 8.7 Kolomogorov-Smirnov test statistics

8.2.3 Homoscedasticity

To satisfy the assumption that the variance appears to be constant, scatterplots of the residuals may be observed. For this assumption to be met the residuals need to be randomly distributed in a rectangular band about the horizontal straight line through 0. As studentised residuals (ie., the residual divided by an estimate of its standard deviation that varies from point to point, depending on the distance of X_i from the mean of X) reflect more precisely differences in the true error variances from point to point these are often preferred in residual plots of continuous variables (Norusis 1988).

A commonly used plot is that of studentised residuals against the predicted values and each individual independent variable. For each continuous variable a random distribution signifies compliance with this assumption. For categorical variables two vertical residual bands of the approximately the same spread indicates that this assumption has been met.

Each continuous variable can be formally tested using Szroeter's test. Szroeter's test is used to test the null hypothesis that the variance of the residuals is constant against the alternative hypothesis that the variance of the residuals is not constant. This test was found by Griffiths and Surekha (1986) to be the most powerful test for detecting non-constant variance when compared with other similar tests.

Szroeter's test statistic is:

$$Q = \left(\frac{6n}{n^2-1}\right)^{0.5} \left(\frac{t}{b} - \frac{n+1}{2}\right)$$

where n is the sample size, and t is the sum of the squared residuals multiplied by the integer i (ranked in order of increasing variance) and b the sum of the squared residuals.

The decision rule for the test using a 5% level of significance is:

Reject H_o if Q > Z alpha
Accept H_o if Q < or = Z alpha

where alpha is the level of significance for the test, and Z alpha is chosen from the standard normal table with an upper-tail area alpha.

Since the number of cases for this data set is constant (n = 776), the formula can be simplified to:

$$Q = \left(\frac{6 * 776}{776^2-1}\right)^{0.5} \left(\frac{t}{b} - \frac{776 + 1}{2}\right)$$

$$Q = 0.0879316 \left(\frac{t}{b} - 388.5\right)$$

Since b will be constant for each and every continuous variable to which the test is applied, by substituting the critical value of 1.645 in place of Q, the confidence intervals for t can be determined by rearranging the formula as follows:

$$\pm 1.645 = 0.0879316 \left(\frac{t}{b} - 388.5\right)$$

The upper confidence interval would become:

$$t = b \left(\frac{+1.645}{0.0879316}\right) - 388.5$$

For example, if b = 2.00, the upper confidence interval for t would be 814.42

The lower confidence interval would become:

$$t = b \left(\frac{-1.645}{0.0879316}\right) - 388.5$$

For example, if b = 2.00, the lower confidence interval for t would be 739.58

If the computed t value falls on or between the confidence intervals then the null hypothesis is accepted, otherwise the null hypothesis is rejected.

It was found that, since the values of t and b can be directly computed, constructing a table of confidence intervals was particularly useful in the practical application of the test. This is time saving in analyses of this kind where there are many independent variables and to which many transformations maybe subsequently applied. Appendix D shows the table of confidence intervals t for

Szroeter's test statistic based on 5% level of significance according to different values of b for 776 cases.

The homogeneity of variance for categorical variables can be formally tested using the Bartlett Box F test (Norusis 1988: 317). If the test probability is less than 5% then the null hypothesis of non-constant variance is rejected. The maximum variance / minimum variance ratio can also be calculated to assess the degree of non-constant variance.

Figure 8.8 shows a scatterplot of the studentised residuals against the predicted values. Although the residuals are quite evenly spread a 'megaphone' shape can clearly be seen indicating the presence of a heteroscedastic trend. The spread of residuals increasing adds further evidence to the suspicions raised in the earlier scatterplot analysis.

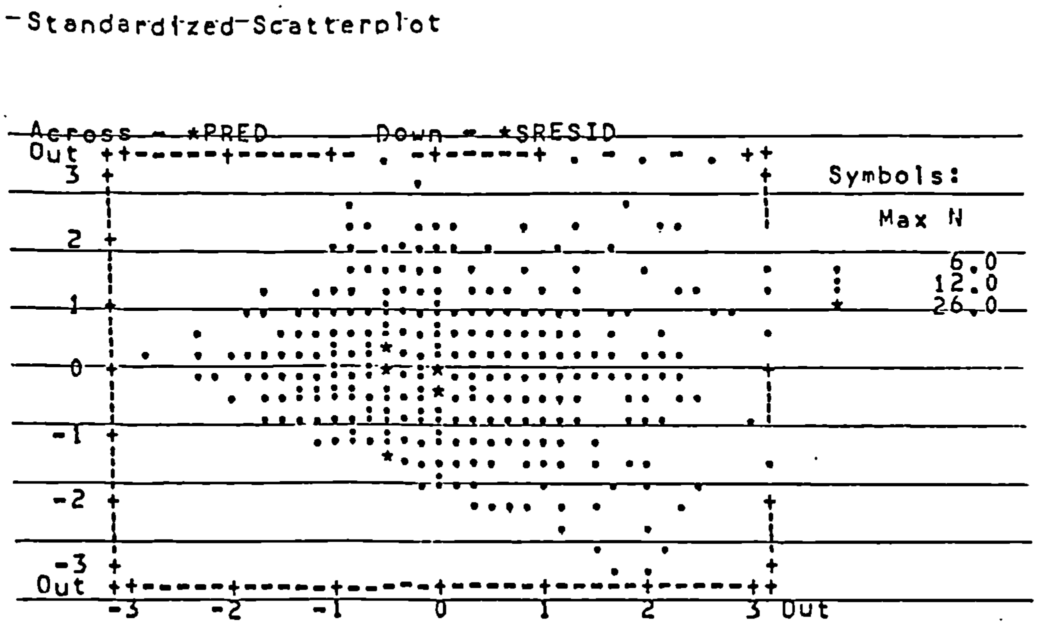


Figure 8.8: Scatterplot of studentised residuals against the predicted values

Figure 8.9 a - z shows the scatterplot for each of the independent variables left in the equation. For the continuous variables the majority of residuals form the shape of a vertical band with the remaining residuals falling both sides for those variables without the squared term and constrained to the positive side for variables with the squared term. The reason for this constraint is that when squared the independent variables cannot take on negative values. For most scatterplots it is not possible to pick out any particular pattern. However, a distinct megaphone shape can be seen in Figure 8.9b (*sresid B1BID2). Figure 8.9n (*sresid J2BID) also shows signs of heteroscedasticity in that there appears to be an uneven spread of residuals either side of the vertical band. Of the categorical scatterplots the two vertical bands of residuals appear to be of approximately the same spread indicating homoscedasticity. The exceptions appear to be Figure 8.9r (*resid B2) and Figure 8.9v (*resid B10) which show signs of non-constant variance.

It is difficult to observe visually from the individual variable scatterplots which independent variables are in fact heteroscedastic. To obtain further evidence each of the independent variables were formally tested.

Table 8.4 shows the results of Szroeter's test for continuous variables and the Bartlett Box test for categorical variables. As can be seen, 6 of the 17 continuous variables attain a Szroeter's Q test statistic greater than 1.645 indicating non-constant variance and 5 of the 9 categorical values attain a Bartlett Box probability value of less than 5%. Therefore 11 of the 26 variables exhibit a non-constant variance.

In respect of the magnitude of non-constant variance it can be seen that the variables with the highest degree of heteroscedasticity are J2BID for continuous variables and B7 for the categorical variables with a respective Szroeter's Q value = - 3.7916 and Bartlett Box probability value = 0.003.

Based on a 5% (ie., 1 in 20 chance) level of significance, for 26 variables it is expected that on average only one or two variables would have a statistically significant non-constant variance. Clearly, 11 out of 26 variables being significantly heteroscedastic is not acceptable. There is, therefore, strong evidence that this assumption has been violated and needs to be corrected.

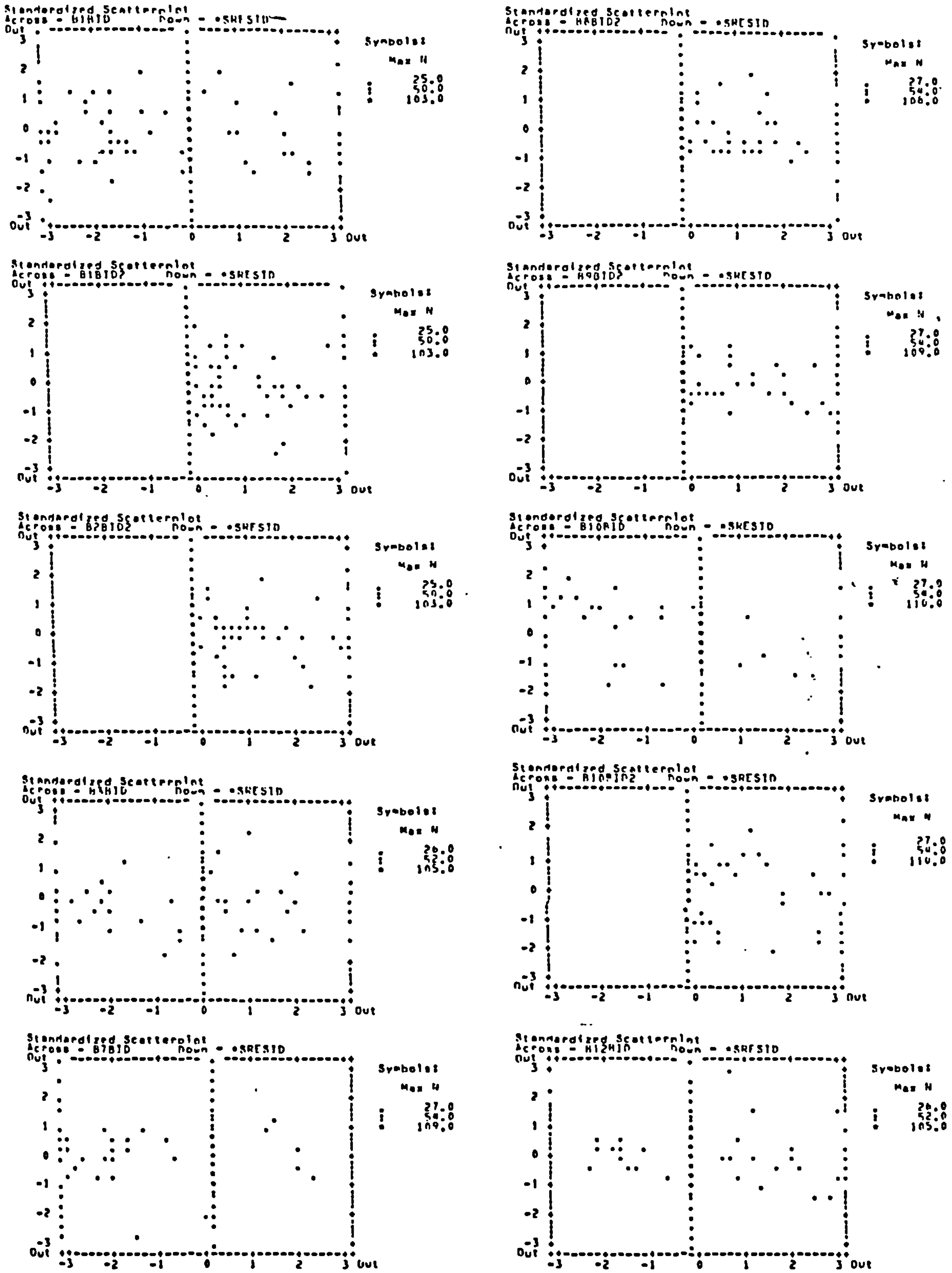


Figure 8.9 a - j: Scatterplot of each of the independent variables left in the equation

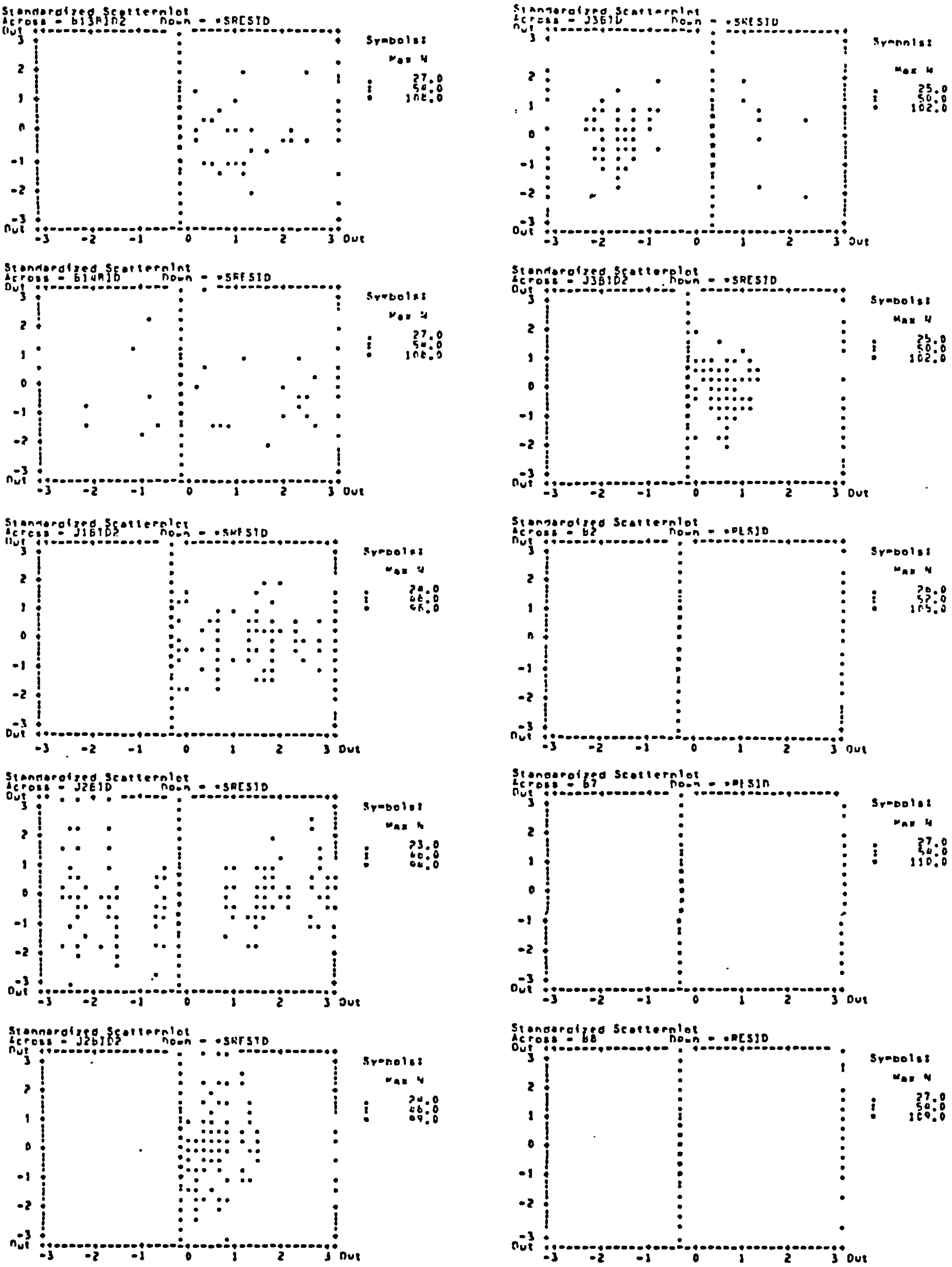


Figure 8.9 k - t: Scatterplot of each of the independent variables left in the equation (cont.)

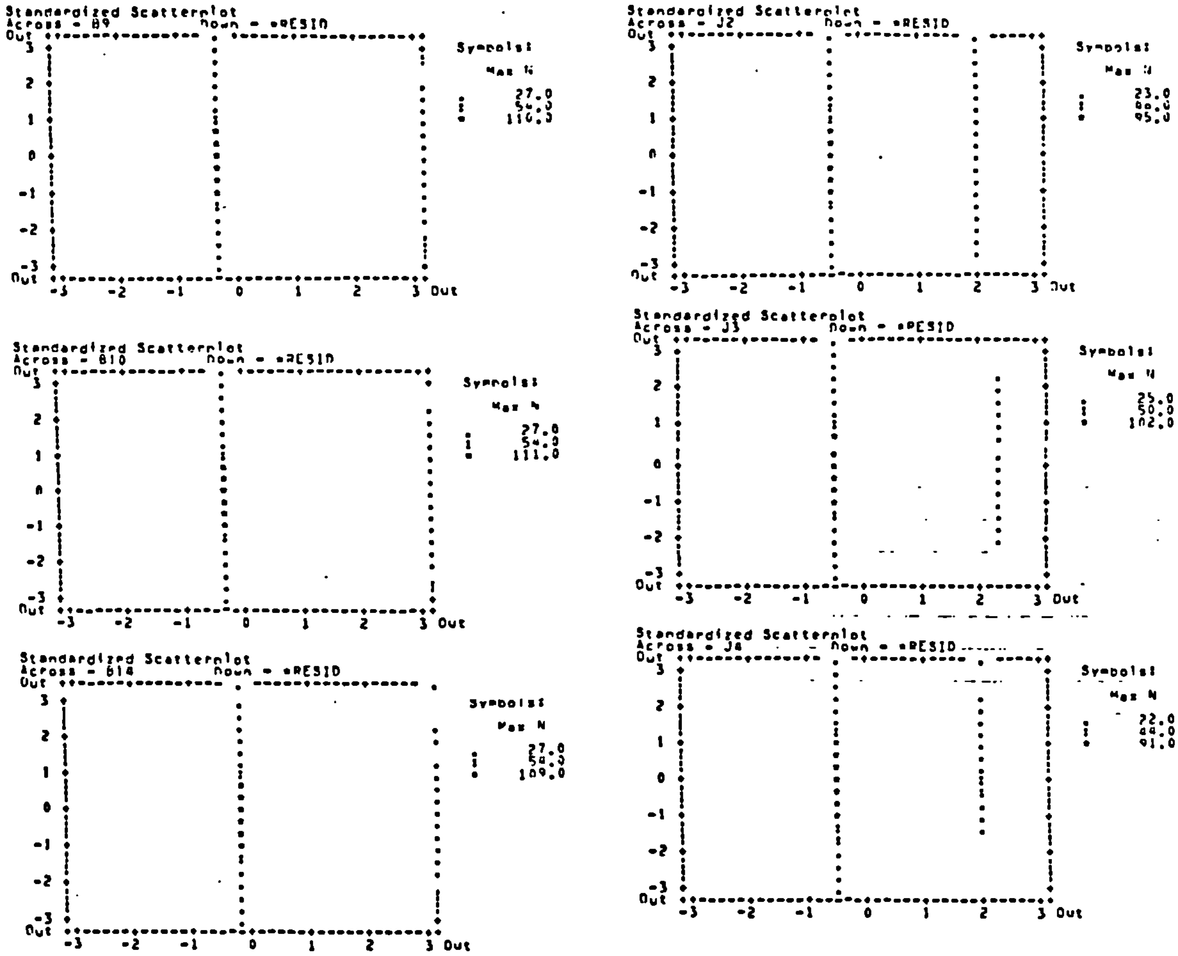


Figure 8.9 u - z: Scatterplot of each of the independent variables left in the equation (cont.)

Szroeter's test				Bartlett Box test			
Variable	Test statistic	Variable	Test statistic	Variable	Test statistic	Prob. Value	Minimum/ maximum variance
B1BID	1.7594	B12BID	0.5532	B2	1.338	0.247	1.251
B1BID2	3.3320	B13BID2	-0.0507	B7	8.700	0.003	1.748
B2BID2	2.1035	B14BID	0.7028	B8	0.572	0.450	1.164
B3BID	2.2039	J1BID2	-0.9286	B9	1.581	0.209	1.319
B7BID	-2.2145	J2BID	-3.7916	B10	4.138	0.042	1.500
B8BID2	0.9918	J2BID2	1.5138	B14	2.447	0.118	1.398
B9BID2	-0.0447	J3BID	2.7204	J2	8.800	0.003	1.448
B10BID	-0.7607	J3BID2	-0.6577	J3	5.838	0.016	1.418
B10BID2	1.3921			J4	8.980	0.003	1.477

Table 8.4: Szroeter's test for continuous variables and Bartlett Box test for categorical variables

8.2.3.1 Correcting heteroscedasticity

To correct heteroscedasticity one approach is to use power (or Box-Cox) transformations where:

$$y = x^{\lambda}$$

for some choice of constant power lambda. According to Cryer and Miller (1991) it is possible to proceed by considering a series of power transformations ranging from lambda equalling -1 to +2. It should be noted that Lambda equalling -1 corresponds to the inverse ratio measure of competitiveness used in the model. It will be seen in the subsequent analysis that the negative power transformations of -0.5 and -1 produce better results in terms of satisfying this assumption, therefore further negative transformations ranging from Lambda equalling -1.5 to -5 were also tested.

Another approach to correcting heteroscedasticity is to use the arcsin transformation (Norusis 1988: 164). Kenkel (1989: 785) recommends correcting heteroscedasticity of error terms by using weighted least squares.

Transforming the dependent variable, competitiveness, and using weighted least squares regression forms the next stage of the analysis.

8.3 Transformation

The principal aim of this section of the analysis is to reduce the number of heteroscedastic variables to an acceptable number by transforming the dependent Y variable competitiveness. It should, however, be noted that the use of transformations has wider benefits other than simply trying to reduce the number of heteroscedastic variables. Seigal (1988) states 'one of the great benefits of transformation is that it simplifies the search for structure in the data ... when motives are exploratory transformation is certainly ethical and its use should always be considered ... to see trends and exceptions'. He also goes on to say that 'important facets of the data can be missed if they are not used'.

Table 8.5 shows the summary statistics for the regression equations according to the different Box-Cox transformations which range from lambda equalling 2 to -5. In terms of predictive power the best adjusted R2 value occurs where lambda is set at 0. Decreasing trends occur either side of this position. The number of outliers produced by the model are also recorded in Table 8.5. There is a decreasing trend in the number of outliers from where lambda is 2 to -5. Lambda settings of -3 to -5 produced no outliers in the model.

	LAMBDA															
	2	1.5	1	0.5	0	-0.5	-1	-1.5	-2	-2.5	-3	-3.5	-4	-4.2	-4.5	-5
R Square	0.29	0.30	0.31	0.32	0.32	0.32	0.31	0.31	0.31	0.30	0.29	0.29	0.28	0.28	0.28	0.27
Adjusted R Square	0.27	0.28	0.29	0.29	0.29	0.29	0.29	0.29	0.28	0.28	0.27	0.26	0.26	0.25	0.25	0.25
Number of variables in equation	27	27	28	28	28	27	26	26	26	26	26	25	25	24	25	25
Number of outliers	8	8	8	7	7	5	5	3	1	1	0	0	0	0	0	0
Largest VIF in equation	8.95	8.95	8.96	8.96	8.96	8.96	8.80	8.80	8.80	8.80	8.80	8.80	8.81	8.78	8.80	8.80
K-S prob.	0.00	0.00	0.00	0.00	0.01	0.05	0.21	0.64	0.94	0.98	0.88	0.54	0.35	0.16	0.16	0.04

Table 8.5: Regression summary statistics for lambda settings ranging from 2 to -5

In respect of satisfying the regression assumptions other than that of heteroscedasticity, it can be seen from Table 8.5 that the largest VIF attained for a variable in the equation has been recorded for the purposes of assessing multicollinearity. As the largest VIF in the equation is less than 10 for all transformations, it therefore appears that this assumption has not been violated. In respect of normality, lambda settings above -0.5 and at or below -5 fail the Kolmogorov-Smirnov test probability of 0.5.

Turning to the homoscedasticity assumption, Tables 8.6 and 8.7 respectively show the results according to each transformation of Szroeter's test for continuous variables and Bartlett Box test for categorical variables. It can be seen that the magnitude of heteroscedasticity in each of the individual variables decreases with the change in lambda setting from 2 to -5. The fewest number of heteroscedastic variables occur in the lambda setting range of -4 to -5.

	LAMBDA															
	2	1.5	1	0.5	0	-0.5	-1	-1.5	-2	-2.5	-3	-3.5	-4	-4.2	-4.5	-5
BID	-12.4	-10.5	-8.56	-7.21	-6.07	-5.19										
BID2															1.780	1.924
B1BID	2.106	1.772	1.766	1.825	1.769	1.865	1.759	1.754	1.760	1.805	1.768	1.822	1.812		1.271	1.469
B1BID2	5.775	5.033	4.559	4 199	3.847	3.617	3.332	3.17	3.067	3.038	2.948	2.905				
B2BID	5.252		4.269													
B2BID2		3.331		2.792	2.566	2.371	2.103	1.927	1.787	1.708	1.563	1.520	1.482	1.388	1.025	1.135
B3BID	3.284	2.938	2.827	2.638	2.507	2.395	2.204	2.101	2.030	2.016	1.678	1.964	2.006	1.951	1.497	1.659
B3BID2																
B4BID																
B4BID2																
B5BID																
B5BID2																
B6BID					-1.43	-0.98									0.712	1.025
B6BID2	-4.51	-3.81	-3.02	-2.35												
B7BID							-2.21	-1.75	-1.33	-0.93	-0.65	-0.30	-0.05	-0.09	-0.23	0.13
B7BID2																
B8BID																
B8BID2	6.011	4.507	3.431	2.566	1.969	1.454	0.992	0.782	0.653	0.610	0.520	0.564	0.566	0.431	0.273	0.445
B9BID													0.036	-0.09		
B9BID2	3.350	2.108	1.300	0.708	0.373	0.091	-0.04	-0.03	0.042	0.190	0.280	0.470	0.420	0.322	0.495	0.813
B10BID							-0.76	-0.78	-0.73	-0.60	-0.54	-0.42	-0.47	-0.56	-0.47	-0.18
B10BID2	2.998	2.301	1.878	1.660	1.565	1.454	1.392	1.469	1.568	1.711	1.770	1.935	1.834	1.707	1.834	2.101
B11BID																
B11BID2	1.028	0.610	0.566	0.614	0.650	0.741									1.835	2.154
B12BID	0.110	-0.15	-0.11	0.027	0.127	0.249	0.533	0.771	1.004	1.258	1.447	1.582	1.533	1.442	1.584	1.920
B12BID2									0.451							
B13BID																
B13BID2	-1.60	-1.52	-1.17	-0.83	-0.57	-0.39	-0.05	0.190	0.407	0.632	0.754	0.857	0.762	0.625	0.704	1.003
B14BID	2.900	2.179	1.779	1.407	1.046	0.773	0.703	0.616	0.572	0.590	0.543	0.511	0.309		0.070	0.280
B14BID2	4.44	3.634	3.041	2.458	1.868									-0.26		
J1BID																
J1BID2	-0.40	-0.61	-0.71	-0.78	-0.93	-0.95	-0.93	-1.00	-1.05	-1.04	-1.11					
J2BID	-11.7	-9.73	-8.04	-6.55	-5.46	-4.51	-3.79	-3.25	-2.80	-2.39	-2.11	-1.71	-1.48	-1.62	-1.61	-1.26
J2BID2	9.361	7.237	5.228	3.854	2.823	1.967	1.514	1.061	0.752	0.579	0.395	0.387	0.557	0.367		
J3BID	9.340	7.486	5.796	4.637	3.798	3.125	2.720	2.339	2.084	1.946	1.778	1.758	1.845	1.599	1.504	1.631
J3BID2	4.804	3.297	1.824	0.874	0.181	-0.45	-0.66	-0.91	-1.05	-1.08	-1.13	-1.04	-0.74	-0.81	-1.07	-0.85
J4BID																
J4BID2																

Table 8.6: Szroeter's test for continuous variables for lambda settings ranging from 2 to -5

	LAMBDA															
	2	1.5	1	0.5	0	-0.5	-1	-1.5	-2	-2.5	-3	-3.5	-4	-4.2	-4.5	-5
B2																
BARTLETT	6.83	3.56	2.42	1.60	1.08	0.99	1.34	1.51	1.79	2.18	2.14	2.73	3.39	3.71	3.48	4.15
P=	0.01	0.06	0.12	0.21	0.30	0.32	0.25	0.22	0.18	0.14	0.12	0.10	0.07	0.05	0.06	0.04
MIN/MAXV	1.70	1.45	1.36	1.28	1.22	1.21	1.25	1.27	1.30	1.34	1.36	1.38	1.44	1.46	1.45	1.50
B7																
BARTLETT	19.9	20.9	19.7	17.7	15.1	12.1	8.70	6.44	4.57	3.08	1.95	1.02	0.52	0.35	0.27	0.06
P=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.08	0.16	0.31	0.47	0.55	0.61	0.81
MIN/MAXV	2.26	2.30	2.25	2.17	2.05	1.92	1.75	1.63	1.51	1.41	1.32	1.22	1.16	1.13	1.11	1.05
B8																
BARTLETT	84.3	48.7	26.9	13.1	5.92	2.28	0.57	0.11	0.01	0.01	0.02	0.01	0.01	0.00	0.00	0.00
P=	0.00	0.00	0.00	0.00	0.02	0.13	0.45	0.74	0.94	0.95	0.89	0.93	0.95	0.97	0.98	0.99
MIN/MAXV	4.53	3.32	2.53	1.96	1.60	1.35	1.16	1.07	1.02	1.01	1.03	1.02	1.01	1.01	1.01	1.00
B9																
BARTLETT	28.9	20.1	13.4	8.78	5.56	3.47	1.58	0.75	0.27	0.05	0.00	0.08	0.05	0.07	0.50	0.81
P=	0.00	0.00	0.00	0.00	0.02	0.06	0.21	0.39	0.60	0.83	0.95	0.78	0.83	0.79	0.48	0.37
MIN/MAXV	3.93	3.02	2.40	2.00	1.71	1.52	1.32	1.21	1.12	1.05	1.01	1.06	1.05	1.06	1.16	1.20
B10																
BARTLETT	0.19	0.14	0.83	1.99	2.95	3.77	4.14	4.53	4.71	4.73	4.64	4.58	4.37	4.28	4.04	3.81
P=	0.67	0.71	0.36	0.16	0.09	0.05	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.05
MIN/MAXV	1.10	1.08	1.21	1.33	1.41	1.47	1.50	1.53	1.54	1.54	1.53	1.53	1.52	1.51	1.49	1.48
B14																
BARTLETT	32.2	25.1	18.2	12.2	7.44	5.05	2.45	0.92	0.19	0.00	0.18	0.53	1.04	1.25	1.95	2.62
P=	0.00	0.00	0.00	0.00	0.01	0.03	0.12	0.34	0.67	0.98	0.68	0.47	0.31	0.27	0.16	0.11
MIN/MAXV	2.95	2.64	2.33	2.03	1.76	1.60	1.40	1.23	1.10	1.01	1.10	1.18	1.27	1.30	1.39	1.47
J2																
BARTLETT			43.6	28.1	18.7	11.9	8.80	6.36	4.83	3.85	3.21	2.66	3.35	2.96		
P=			0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.05	0.07	0.10	0.07	0.09		
MIN/MAXV			2.21	1.91	1.70	1.54	1.45	1.37	1.32	1.28	1.25	1.23	1.26	1.24		
J3																
BARTLETT	20.9	15.9	12.5	9.90	8.01	7.06	5.84	4.87	4.08	3.44	2.89	2.45	1.95	1.65	1.68	1.41
P=	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.06	0.09	0.12	0.16	0.20	0.20	0.24
MIN/MAXV	1.99	1.81	1.69	1.59	1.51	1.47	1.42	1.37	1.34	1.30	1.28	1.25	1.22	1.12	1.20	1.18
J4																
BARTLETT	56.5	41.7	27.3	20.8	15.6	12.0	8.98	6.99	5.54	4.45	3.63	3.09	2.67	2.46	2.98	2.59
P=	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.04	0.06	0.08	0.10	0.12	0.08	0.11
MIN/MAXV	2.85	2.42	2.02	1.83	1.68	1.57	1.48	1.41	1.35	1.31	1.28	1.25	1.23	1.22	1.25	1.23

Table 8.7 : Bartlett Box test for categorical variables for lambda settings ranging from 2 to -5

Since the range of lambda settings between -4 to -5 produced the fewest number of heteroscedastic variables, the settings between these values was tested in 0.1 incremental stages in an attempt to find the optimal lambda setting. It was found that the optimal transformation was with lambda at a setting of -4.2. The individual variable scatterplots shown in Figure 8.10 a-x provide reassurance that this transformed model is appropriate because it is not possible to pick out any particular pattern. When tested formally it was found that only three of the 24

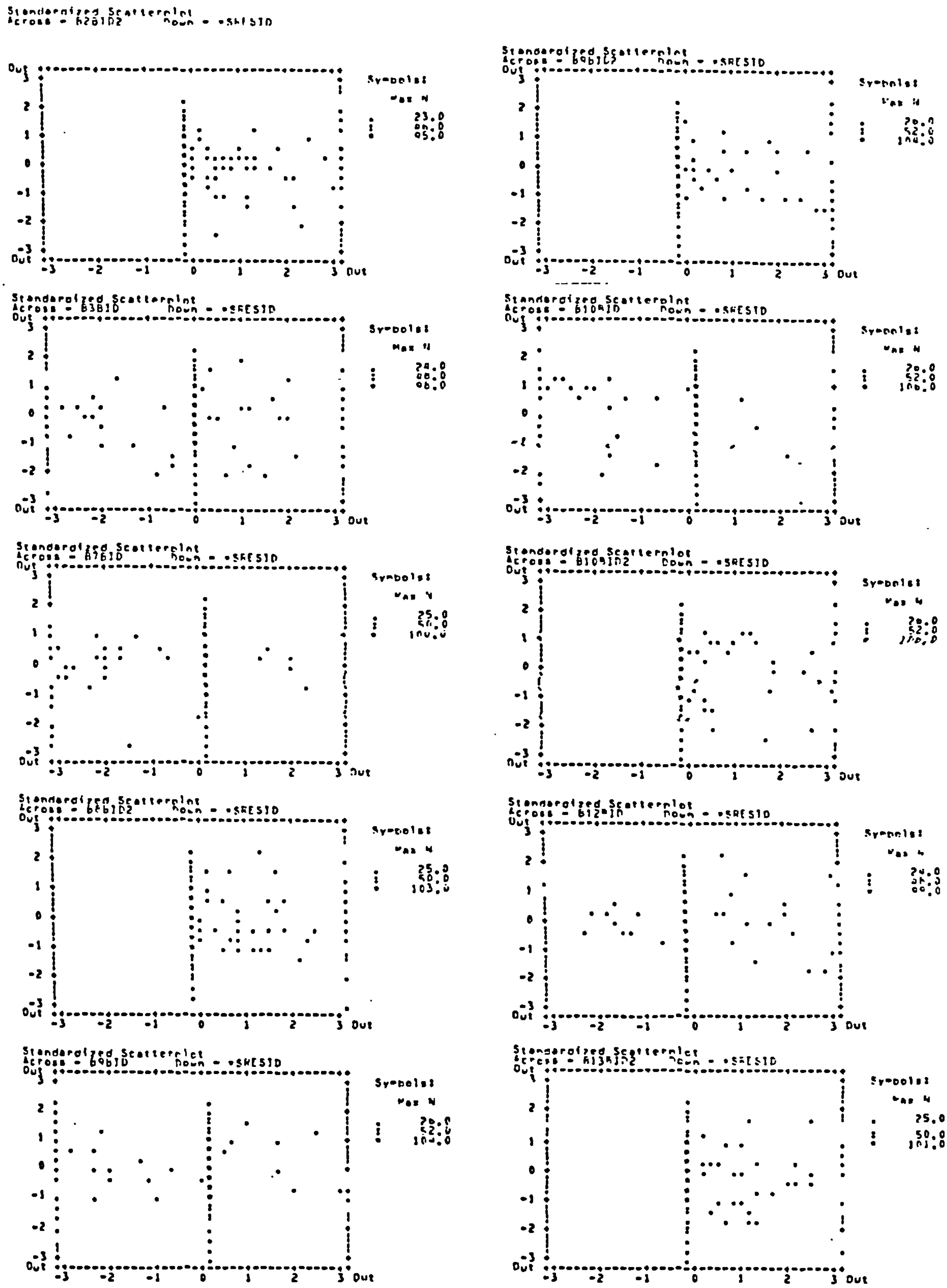


Figure 8.10 a - j: Scatterplot of each of the independent variables left in the equation for lambda setting of 4.2

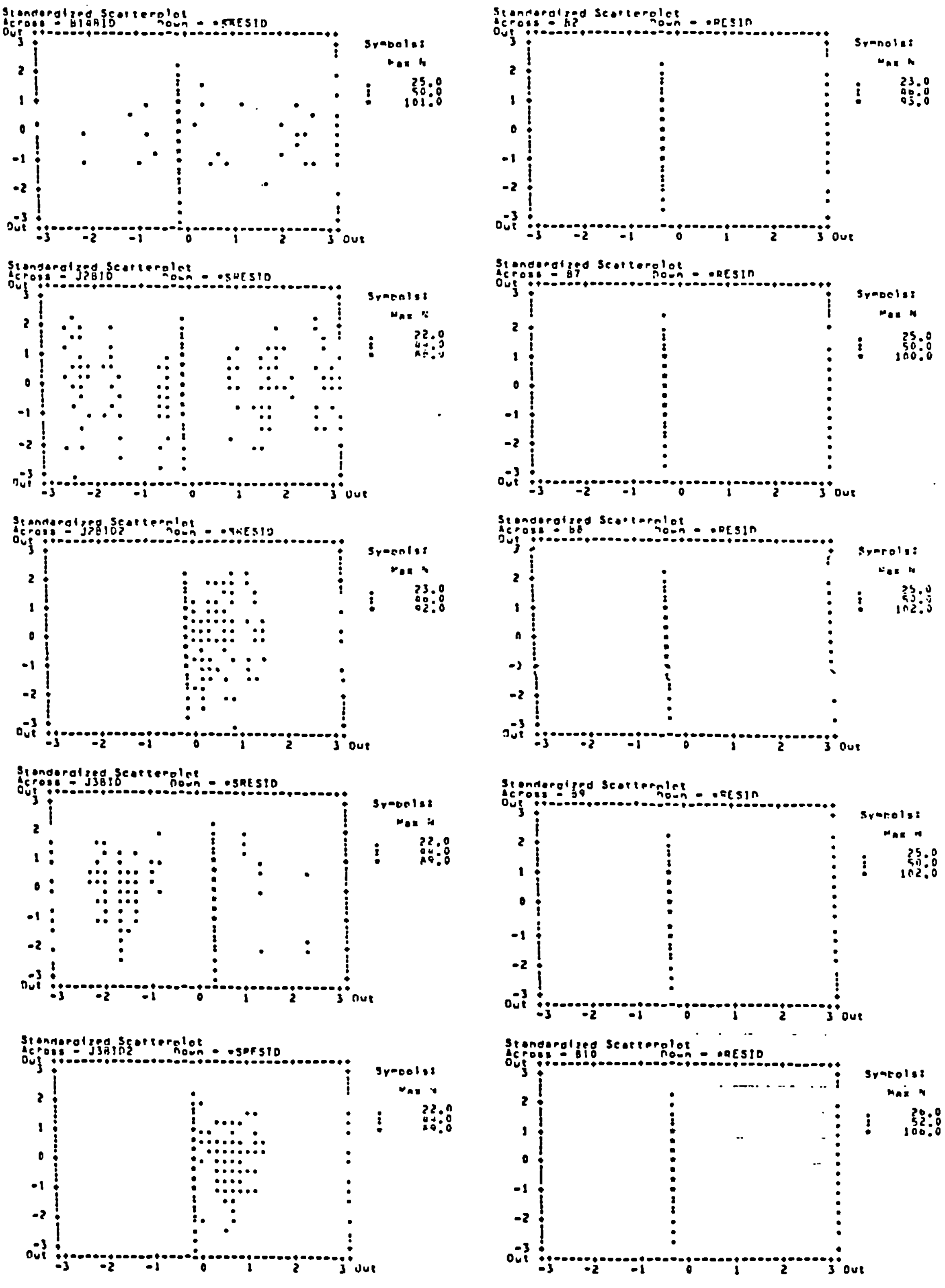


Figure 8.10 j - t: Scatterplot of each of the independent variables left in the equation for lambda setting of 4.2 (cont.)

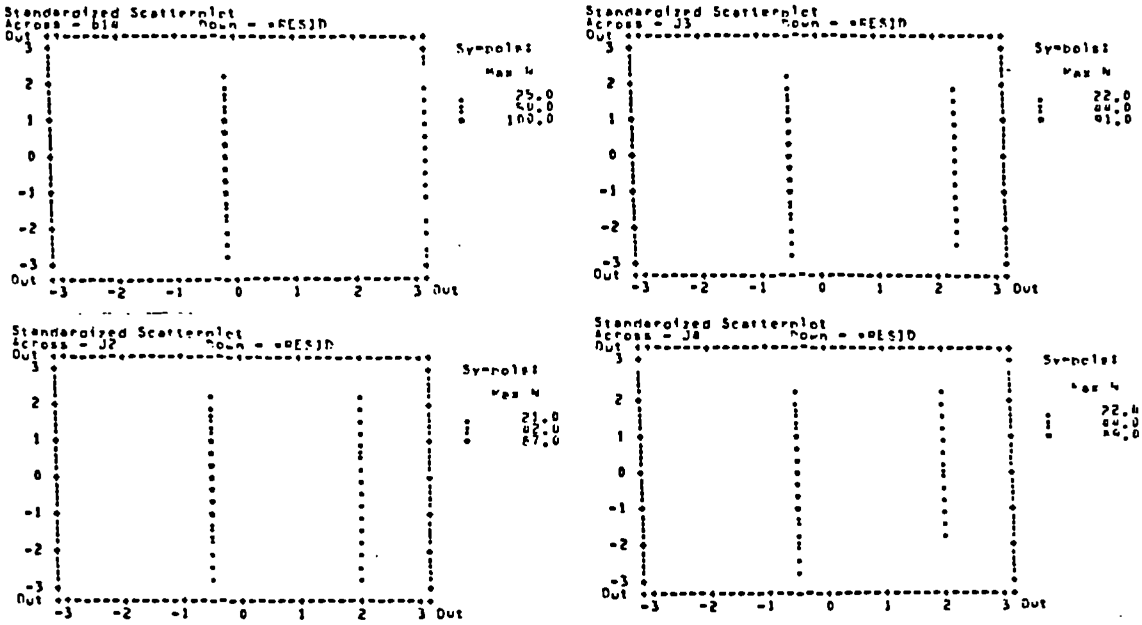


Figure 8.10 t - x: Scatterplot of each of the independent variables left in the equation for lambda setting of 4.2 (cont.)

variables remained heteroscedastic. It can be seen from Figures 8.6 and 8.7 that two of these were for the continuous variables of B1BID and B10BID2 and for the categorical value B10. With respective Szroeter's test Q values of 1.951 and 1.707 and Bartlett Box test probability of 4%, all three variables fail the test albeit marginally.

The probability of obtaining three out of 24 variables being significantly heteroscedastic is :-

$$P(\text{3 significant variables}) = \binom{24}{3} (0.05)^3 (0.95)^{21}$$

$$= \frac{24 * 23 * 22}{1 * 2 * 3} * 0.000125 * 0.340562$$

$$= 0.086162$$

Although it is expected that on average only one or two variables should have non-constant variance, the probability of 0.086162 exceeds the critical 0.05 value, therefore having three out of 24 variables heteroscedastic appears to be acceptable.

Visual evidence of stabilizing the variance can be seen in Figure 8.11 which shows the scatterplot of the studentised residuals against the predicted values. A greater negative residual value along the x-axis indicates greater competitiveness and vice versa. There is a slight indication that the variance for the most competitive bidders is smaller where the studentised residuals fall between -2 and -3. This is probably symptomatic of the measure used in where extreme cases of competitiveness give rise to smaller variability. However, compare Figure 8.11 with 8.8 and note the improvement in the behaviour of the residuals. The residuals now appear more randomly scattered.

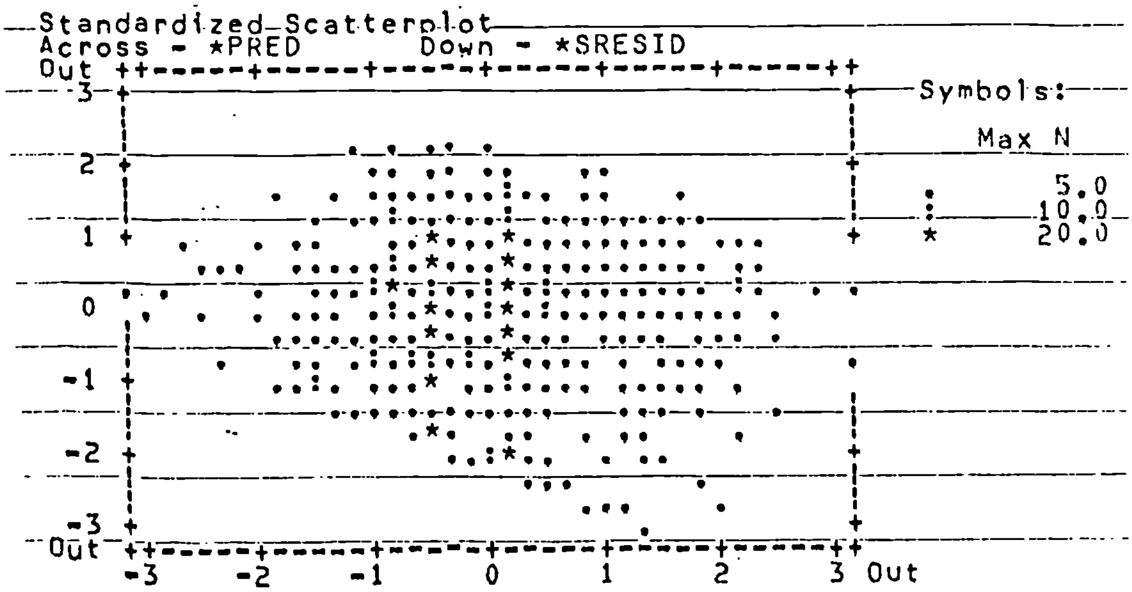


Figure 8.11: Scatterplot of studentised residuals against the predicted values for lambda setting of -4.2

Further graphical evidence of variance stabilisation can be seen in Figures 8.12 and 8.13. With regard to the continuous independent variables, Figure 8.12 shows a heteroscedasticity plot for Szroeter's Q test statistic relative to the 5% confidence interval according to lambda settings +2 to -5. When the variables are observed in relation to the confidence intervals of 1.645, it can be clearly seen that there is a convergence up to the approximate lambda setting of -4.2. This indicates that there is a gradual improvement toward homoscedasticity. After this setting there appears to be a slight kink causing a deterioration in homoscedasticity.

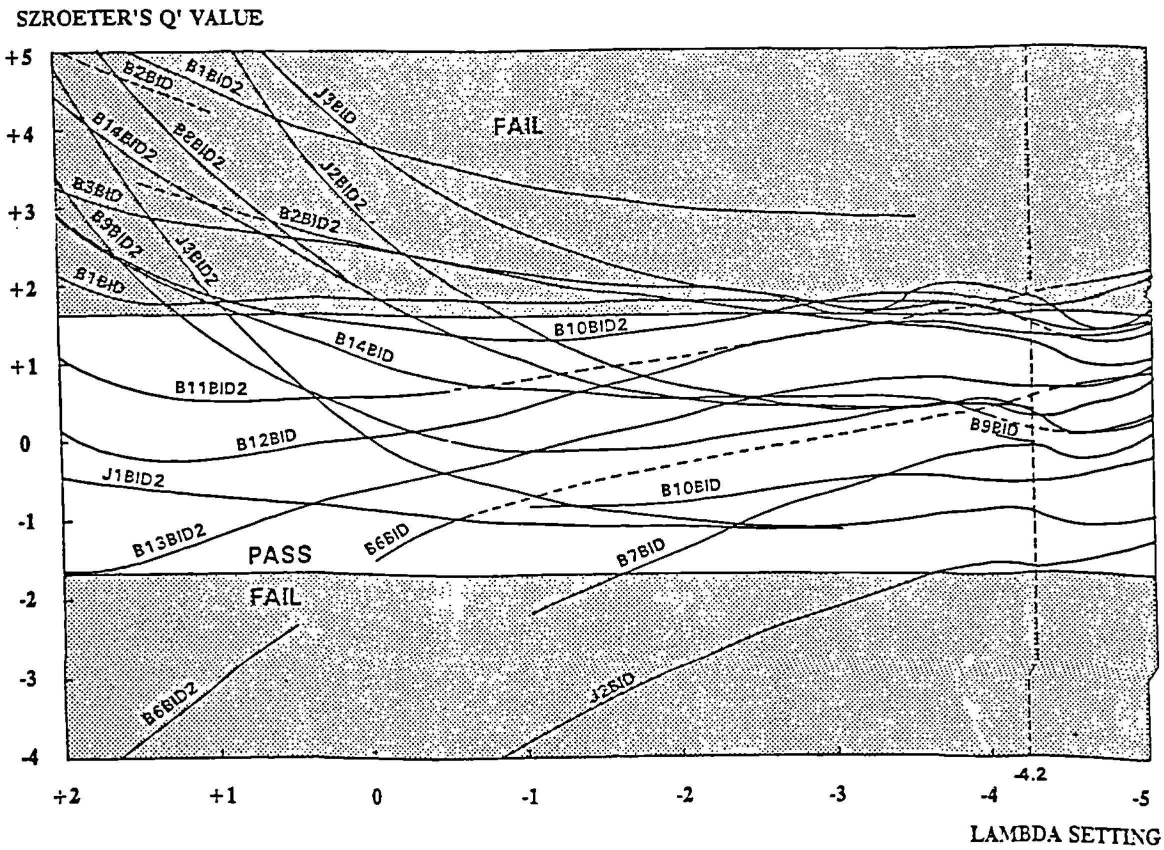


Figure 8.12: Confidence intervals for Szroeter's test statistic for continuous independent variables according to lambda settings between +2 and -5

Turning to the categorical variables, Figure 8.13 shows a probability plot for the Bartlett Box test statistic relative to the 5% confidence intervals according to lambda settings +2 to -5. It can be seen that the number of variables in the significant region of 5% or less decreases as the negative settings of lambda increase.

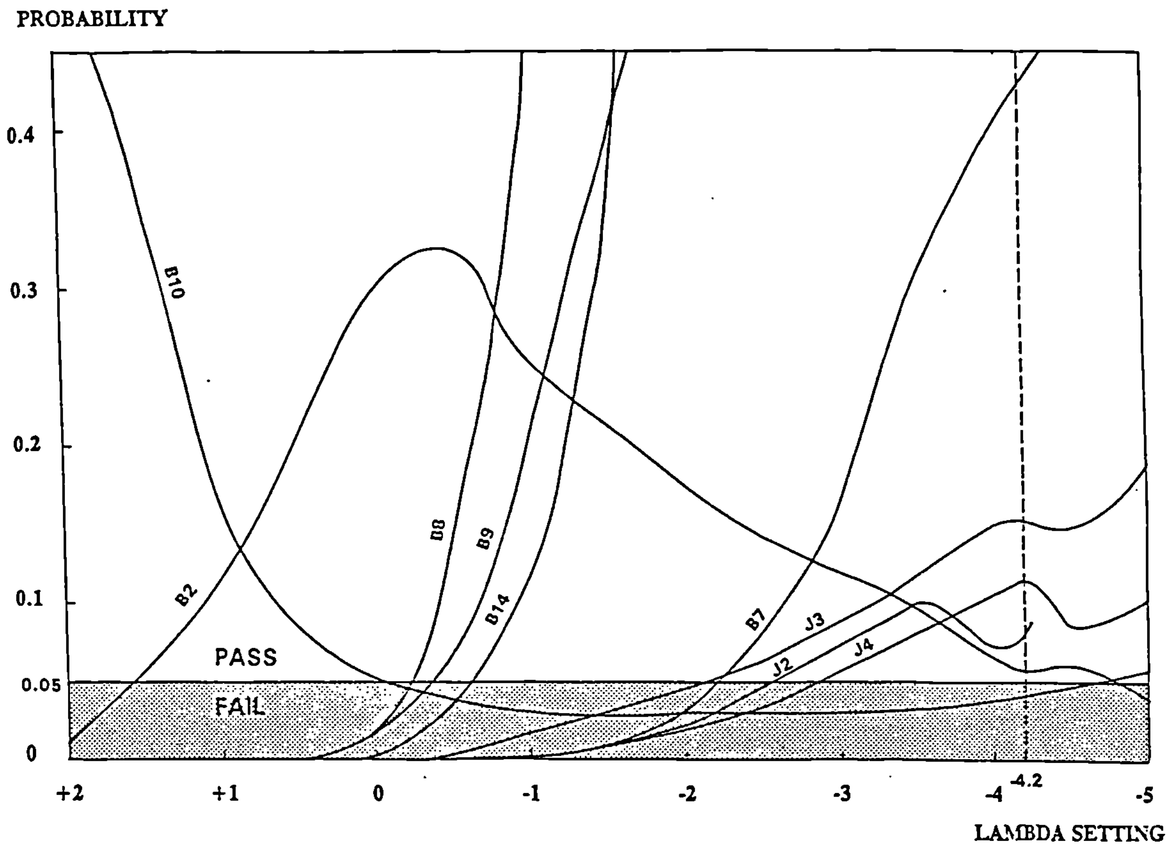


Figure 8.13: Probability values for Bartlett Box test statistic for categorical independent variables according to lambda settings between +2 and -5

As for remaining regression assumptions, at a lambda setting of - 4.2, a largest recorded VIF of 8.777 and Kolmogorov- Smirnov test probability value of 0.16 shows that both the respective assumptions of multicollinearity and normality have been met.

Figure 8.14 provides a summary of the regression model where lambda is set at -4.2. Improving the model in terms of heteroscedasticity from 11 to 3 heteroscedastic variables has meant a slight reduction in the overall capability of the model. The adjusted R square statistic has dropped from 0.28888 to 0.25392 (compare Figures 8.4 and 8.14). However, this transformed model is still statistically useful for predicting competitiveness as can be seen by referring to the global F values (F = 11.99027, p = 0.0000).

**** MULTIPLE REGRESSION ****

Equation Number 1 Dependent Variable .. DEP

Variable(s) Removed on Step Number
88.. B1BID

Multiple R	.52633
R Square	.27703
Adjusted R Square	.25392
Standard Error	.05090

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	24	.74564	.03107
Residual	751	1.94595	.00259

F = 11.99027 Signif F = .0000

------------------ *Variables in the Equation* ------------------

Variable	B	SE B	Beta	Tolerance	VIF
B10	.044678	.011645	.184513	.416241	2.402
B3BID	- .003869	.001482	-.084180	.926319	1.080
B13BID2	.001603	6.3808E-04	.079277	.966278	1.035
B9BID2	.002266	8.5808E-04	.131902	.385807	2.592
J2BID2	1.84505E-04	7.4295E-05	.110088	.489889	2.041
B8BID2	.001263	6.6421E-04	.083631	.497799	2.009
B14BID	- .009123	.002266	-.157495	.628896	1.590
B2	.046624	.008524	.216217	.616060	1.623
J3	- .025030	.009048	-.156230	.301856	3.313
B10BID	.005548	.002021	.102196	.694663	1.440
J2	- .011214	.005380	-.074997	.743579	1.345
B14	.055662	.010134	.216228	.621131	1.610
J3BID2	.003888	9.0530E-04	.304454	.191582	5.220
J4	- .018339	.005082	-.126844	.779257	1.283
B9BID	.006071	.003486	.079935	.456917	2.189
B10BID2	- .001245	3.9433E-04	-.143149	.468274	2.136
B8	- .026861	.010369	-.114042	.496745	2.013
B9	- .048195	.010822	-.199038	.481934	2.075
B2BID2	-9.15487E-04	4.0451E-04	-.088090	.635448	1.574
J2BID	- .004336	.001093	-.179579	.469617	2.129
B7	.077189	.012002	.327712	.370794	2.697
B12BID	- .005511	.001479	-.117635	.965964	1.035
J3BID	.010761	.005403	.183080	.113938	8.777
B7BID	.008211	.003458	.120991	.370805	2.697
(Constant)	.103058	.003399			

Figure 8.14 Regression model summary at a lambda setting of -4.2

Other x-variable transformations, comprising exponential functions of 0.9, 0.75, 1/3, 0.25, 0.1 and natural log, were tried and tested according to different settings of lambda in an attempt to try and improve upon the above model. The results were similar to that of above in that transformations with lambda settings between -4 to -5 being the closest at satisfying the regression assumptions. However, in all cases no fewer than three heteroscedastic variables could be found. Since the adjusted R2 values were found to be inferior in these other transformations it appears that the above model may still be regarded as the best model that is closest to satisfying all of the regression assumptions.

8.4 Arcsin transformation

An arcsin transformation of the Y variable based on the x-variable exponential of 2/3 was also undertaken in attempt to improve the above model. With regard to the multicollinearity assumption the largest VIF was 8.818. However, this failed the test for normality with Kolmogorov-Smirnov test probability value of 0.008. In addition 10 of the remaining 27 variables were found to be heteroscedastic. This transformation also produced an inferior adjusted R2 value of 0.24026. Other arcsin transformations produced similar results.

8.5 Weighted least squares

Attempts were also made using weighted least squares regression based on different settings of lambda ranging from 2 to -5. The relationship between the residual variances and different functions of x need to be found in order to determine appropriate weights. This is achieved by splitting the regression residuals (obtained from using the least squares regression) into several groups of approximately equal size based on the value of the independent variable x. The variance of the observed residuals in each group is then calculated.

When applied to this data set, it was found that when the data was split into groups of approximately the same size it was not possible to determine any suitable functional relationships. The reason for this could be due to the specification of the model which is polynomial and contains many independent variables. Mendenhall and Sinich (1993: 439) point out that it may not be easy to identify the appropriate groupings in which to apply the weights, if first more than one independent variable is included in the regression (as is the case in this analysis) and second that the relationship between the residual variance and some preselected function of the independent variables may not reveal a consistent pattern over the groups.

8.6 Summary

In order to comply with the regression assumptions the best model requires transforming by applying a series of statistical corrections. By centring the x-variable, deleting insignificant variables using backwards stepwise regression and transforming the x-variable based on the exponential 2/3, the selected model is able to satisfy all of the regression assumptions except that of homoscedasticity. It was found that 11 out of 26 variables were significantly heteroscedastic. The approach taken in attempting to satisfy the homoscedasticity assumption is to transform the y-variable systematically using a sequence of Box-Cox transformations according to different settings of lambda. When applying the various Box-Cox transformations to the selected model it was determined that the transformation that best satisfied the homoscedasticity assumption was where lambda was set at -4.2. This was found using a combination of Szroeter's test for continuous variables and Bartlett Box test for categorical variables. Three out of the 24 remaining independent variables were significant.

Ideally with 24 variables remaining in the equation, at a 5% level of significance, it is expected that on average one or two should be heteroscedastic. However, it is still admissible to have three significantly heteroscedastic variables out of a total of 24 variables. This is considered acceptable because the combined probabilities of the three heteroscedastic variables out of 24 exceeds 5%. The magnitude of heteroscedasticity in terms of significance of the three variables is a determining factor in this result - with Szroeter's Q test statistic of 1.9510 and 1.7075 and a

Bartlett Box probability of 0.039 none of these three outstanding cases show signs of severe heteroscedasticity.

Visual evidence of the homoscedasticity assumption being satisfied can be seen in Figure 8.18 which shows the scatterplot of the studentised residuals against the predicted values. This shows the residuals apparently randomly scattered in a rectangular band about the horizontal straight line through 0.

In respect of the remaining assumptions, with all independent variables having a VIF of less than 10 and a Kolmogorov-Smirnov test probability greater than 5%, both the multicollinearity and normality assumptions have been satisfied.

Testing different Box-Cox transformations on a systematic basis against other x-variable transformations (ie. exponential functions of 0.9, 0.75, 1/3, 0.25, 0.1 and natural log) eventually produced models that satisfied all the regression assumptions to virtually the same degree. In respect of other transformations, the arcsin transformation was found to be unsuitable in that the assumptions of autocorrelation, normality and homoscedasticity were all violated. The use of weighted regression did not appear to be a suitable solution either. It was not possible to determine any suitable functional relationships between the residual variances and the different functions of x. A possible reason for this is that the model is polynomial and contains many independent variables. This makes it more difficult to apply appropriate groupings. Also the relationship between the residual variance and some preselected function of the independent variables may not reveal a consistent pattern over the groups.

The transformed model at a lambda setting of -4.2 is closest to satisfying all of the regression assumptions. Also no outliers were generated using this transformation. Given the general robustness of regression technique, it was contended that this transformed model may be treated as one that satisfies all regression assumptions.

CHAPTER 9

Model verification, prediction and reliability

9 MODEL VERIFICATION, PREDICTION AND RELIABILITY

9.1 Introduction

The previous chapter considered the reliability of the best model (ie. model 12) by examining the residuals to see if one or more of the regression assumptions were violated. Each assumption was examined in turn. If an assumption was violated the model was corrected by transforming it in such a way that it no longer violates the assumption. It was found that the model violated the regression assumptions of multicollinearity and homoscedasticity and was transformed accordingly.

This chapter is in three sections. The first section examines the transformed version of model 12 to verify whether it as the best model in its transformed state remains as the best model. The second section observes the individual bidder competitiveness predictions according to contract type, contract size and bidder size. The third section considers the model's reliability by constructing 95% prediction intervals.

9.2 Model verification

To verify that model 12 in its transformed state remains as the best model, ideally each and every candidate model needs first to be transformed in such a way that it satisfies all the regression assumptions. Since the approach needed to satisfy all the regression assumptions is very time consuming and time constraints make it impractical to attempt to transform every model, attempts were made to transform the closest challengers to model 12 (ie. models 18 and 20).

Models 18 and 20 were selected from Table 7.2 which shows a summary of calculated and tabulated F values for all the candidate models based on 15 bidders and 5 contract types. Given that a smaller positive difference between the tabulated and calculated values is indicative of a better model, it can be seen that models 18 and 20 are the closest challengers to model 12. The difference between values is 0.10 (ie. 1.26 - 1.16) for model 18 and 0.19 (ie. 1.24 - 1.05) for model 20. The differences between tabulated and calculated values for all the other remaining candidate models are larger, indicating that these other models are inferior to models 18 and 20.

Models 18 and 20 are both high order models containing 6 chunks. In line with previous procedures, multicollinearity was the first regression assumption to be tested and, as to be expected with high order models, both failed this assumption and, therefore, required correcting. It was, however, not possible to bring multicollinearity down to an acceptable level, despite trying different combinations of correction procedures which comprised centring, backwards stepwise regression and x-variable transformations. The number of significant variables remaining in the equation for both models were too many. Since no suitable transformation to reduce multicollinearity to an acceptable level for either model could be found, the approach taken in the verification process was to analyse all other candidate models using the same transformation that was used for model 12.

It is recognised that this is not the most ideal transformation with which to verify model 12. However, apart from being an acceptable transformation for model 12, this transformation does at least dampen the severity of regression assumption violations for the other candidate models. Although other suitable transformations could have been found and tried and tested for lower order models, Table 7.2 shows these models to be even more inferior than the higher order models. Given this, coupled with the time consuming process in transforming the model to satisfy all the regression assumptions, there appears to be little point in attempting to verify model 12 against these lower order models.

The verification analysis is in two parts. Using the 15 bidder, 5 contract type data set, the first part of this section of the analysis assesses the degree to which the transformation used for model 12 satisfies the regression assumptions pertaining to the other candidate models. The second part considers analyzing the candidate models so as to verify whether model 12 in its transformed state remains as the best model. In accordance with previously adopted procedures, bidders have been added incrementally into the sample up to the predetermined 15 bidder cut off point. For each bidder added into the analysis the candidate models have then been tested using a forward sequential candidate model selection technique based on the F-test to see if model 12 in its transformed state continued to be the best model.

9.2.1 Regression assumption assessment for candidate models

Table 9.1 shows the regression assumption statistics relating to the candidate models. This is based on the same transformation that was used for model 12. Since backwards stepwise regression was used the number of variables left in the equation have been recorded for comparison purposes. The statistics for models 17, 19, 20 and 22 were unobtainable due to what is believed to be an error in the SPSS program relating to integer overflow. In addition, insufficient virtual memory prevented the determination of the number of heteroscedastic variables for models 15, 16 and 18.

Commenting on each of the regression assumptions, starting with multicollinearity, for 13 models the largest VIF factor obtained by a variable was less than 10 thereby satisfying this assumption. All these models had 28 or less variables left in the equation after using the backwards stepwise procedure. Those models that failed this assumption had 36 or more variables remaining. Since multicollinearity is concerned with interdependency between variables, a probable reason why those remaining models failed therefore relates to the large number of variables remaining in the equation.

For normality, all the models tested achieved a Kolmogorov-Smirnov test probability greater than 5% thereby satisfying this assumption. However, in respect of the homoscedasticity assumption only models 5, 12, and 14 achieved a probability of greater than 5% in terms of number of heteroscedastic variables relative to total number of variables in the equation. The high failure rate for this assumption is likely to be attributed to model 12's transformation not being suitable for the other candidate models.

Model no.	Multicollinearity	Normality	Homoscedasticity
	Largest VIF left in equation	K - S test statistic / Probability	No. of heteroscedastic variables/Total no. of variables in equation
1	N/A	N/A	N/A
2	1.000	1.264 / 0.082	1 / 1
3	1.168	1.290 / 0.072	1 / 3
4	1.784	0.875 / 0.429	3 / 9
5	8.810	1.133 / 0.153	1 / 9
6	4.346	0.940 / 0.340	6 / 20
7	1.843	0.764 / 0.604	3 / 10
8	8.874	1.076 / 0.197	4 / 15
9	4.372	0.986 / 0.286	10 / 23
10	1.769	0.869 / 0.438	4 / 20
11	109.209	1.160 / 0.136	29 / 36
12	8.777	1.124 / 0.160	3 / 24
13	4.071	1.067 / 0.205	7 / 24
14	6.008	1.162 / 0.135	3 / 25
15	109.204	1.055 / 0.216	SPSS Computational problem: insufficient virtual memory / 46
16	108.916	1.098 / 0.210	ditto / 49
17	Not known/error in SPSS Program: integer overflow		
18	108.923	1.146 / 0.144	SPSS Computational problem: insufficient virtual memory / 46
19 20	Not known/error in SPSS Program; integer overflow		
21	5.494	1.119 / 0.163	6 / 28
22	Not known/error in SPSS Program; integer overflow		

Table 9.1: Regression assumption statistics for candidate models 1 to 22 (based on model 12 transformation)

Turning to the degree to which the candidate models themselves satisfy the regression assumptions, models 2 to 4, 6 to 10, 13 and 21 fail only one regression assumption, that of homoscedasticity. Model 11 fails both the assumptions of multicollinearity and homoscedasticity. Models 15, 16 and 18 fail the multicollinearity assumption. The homoscedasticity findings are unknown for these three models due to there being insufficient virtual memory in the main frame computer. The results for models 17, 19, 20 and 22 are also unknown due to a likely error in the SPSS program.

9.2.2 Best model verification

In testing the transformed model 12 against all other candidate models to verify whether model 12 in its transformed state remains as the best model, all variables, rather than just the significant variables, were retained within the transformed candidate models. This approach was taken due to the rationale underlying the chunkwise model building process. Candidate models have been built and analysed on the basis of collective groups (or chunks) of variables in preference to using individual significant variables.

To satisfy the regression assumption of multicollinearity, backward stepwise regression was used in conjunction with other correction techniques to reduce multicollinearity to an acceptable level. This procedure was considered appropriate because the large number of variables in model 12 contributed to producing excessive multicollinearity. Backwards stepwise regression helped to solve this problem by deleting all non-significant variables from the equation.

However, eliminating variables from the equation in this manner means that the chunks no longer remain intact as complete sets of variables. Only the significant variables within the chunk remain. This drastically alters the make-up of the chunk from a complete one that contains both significant and insignificant variables to an incomplete one that contains only significant variables. The proportion of variables left within a chunk after the backwards stepwise procedure is dependent on the number of significant variables contained within that particular chunk.

By retaining only the significant variables it follows that the greater the number of significant variables left in the model after the backwards stepwise regression procedure the better the likely predictive ability of the model. In the model verification process the higher order models are likely to outperform other the models, such as model 12, as they have a wider array of individual variables from which significant variables can be retained. For this reason is not logical to attempt to verify using models containing only significant variables as this goes against the principles of the chunkwise approach in which variables are considered in collective groups and not on an individual basis.

Table 9.2 shows the model order based on the number of explained degrees of freedom for the incremental increase in terms of numbers of bidders up to the predetermined 15 bidder cut off point (For the sake of brevity this has been reported in three bidder increments). The global F values for all candidate models are significant, indicating that the transformed models are useful in predicting competitiveness. The vast majority of transformed models also show a slightly improved adjusted R2 statistic when compared to their untransformed versions (see Table 7.1) indicating a better fit to the data.

A summary of model comparison using a forward sequential candidate model selection technique based on the F-test can be seen in Table 9.3. The respective best transformed models for the 6 bidder, 9 bidder, 12 bidder and 15 bidder data sets are models 19, 12, 12 and 12. Although the best model prediction is not consistent for the smaller data set, transformed model 12 does pull through as being the best model where there are 9 or more bidders. These findings are consistent with the adjusted R2 values in Table 9.2 where the same very same models obtain comparatively high adjusted R2 scores for the respective combination of bidders. These results are also borne out with Mallow's Cp scores shown in Figure 9.1. It can be seen that model 12's performance in terms of bias improves as the number of bidders increases.

6 BIDDERS 5 TYPES							9 BIDDERS 5 TYPES						
Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2	Mod No.	Exp df	Res	SSE	M S Error	F Value	Adj R2
1	0	360	1.14	0.003171	0.00	0.00	1	0	513	1.86	0.003617	0.00	0.00
2	3	357	1.07	0.002992	12.32	0.06	2	3	510	1.78	0.003490	10.80	0.03
3	7	353	1.03	0.002918	6.38	0.08	3	7	506	1.74	0.003439	5.59	0.05
4	8	352	0.98	0.002784	8.30	0.12	4	11	502	1.46	0.002908	13.59	0.20
5	12	348	0.96	0.002759	5.99	0.13	5	15	498	1.66	0.003333	4.19	0.08
7	15	345	0.98	0.002841	4.07	0.10	7	15	498	1.43	0.002871	10.58	0.21
6	18	342	0.94	0.002749	4.32	0.13	8	23	490	1.34	0.002735	8.57	0.24
8	20	340	0.90	0.002647	4.81	0.17	6	27	486	1.35	0.002778	7.00	0.23
9	22	338	0.91	0.002692	4.10	0.15	9	31	482	1.32	0.002739	6.52	0.24
12	30	330	0.87	0.002636	3.55	0.17	12	39	474	1.26	0.002658	5.89	0.27
10	32	328	0.88	0.002683	3.15	0.15	10	47	466	1.30	0.002790	4.33	0.23
13	40	320	0.84	0.002625	2.95	0.17	13	55	458	1.23	0.002686	4.31	0.26
14	42	318	0.84	0.002642	2.79	0.17	14	63	450	1.21	0.002689	3.87	0.26
21	50	310	0.81	0.002613	2.59	0.18	21	71	442	1.17	0.002647	3.70	0.27
11	52	308	0.82	0.002662	2.37	0.16	11	79	434	1.17	0.002696	3.26	0.25
15	60	300	0.79	0.002633	2.26	0.17	15	87	426	1.11	0.002606	3.33	0.28
16	62	298	0.78	0.002617	2.27	0.17	16	95	418	1.09	0.002608	3.12	0.28
18	70	290	0.75	0.002586	2.20	0.18	18	103	410	1.05	0.002561	3.08	0.29
17	72	288	0.74	0.002569	2.20	0.19	17	111	402	1.07	0.002662	2.68	0.26
20	80	280	0.71	0.002536	2.16	0.20	20	119	394	1.02	0.002589	2.73	0.28
19	82	278	0.70	0.002518	2.17	0.21	19	127	386	1.01	0.002617	2.56	0.28
22	90	270	0.68	0.002519	2.06	0.21	22	135	378	0.98	0.002593	2.52	0.28

12 BIDDERS 5 TYPES							15 BIDDERS 5 TYPES						
Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2	Mod No.	Exp df	Res df	SSE	M S Error	F Value	Adj R2
1	0	652	2.32	0.003553	0.00	0.00	1	0	776	2.69	0.003470	0.00	0.00
2	3	649	2.23	0.003430	13.16	0.03	2	3	773	2.59	0.003351	15.37	0.03
3	7	645	2.19	0.003395	6.20	0.04	3	7	769	2.53	0.003290	8.26	0.05
4	14	638	1.90	0.002978	10.75	0.16	5	15	761	2.45	0.003219	5.39	0.07
5	15	637	2.10	0.003297	4.69	0.07	4	17	759	2.21	0.002912	10.37	0.16
7	18	634	1.86	0.002934	9.15	0.17	7	21	755	2.16	0.002861	9.32	0.18
8	26	626	1.78	0.002843	7.54	0.20	8	29	747	2.09	0.002798	7.70	0.19
6	36	616	1.74	0.002825	5.83	0.20	6	45	731	2.00	0.002736	5.76	0.21
9	40	612	1.70	0.002778	5.69	0.22	9	49	727	1.95	0.002682	5.77	0.23
12	48	604	1.62	0.002682	5.52	0.25	12	57	719	1.88	0.002615	5.55	0.25
10	62	590	1.70	0.002881	3.51	0.19	10	77	699	1.95	0.002790	3.50	0.20
13	70	582	1.63	0.002801	3.55	0.21	13	85	691	1.89	0.002735	3.50	0.21
14	84	568	1.56	0.002746	3.32	0.23	14	105	671	1.78	0.002653	3.31	0.24
21	92	560	1.51	0.002696	3.29	0.24	21	113	663	1.72	0.002594	3.35	0.25
11	106	546	1.50	0.002747	2.83	0.23	11	133	643	1.68	0.002613	2.94	0.25
15	114	538	1.45	0.002695	2.84	0.24	15	141	635	1.65	0.002598	2.87	0.25
16	128	524	1.41	0.002691	2.65	0.24	16	161	615	1.59	0.002585	2.67	0.26
18	136	516	1.36	0.002636	2.69	0.26	18	169	607	1.56	0.002570	2.62	0.26
17	150	502	1.36	0.002709	2.37	0.24	17	189	587	1.53	0.002606	2.37	0.25
20	158	494	1.32	0.002672	2.37	0.25	20	197	579	1.51	0.002608	2.31	0.25
19	172	480	1.30	0.002708	2.19	0.24	19	217	559	1.47	0.002630	2.15	0.24
22	180	472	1.27	0.002691	2.17	0.24	22	225	551	1.45	0.002632	2.11	0.24

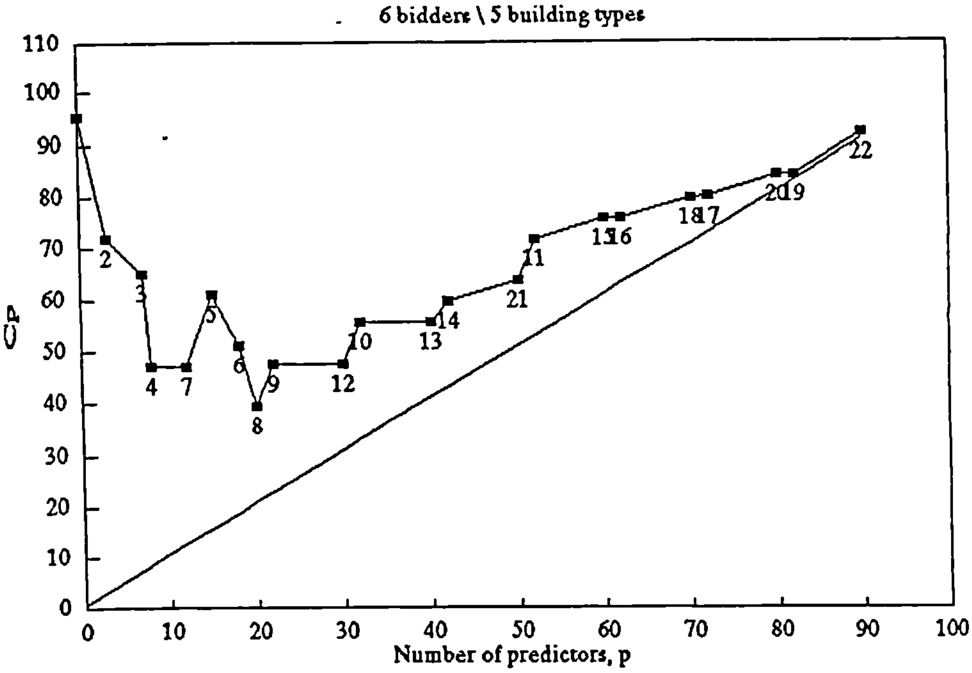
Table 9.2: A summary of candidate model 1 to 22 statistics based on 6, 9, 12 and 15 bidders

When comparing the adjusted R2 values for the candidate models in Table 9.2, turning to the summaries of model comparisons in Table 9.3 and looking at

Mallow's Cp scores in Figure 9.1, it was concluded that there appears to be sufficient evidence to verify that the transformed version of model 12 is still the best model.

6 BIDDERS 5 TYPES				9 BIDDERS 5 TYPES			
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.	Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	8.21	2.63	2	1 / 2	7.20	2.62	2
2 / 3	3.26	2.39	3	2 / 3	2.91	2.39	3
3 / 4	17.96	3.86	4	3 / 4	24.07	2.39	4
4 / 7	1.81	2.40	4	4 / 5	-	-	4
4 / 5	-	-	4	4 / 7	2.61	2.39	7
4 / 6	1.46	1.85	4	7 / 8	4.11	1.96	8
4 / 8	2.52	1.79	8	8 / 6	-	-	8
4 / 9	1.86	1.73	9	8 / 9	0.91	1.96	8
9 / 12	1.90	1.96	9	8 / 12	1.88	1.67	12
9 / 10	1.12	1.86	9	12 / 10	-	-	12
9 / 13	1.48	1.64	9	12 / 13	0.70	1.47	12
9 / 14	1.33	1.61	9	12 / 14	0.77	1.54	12
9 / 21	1.37	1.51	9	12 / 21	1.06	1.48	12
9 / 11	1.13	1.50	9	12 / 11	0.83	1.42	12
9 / 15	1.20	1.43	9	12 / 15	1.20	1.38	12
9 / 16	1.24	1.43	9	12 / 16	1.16	1.36	12
9 / 18	1.29	1.40	9	12 / 18	1.28	1.35	12
9 / 17	1.32	1.38	9	12 / 17	0.99	1.32	12
9 / 20	1.36	1.36	9	12 / 20	1.16	1.31	12
9 / 19	1.39	1.36	19	12 / 19	1.09	1.30	12
19 / 22	0.99	1.97	19	12 / 22	1.12	1.28	12
12 BIDDERS 5 TYPES				**15 BIDDERS 5 TYPES**			
Compared Models	Calculated Value	Tabulated Value	Accepted Model No.	Compared Models	Calculated Value	Tabulated Value	Accepted Model No.
1 / 2	8.78	2.61	2	1/2	10.25	2.61	2
2 / 3	2.65	2.39	3	2/3	4.56	2.38	3
3 / 4	13.91	2.03	4	3/5	3.11	1.95	5
4 / 5	-	-	4	5/4	41.21	3.01	4
4 / 7	3.41	2.39	7	4/7	4.37	2.38	7
7 / 8	3.52	1.96	8	7/8	3.13	1.96	8
8 / 6	1.42	1.85	8	8/6	2.06	1.66	6
8 / 9	2.06	1.71	9	8/9	2.61	1.59	9
9 / 12	3.73	1.96	12	9/12	3.35	1.96	12
12 / 10	-	-	12	12/10	-	-	12
12 / 13	-	-	12	12/13	-	-	12
12 / 14	0.61	1.45	12	12/14	0.79	1.37	12
12 / 21	0.93	1.40	12	12/21	1.10	1.37	12
12 / 11	0.75	1.35	12	12/11	1.01	1.31	12
12 / 15	0.96	1.34	12	12/15	1.05	1.29	12
12 / 16	0.98	1.31	12	12/16	1.08	1.27	12
12 / 18	1.12	1.30	12	12/18	1.11	1.26	12
12 / 17	0.94	1.28	12	12/17	1.02	1.25	12
12 / 20	1.02	1.27	12	12/20	1.01	1.24	12
12 / 19	0.95	1.26	12	12/19	0.97	1.23	12
12 / 22	0.99	1.26	12	12/22	0.97	1.23	12

Table 9.3: Summary of calculated and tabulated F values for candidate models 1 to 22 based on 6, 9, 12 and 15 bidders



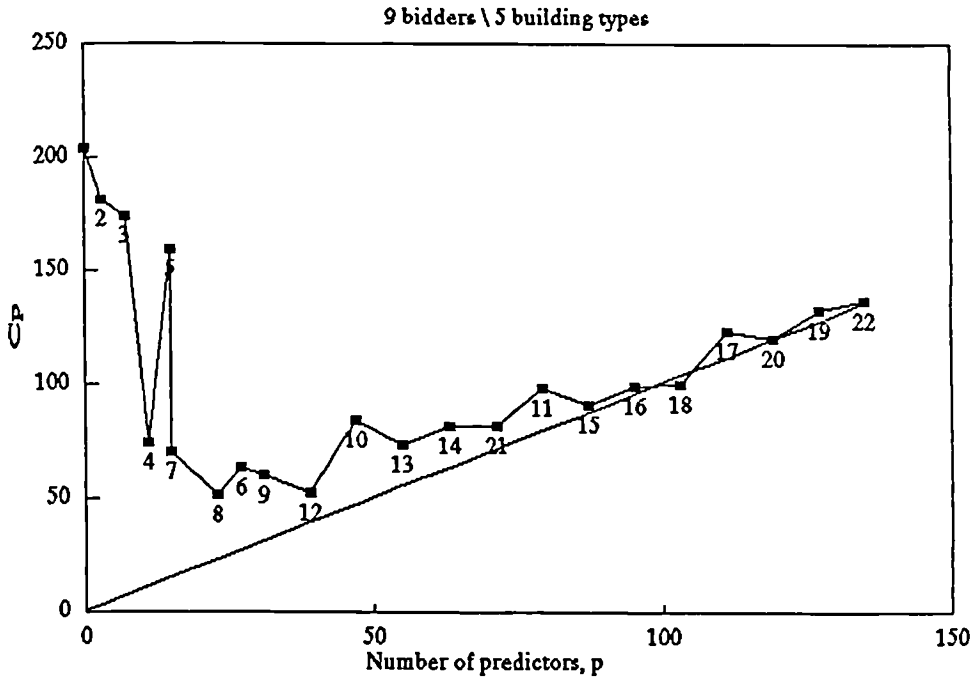


Figure 9.1 a: Plots of Mallow's Cp scores for candidate models 1 to 22 based on 6 and 9 bidders

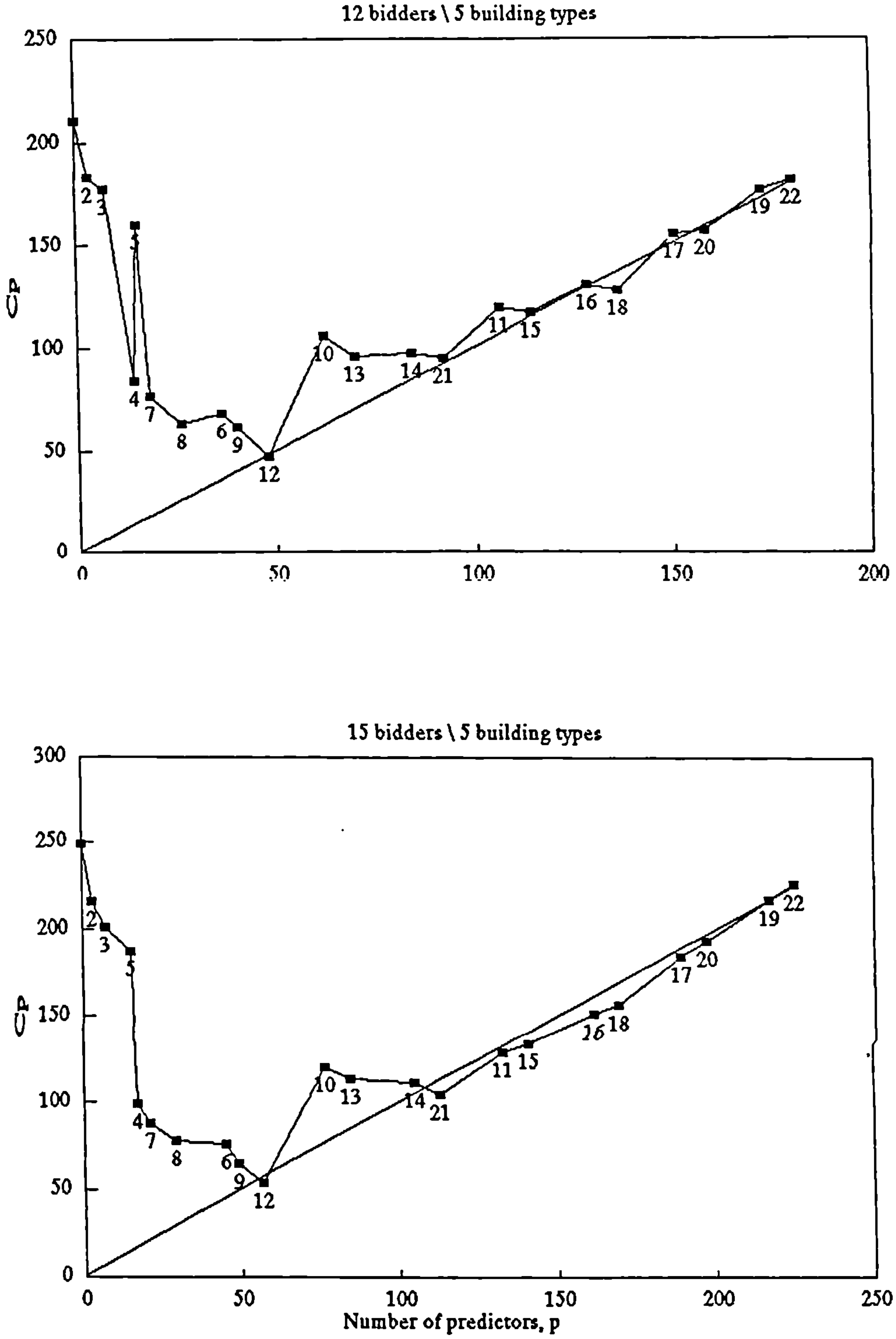


Figure 9.1 b: Plots of Mallow's Cp scores for candidate models 1 to 22 based on 12 and 15 bidders

9.3 Model prediction

After transforming the best model to satisfy the assumptions and verifying that the transformed version is still the best model as described above, the model's utility was examined (see Figure 9.2). The global F test statistics are found to be significant ($F_{.05}$ = 11.99, p = .0000, df= 24, 751). This means that at least one of the model coefficients is non-zero and, therefore, the model is useful at predicting competitiveness. The model achieves an adjusted R square statistic of 0.25392 which indicates that 25% of competitiveness variation is explained by the model.

To satisfy the regression assumptions model 12 was modified by centring and also transforming the x-variable to exponential 2/3 and transforming the y-variable to a lambda setting of -4.2. This transformed the competitiveness prediction equation as follows:

$$
\begin{aligned}
\hat{y} = [(-4.2)\ [\ a &+ b_1\ (x^{2/3}-7.68) + b_2\ (x^{2/3}-7.68)^2 \\
&+ b_3T_1 + b_4T_2 + \ldots\ b_nT_n + b_5B_1 + b_6B_1 + \ldots\ b_nT_n \\
&+ b_7T_1\ (x^{2/3}-7.68) + b_8T_1\ (x^{2/3}-7.68)^2\ \ldots \\
&+ b_nT_n\ (x^{2/3}-7.68) + b_nT_n\ (x^{2/3}-7.68)^2 \\
&+ b_9B_1\ (x^{2/3}-7.68) + b_{10}B_1\ (x^{2/3}-7.68)^2\ \ldots \\
&+ b_nB_n\ (x^{2/3}-7.68) + b_nB_n\ (x^{2/3}-7.68)^2]\ +1]^{-1/4.2}
\end{aligned}
$$

where

$\hat{y}$ = predicted competitiveness

x = contract size

T = contract type

B = bidder

Figure 9.2 illustrates the computer generated output relating to this model. Before transformation the model contained 56 variables. The backwards stepwise regression procedure (used to bring multicollinearity down to an acceptable level) eliminated all the insignificant variables and thereby reduced this number to 24 significant variables. Consequently all the predictor variables were deleted for fire

**** MULTIPLE REGRESSION ****

Equation Number 1 Dependent Variable .. DEP

Variable(s) Removed on Step Number
88.. B1BID

Multiple R	.52633
R Square	.27703
Adjusted R Square	.25392
Standard Error	.05090

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	24	.74564	.03107
Residual	751	1.94595	.00259

F = 11.99027 Signif F = .0000

------------------ Variables in the Equation ------------------

Variable	B	SE B	Beta	Tolerance	VIF
B10	.044678	.011645	.184513	.416241	2.402
B3BID	- .003869	.001482	-.084180	.926319	1.080
B13BID2	.001603	6.3808E-04	.079277	.966278	1.035
B9BID2	.002266	8.5808E-04	.131902	.385807	2.592
J2BID2	1.84505E-04	7.4295E-05	.110088	.489889	2.041
B8BID2	.001263	6.6421E-04	.083631	.497799	2.009
B14BID	- .009123	.002266	-.157495	.628896	1.590
B2	.046624	.008524	.216217	.616060	1.623
J3	- .025030	.009048	-.156230	.301856	3.313
B10BID	.005548	.002021	.102196	.694663	1.440
J2	- .011214	.005380	-.074997	.743579	1.345
B14	.055662	.010134	.216228	.621131	1.610
J3BID2	.003888	9.0530E-04	.304454	.191582	5.220
J4	- .018339	.005082	-.126844	.779257	1.283
B9BID	.006071	.003486	.079935	.456917	2.189
B10BID2	- .001245	3.9433E-04	-.143149	.468274	2.136
B8	- .026861	.010369	-.114042	.496745	2.013
B9	- .048195	.010822	-.199038	.481934	2.075
B2BID2	-9.15487E-04	4.0451E-04	-.088090	.635448	1.574
J2BID	- .004336	.001093	-.179579	.469617	2.129
B7	.077189	.012002	.327712	.370794	2.697
B12BID	- .005511	.001479	-.117635	.965964	1.035
J3BID	.010761	.005403	.183080	.113938	8.777
B7BID	.008211	.003458	.120991	.370805	2.697
(Constant)	.103058	.003399			

Figure 9.2 Regression model summary at a lambda setting of -4.2

stations and bidders coded 18, 109, 122, 127 and 148. The coefficients of these variables are given in the B column under the section of 'Variables in the Equation'. Since it is standard regression procedure to base the predictor variables on the last set of dummy variables in the equation (ie. hostels and bidder coded 9) this means that bidders' competitiveness toward fire stations is not significantly different to hostels. Also bidders' 9, 18, 109, 122, 127 and 148 competitiveness is not significantly different from each other.

Differences in the values of the dummy variable coefficients represent vertical shifts in competitiveness. A negative coefficient means that the bidder or contract type is more competitive than bidder 9 or hostels and vice versa. The interaction variables show differences *in the slope of the line relative to the bidder 9 - hostels* equation. Negative values mean the slope is less steep than that in this equation and vice versa. The size of the coefficient represents the steepness of the line. In respect of the interaction squared terms, the size of the coefficient in the squared term represents the difference in the degree of curvature relative to the bidder 9-hostels equation. A positive value indicates a convex curve and vice versa.

The backwards stepwise regression procedure deleted all the non-significant variables. For bidders coded 18, 127, 122, 148 and 109 the dummy variables (denoted in the output as B1, B4, B5, B6 B11), interaction (denoted in the output as B1BID, B4BID, B5BID, B6BID and B11BID) and interaction squared terms (denoted in the output as B1BID2, B4BID2, B5BID2, B6BID2 and B11BID2) are no longer in the equation. The deletion indicates that the competitiveness of these bidders is not significantly different from bidder 9, the 15th bidder. The model will show all these bidders as having an identical competitiveness over all the different contract sizes. Similarly for fire stations the dummy variable (ie. J1), interaction (ie. J1BID) and interaction squared term (ie. J1BID2) have all been deleted from the equation. This indicates that competitiveness towards fire stations is not significantly different from that of hostels. The model will show these two contract types as having identical competitiveness.

It should be noted that the contract size main effect variables (ie. BID and BID2) have been eliminated from the equation by the backwards stepwise procedure as being insignificant.

To predict the competitiveness the values of the predictor variables are multiplied by the b coefficients remaining in the equation and added together with the a coefficient (ie. the constant). For example, the competitiveness model for bidder 96 (denoted as 'B9' in the output shown in Figure 9.2) on police stations (denoted as 'J2' in the output shown in Figure 9.2) is as follows:

$$\hat{y} = [(-4.2)\ [\ a + J2 + B9 + J2BID\ (x^{2/3} - 7.68) + J2BID2\ (x^{2/3} - 7.68)^2 + B9BID\ (x^{2/3} - 7.68) + B9BID2\ (x^{2/3} - 7.68)^2] + 1]^{-1/4.2}$$

For a contract size of \$20 million, coefficients from the output in Figure 9.2 can be entered into the equation as follows:

$$\hat{y} = [(-4.2)\ [0.103058 - 0.011214 - 0.048195 - 0.004336\ (20^{2/3} - 7.68) - 1.84505E\text{-}4(20^{2/3} - 7.68)^2 - 0.006071\ (20^{2/3} - 7.68) - 0.002266(20^{2/3} - 7.68)^2] + 1)^{-1/4.2}$$

$$\hat{y} = 0.962$$

Assuming the model represents the true relationship between competitiveness and contract size, bidder 96's predicted competitiveness for a police station of \$20 million is 0.962.

With the aid of a standard spreadsheet package the competitiveness prediction equations were estimated for each of the 15 bidders according to each of the five types, thus producing a total 75 curvilinear regression lines. As expected the model shows bidders coded 9, 18, 109, 127, 122, and 148, and also fire stations and hostels as having identical competitiveness. The curvilinear regression lines are grouped first, according to types and second, according to individual bidders.

9.3.1 Contract type

Figure 9.3 a - d shows the competitiveness predictions for each of the bidders according to the five types. In respect of the shape of the curves for fire stations and hostels, it can be seen that six lines are of the expected convex shape, 3 are concave and one line is straight and horizontal. The straight and horizontal line represents the competitiveness of the six bidders (ie. bidders coded 9, 18, 109, 122, 127 and 148) whose competitiveness is not significantly different from each other.

It should be noted that the reason for the straight and horizontal line is that all the coefficients except the constant have been deleted from the equation. The horizontal line suggests that the competitiveness of these bidders is unaffected by contract size.

Thirteen of the competitiveness curves are convex for police stations. Six of these are identical in shape (ie. for bidders 18, 127, 122, 148, 109 and 9) for reasons previously described. The remaining two curves are concave. Each of the curves is shaped similarly to that of fire stations and hostels. Comparing police stations to fire stations and hostels, it can be seen that bidders look to be slightly less competitive on the smaller police station contracts, but more competitive on the larger contracts. The difference is probably attributable to the contract type make up. The data sample for police stations contained a higher proportion of smaller alteration contracts plus some comparatively large new works projects.

For secondary schools the shape of the curves is identical to that of fire stations and hostels. The reason for this is that the interaction (ie. J1BID and J4BID) and squared interaction variables (ie. J1BID2 and J4BID2) have been deleted for these types. The difference is in the secondary school dummy variable (ie. J4) which has remained in the equation causing an upward vertical shift in the competitiveness predictions. The vertical shift of the regression lines toward unity mean that the bids

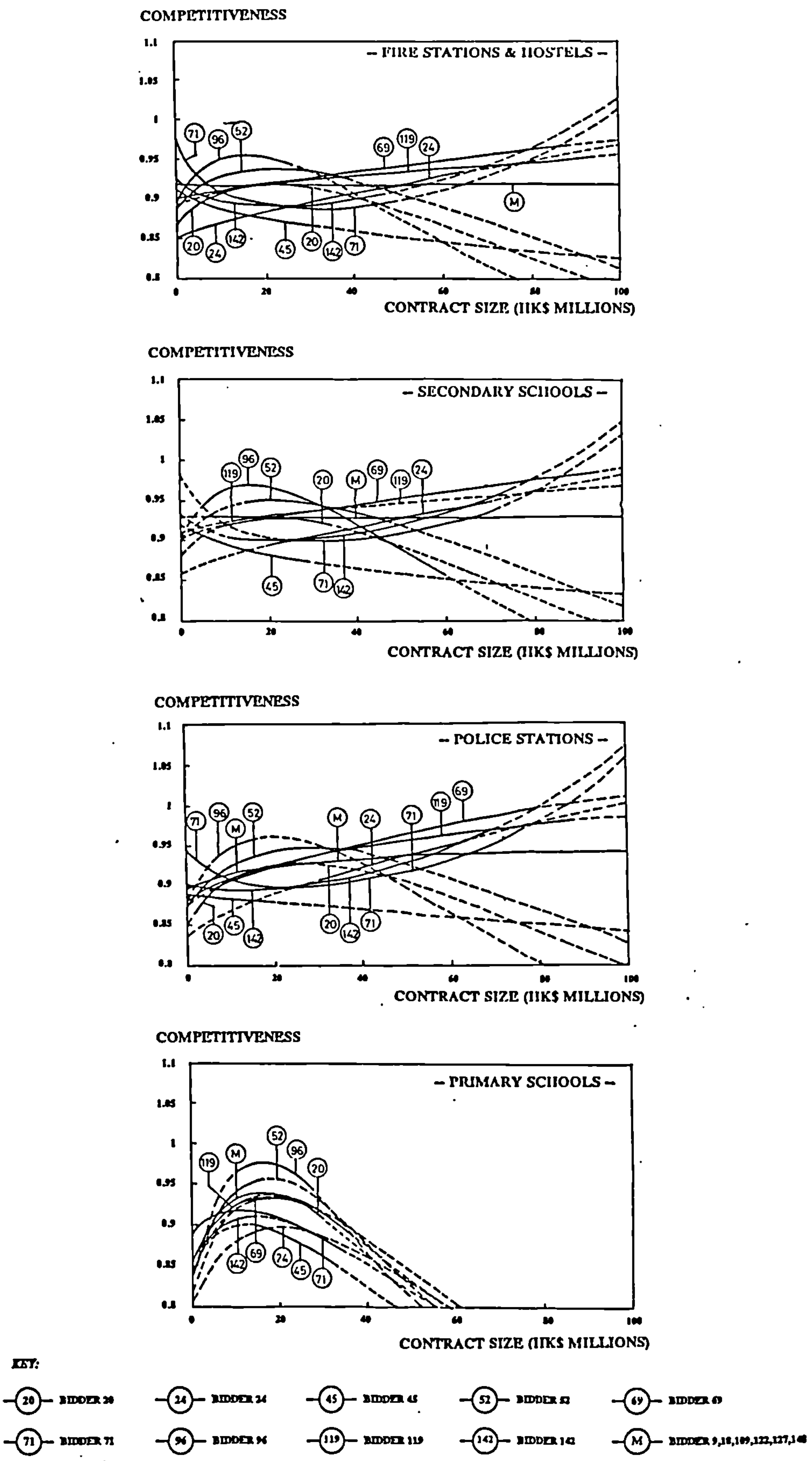


Figure 9.3: Competitiveness prediction models according to contract type

received for secondary schools are slightly more competitive than those for fire stations and hostels. A possible reason for this may be that there is a greater building type standardisation in secondary schools.

For primary schools all 15 bidders displayed the expected convex shape. As expected the competitiveness curves were identical for the same six bidders (ie. bidders 9, 18, 109, 122, 127 and 148).

9.3.2 Contract size

A major difference between primary schools and the other four contract types is the range and distribution of contract sizes. The data sets for the other four contract types are made up of a wider, more evenly distributed range of contract sizes whereas the majority of primary school contracts fall into a very narrow concentrated band. The probable reason why all 15 curves are concave in shape is the make up of this particular sample in which nearly all of the primary schools are of a standard size. It appears that in being a standard size, bidders from past experience can be more confident in predicting what the market price is likely to be and bid accordingly at the market price, thereby making the bids between bidders less variable and more competitive. An important contributory factor to this is that the sample for this type also contained a few smaller alteration contracts and a few larger primary school contracts in which the bids are more variable and overall less competitive. It would seem that the combination of the wider dispersion of bids for the smaller alteration work and larger primary school contracts combined with the narrower dispersion of bids for the standard new work primary school contracts has produced convex curves for every bidder. It seems that there are likely to a few bidders who dominate the construction of primary schools because of the effect of the learning curve, enabling bidders to produce more competitive bids, coupled with the degree of building type standardisation.

The essential difference, therefore, between primary schools and the other four contract types comprising fire stations, police stations, secondary schools and hostels is the contract size distribution and range. Since primary schools consists of only smaller contracts bidders' competitiveness is confined to small contracts. However, since the other four contract types contain both smaller and larger contracts, bidders' competitiveness is not so restricted.

The expected shape of the bidders' competitiveness curves appears to be dictated, to a large extent, by any one or combination of the following:

(1) the degree of contract type standardisation;
(2) the inclusion/exclusion of alteration work in the data sample;
(3) the inclusion/exclusion of non-standard size contracts in the data sample;
(4) the range of contract sizes contained in a particular type grouping;

The influence (1) - (3) has on the shape of bidders' curves can clearly be seen with the primary schools. The high degree of contract size standardisation coupled with the inclusion of smaller alteration work contracts and larger non-standard size contracts results in the curvilinear regression lines for all the bidders being convex. The effect (4) has on competitiveness can be seen in the remaining four contract types in which some bidders' were more competitive on the smaller contracts and vice versa whilst other bidders competitiveness appears unaffected by contract size.

9.3.3 Individual bidder performance

The same competitiveness predictions for the five contract types were regrouped according to each of the individual bidders (see Figure 9.4 a - j). Bold lines indicate the fit within the recorded data values and dashed lines show the curve extrapolated outside the data values.

The shape of the curvilinear regression line indicates the degree of competitiveness. A convex shape points to bidders having a preferred size range at which they are more competitive. A straight horizontal line shows that bidders do not have a preferred size range at which they are competitive. A concave shape is an indication of non-competitiveness at a particular contract size range. It also signifies two or

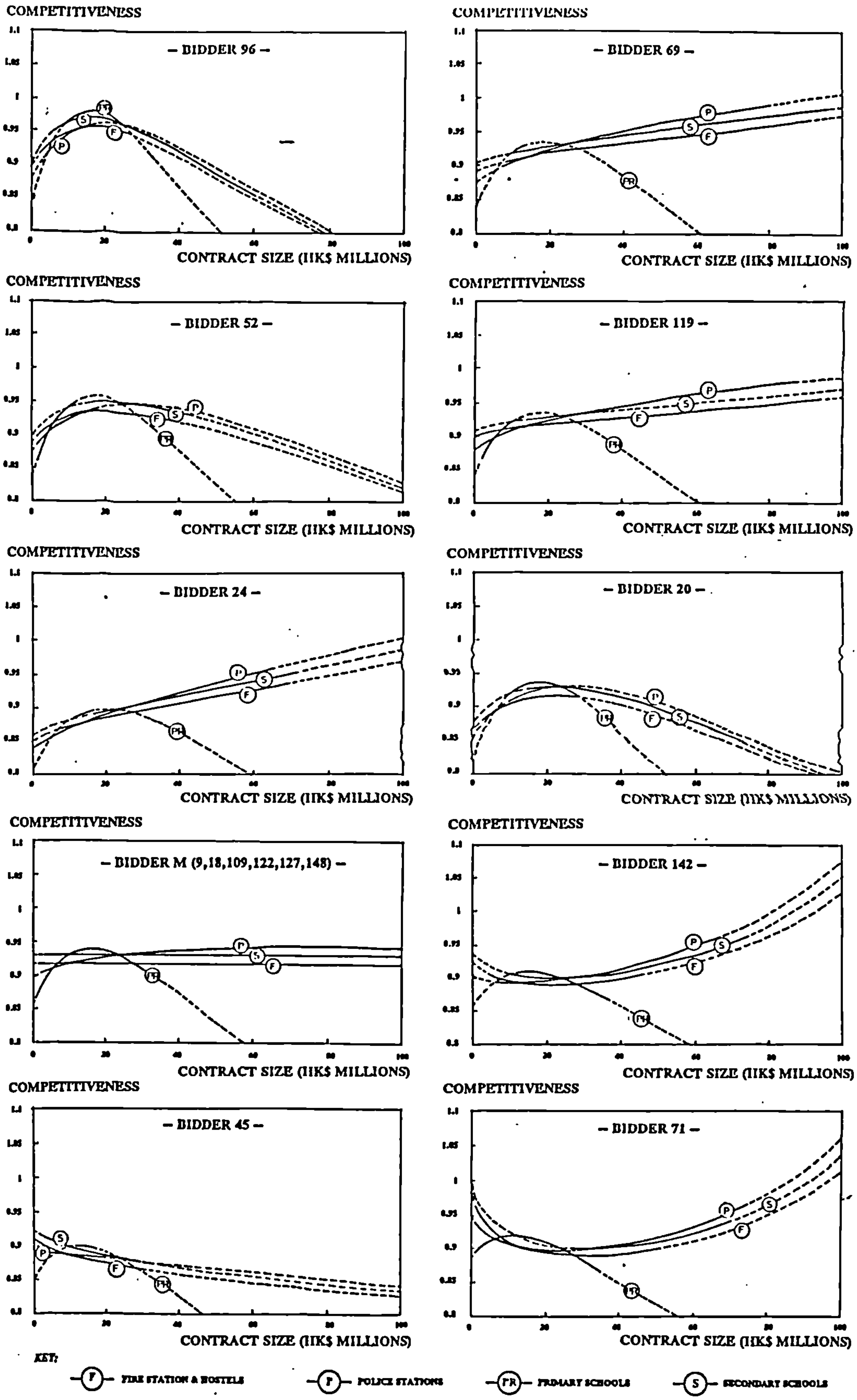


Figure 9.4: Competitiveness prediction models according to bidder

more preferred size ranges (Other possible reasons for concavity are given in Chapter 5).

Those bidders whose curves are convex, and therefore have a preferred size range for all five types, are bidders coded 20, 24, 52, 69, 96, 119. Of these bidders 20, 52 and 96 prefer smaller contracts and bidders 24, 69 and 119 prefer larger contracts. Those bidders whose bidding performance was not significantly different from each other (ie. bidders 9, 18, 109, 122, 127 and 148) have a preferred contract size for two contract types (ie. fire stations and primary schools) but, on account of the horizontal competitiveness prediction line, look not to have a preferred size range at which they are competitive for three contract types (ie. fire stations, secondary schools and hostels). Of the remaining bidders, bidders 45, 71 and 142 have a preferred contract size range for primary schools. Bidders 71 and 142 look to be uncompetitive on the smaller contracts but more competitive on the larger contracts of the other four contract types. Bidder 45, however, looks to be less competitive on the larger contracts of these other contract types.

Competitiveness performances of the 15 bidders can, therefore, be split into five main groupings:

(1) bidders who, in terms of competitiveness, have a preferred contract size range for smaller contracts (ie. bidders 24, 52 and 96);
(2) bidders who, in terms of competitiveness, have a preferred contract size range for larger contracts (ie. bidders 20, 69, 119);
(3) bidders who are more competitive on the larger contracts (ie. bidders 71 and 142);
(4) bidders whose competitiveness is largely unaffected by contract size (ie. bidders 9, 18, 109, 122, 127 and 148);
(5) bidders who are less competitive on larger contracts (ie. bidder 45).

It should be noted that the distinction between (2) and (3) is in the shape of the competitiveness curves which are respectively concave and convex. The competitiveness consistency of a bidder influences the shape of the curve. The analysis indicates that a bidder who is consistently competitive towards a particular type is more likely to acquire the expected convex curve. However, a bidder who is either inconsistently competitive or consistently uncompetitive is less likely to attain the expected convex curve.

9.3.4 Contract type and size

The regression analysis indicates that bidding performances according to contract type can be split into two contract size competitiveness groupings. One for the four contract types comprising *fire stations*, *police stations*, *secondary schools and* hostels which look to be made up of smaller and larger contracts, the other for the single contract type of primary schools, made up of only smaller contracts. Evidence of the two contract type groupings can clearly be seen in Figure 9.4 a-j which shows competitiveness predictions for the four contract types falling roughly into a parallel band. This indicates that bidders' competitiveness does not appear to differ very much between these types. It looks as though competitiveness predictions for primary schools appear different simply because they only contain smaller contracts. It is suggested that all five contract types are part of the same market sector because it is the same bidders who show preferred contract sizes for the smaller contracts for all five contract types (ie. bidders 20, 52 and 96). It appears those bidders who have a preferred contract size range for larger contracts (ie. bidders 24, 69, 119) or are more competitive towards larger contracts (ie. bidders 71 and 142) in the four contract type grouping do not appear to be competitive toward primary schools simply because there are no large contract sizes pertaining to this type.

9.3.5 Bidder size

Each contract type and bidder is interrelated to contract size. Each contract type will generate a range of contract sizes in the form of bidding attempts. Similarly each bidder will produce a range of contract sizes in the form of bids. The effect contract size has on contract type and the effect contract size has on the bidder can be measured by considering the effect of the coefficient of the x squared term. The larger the coefficient the steeper is the slope of the regression line and thus the greater the correlation between contract size and competitiveness.

In respect of the effect contract size has on contract type, the x squared coefficients in Figure 9.2 show primary schools (J3BID2 = 0.00388) as being affected the most followed by police stations (J2BID2 = 1.84505E-4). The respective x squared coefficients for fire stations and secondary schools have been deleted from the equation so it would seem that these types are not significantly affected. As for the effect contract size has on bidder, the x squared coefficients in Figure 9.2 show the following bidders are affected in decreasing order of influence; bidder 96 (B9BID2 = 0.002266), bidder 20 (B13BID2 = 0.001603), bidder 52 (B8BID2 = 0.001263), bidder 71 (B10BID2 = -0.001245), bidder 142 (B2BID2 = -9.15487E-4). The remaining bidders have been deleted from the equation, therefore, it would seem that they are not significantly affected by contract size.

9.3.6 Bidder size, contract type and size

Flanagan and Norman's study is based on the bidding performance of a small, medium and large bidder. Using the Government classification system (see Methodology, Chapter 5) the 15 bidders can be grouped into smaller and larger bidders. The smaller bidders are those coded 9, 20, 45, 52, 96, 122 and 127. The larger bidders are those coded 18, 24, 69, 71, 109, 119, 142 and 148.

For the four contract type grouping comprising fire stations, police stations, secondary schools and hostels, it can be seen that the strongest competitors for the smaller contracts are the smaller bidders (ie. bidders 52 and 96) and for the larger contracts the larger bidders (ie. bidders 69 and 119). Also, four of the larger bidders (ie. bidders 69, 71, 119 and 142) appear to be less competitive on the smaller contracts and more competitive on the larger contracts. Bidder 45 (classified as a smaller bidder) was less competitive toward the larger contracts. For primary schools, which consists of only smaller contracts, the smaller bidders (ie. bidders

52 and 96) are the strongest competitors. All of this evidence supports the economies of scale theory in that larger bidders undertake larger contracts with increased rates of efficiency.

Evidence that neither supports nor contradicts this theory is that of the six bidders (ie. bidders 9, 18, 109, 122, 127 and 148), whose bidding performance did not differ significantly from each other. It seems their bidding performance was largely unaffected by contract type and contract size.

Competitiveness differences in bidding performance in relation to bidder size perhaps explain why the bidder model in which bidders were grouped into small, medium and large performed so badly during the best model selection process. It would seem that the findings from the individual bidding performances do support the economies of scale theory that relates size of contract with size of bidder. A corollary, however, to this finding is the possible undue influence of using the Government bidder classification system to measure bidder size as it is the same classification system which determines the range of contract sizes a bidder can bid for. Therefore in using this measure it seems logical that smaller bidders who are restricted only to bidding on smaller contracts should be more competitive in this range contract sizes. Also that the larger bidders should appear to be more competitive on the larger contracts because they are not competing with the smaller bidders. It would seem the essential difference between this and any 'natural' bidder size-contract size selection process is that the Government selection process is more formalised. Therefore it is acknowledged that using such a measure may unduly influence these findings.

9.4 Reliability

The reliability of the model is examined by comparing the predicted values with the 95% upper and lower prediction intervals according to contract type and bidder.

Since it appears that bidders fall into five competitiveness groupings, and contract types into two, for the sake of brevity. a representative sample made up of bidders 96, 69, 71, 45 and the 6 bidder grouping (ie. bidders 9, 18, 109, 122, 127 and 148) for primary and secondary schools is shown in Figure 9.5. This figure shows a scatterplot of the predicted values (denoted by squares), 95% upper and lower prediction intervals (respectively denoted by diamonds and triangles) and actual bidding attempts (denoted by crosses). As can be seen, due to the logarithmic nature of the scale, the upper and lower prediction intervals are not equidistant from the predicted values. As expected, the distances between the predictions and prediction intervals form a relatively wide band which signifies that the competitiveness predictions are not very reliable.

Despite the competitiveness predictions not being very reliable, Figure 9.5 does show which bidders are likely to have the potential of submitting the lowest bid. This can be observed by comparing the 95% upper interval predictions with the competitiveness value of unity (ie. equivalent to the lowest bid). If the upper interval prediction falls directly on a competitiveness value of unity (ie. equivalent to the lowest bid) then it is predicted that the bidder has a 1 in 20 chance of submitting the lowest bid. If this interval prediction is greater than unity then this probability prediction increases.

The competitiveness model shown in Figure 9.5 predicts that bidder 96 becomes the lowest bidder for smaller primary school contracts as high. A similar forecast is given in respect of bidder 69 for larger secondary school contracts. However, the probability that bidder 45 chance becomes the lowest bidder appears very remote. Bidder 71 chances of becoming the lowest bidder seems to improve with the larger contracts. In comparison, bidders 9, 18, 109, 122, 127 and 148 likelihood of providing the lowest bid looks only to be moderate.

Although the prediction intervals reveal that the model is quite limited at predicting competitiveness, it seems that the model does, at least, give an indication of whether a bidder's competitiveness is likely to be above, below or just average in relation to other bidders. Table 9.4 suggests the competitiveness grouping of the 15

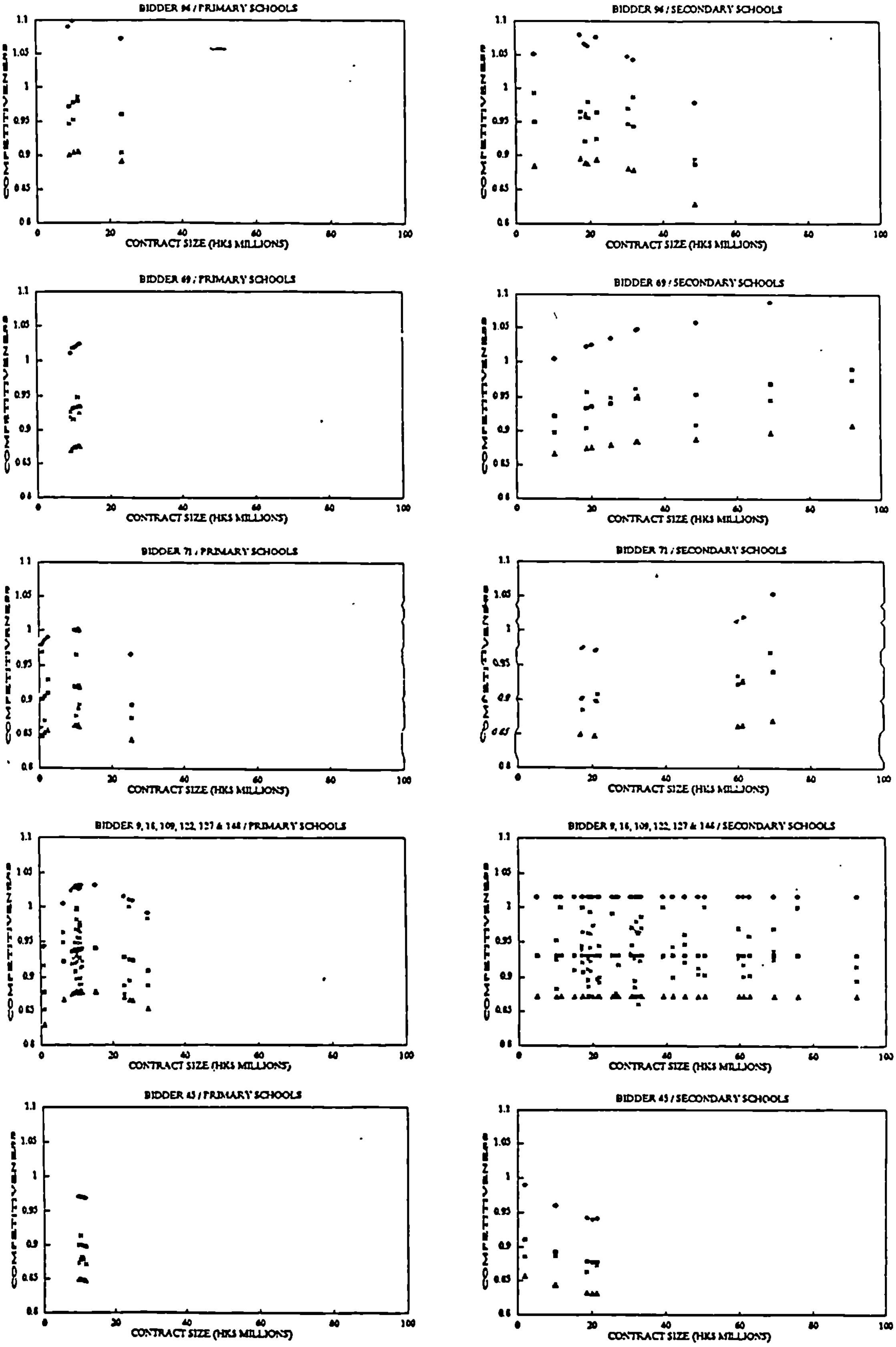


Figure 9.5: Scatterplot of the 95% upper and lower prediction intervals, predicted values and actual bidding attempts according to bidder

bidders for the 5 contract types, according to smaller and larger contracts and according to the three levels of competitiveness just described.

Competitiveness	Primary Schools	Fire Stations, Police Stations Secondary Schools & Hostels	
		Smaller	Larger
Above average	52, 96	52, 96	69, 119, 142
Average	9, 18, 20, 69, 71, 109, 119, 122, 127, 142, 148	9, 18, 20, 69, 71, 109, 119, 122, 127, 142, 148	9, 18, 24, 71, 109, 122, 127, 148
Below average	24, 45	24, 45	

Table 9.4: Competitiveness of bidders according to five contract types

9.5 Summary

To attempt to transform every candidate model to satisfy the regression assumptions for the purposes of verification would be too time consuming due to the approach used in testing each assumption. Attempts were made, therefore, to transform the closest challengers to model 12. However, suitable transformations to reduce multicollinearity to an acceptable level for the closest challengers could not be found. Hence, the approach taken in the verification process has been to analyse all other candidate models using the same transformation that was used for model 12.

In assessing the degree to which the candidate models satisfied the regression assumptions it was only possible to obtain statistics for 17 of the 21 models due to computer related problems. Of the assessed models it was found that only three models satisfied the homoscedasticity assumption. The high failure rate is likely to be attributable to model 12's transformation not being suitable for the other candidate models. It was the higher order models that failed the multicollinearity assumption. A probable reason for failing this assumption was because of the large number of variables left in the equation. No candidate model, for which statistics were produced, failed the normality assumption.

In testing the transformed model 12 against all other candidate models to verify whether model 12 in its transformed state remains as the best model, all variables, rather than just the significant variables, were retained within the transformed candidate models. This approach was taken due to the rationale underlying the chunkwise model building process. Candidate models have been built and analysed on the basis of collective groups (or chunks) of variables in preference to using individual significant variables.

Bidders were added incrementally into the sample and for each bidder added into the analysis the candidate models were tested using a forward sequential candidate model selection technique based on the F-test. It was found that model 12 in its transformed state continued to be the best model.

The model's utility statistics, when examined, *shows the global F test statistic to* be significant ($F_{.05}$ = 11.99, p = .0000, df= 24, 751). This means that at least one of the model coefficients is non-zero and, therefore, the model is useful at predicting competitiveness. The model achieves an adjusted R square statistic of 0.25392 which indicates that approximately 25% of competitiveness variation is explained by the model.

Competitiveness predictions for the four contract types of fire stations, police stations, secondary schools and hostels fall roughly into a parallel band. This indicates that bidders' competitiveness does not appear to differ very much between these types. The essential difference between primary schools and these other four contract types is in the distribution and range of contract sizes. These two groupings appear to be part of the same market sector since it is the same bidders who have preferred contract sizes for the smaller contracts in both groupings.

The analysis shows that the competitiveness of the 15 bidders can be classified into five distinct groupings:

(1) bidders who, in terms of competitiveness, have a preferred contract size

range for smaller contracts (ie. bidders 24, 52 and 96);

(2) bidders who, in terms of competitiveness, have a preferred contract size range for larger contracts (ie. bidders 20, 69, 119);

(3) bidders who are more competitive on the larger contracts (ie. bidders 71 and 142);

(4) bidders whose competitiveness is largely unaffected by contract size (ie. bidders 9, 18, 109, 122, 127 and 148);

(5) bidders who are less competitive on larger contracts (ie. bidder 45).

There is some evidence that supports the economies of scale theory in that larger bidders undertake larger contracts with increased rates of efficiency. However, it is acknowledged that using such a bidder size measure based on Government classification may unduly influence these findings.

Although the prediction intervals reveal that the model is quite limited at predicting competitiveness, it seems that the model does, at least, give an indication of whether a bidder's competitiveness is likely to be above, below or just average in relation to other bidders.

The model presented in this chapter is based on a matrix inversion with hostels and bidder 9 as last dummy variables. Based on this particular matrix inversion and using the backwards stepwise procedure, bidders' competitiveness towards hostels and fire stations are found not to be significantly different. Likewise bidders 9, 18, 109, 122, 127 and 148 are also not significantly different. Using other contract types and bidders as last dummy variables and iterating the regression procedure, the next chapter examines the possibility of other contract types and bidders not being significantly different in terms of competitiveness. In instances where this occurs, the model is refined by grouping these contract types and bidders together.

CHAPTER 10

Refining the model

10 REFINING THE MODEL

10.1 Introduction

The regression model in Chapter 9 shows that bidders' competitiveness towards hostels and fire stations are not significantly different. Likewise, the competitiveness of bidders coded 9, 18, 109, 122, 127 and 148 are also not significantly different. The reason the model shows this is that all the coefficients pertaining to these contract types and bidders are deleted from the regression equation. This is the result of inverting the regression matrix with hostels and bidder 9 as last dummy variables, using the chunkwise algorithm (which deleted the non-significant chunks) and the backward stepwise procedure (which has deleted the remaining non-significant coefficients) for these contract types and bidders.

The coefficients making up the regression equation are computed on the last dummy variables entered into the equation (ie. hostels and bidder 9). The closer, in terms of competitiveness, the other contract types and bidders are in relation to these last dummy variables, the smaller the difference in the resulting coefficients. If the computed difference is not significant the coefficient will, through the backwards stepwise procedure, be deleted from the equation. With hostels and bidder 9 as the last dummy variables, all coefficients pertaining to fire stations and bidders 18, 109, 122, 127 and 142 were deleted from the equation.

By iterating the regression analysis on the last dummy variables of other contract types and bidders, the competitiveness model can be refined by identifying which other contract types and bidders are also not significantly different from each other. A fundamental goal of model building is to find the best prediction model containing the least number of predictor variables. Since the competitiveness predictions between fire stations and hostels and bidders 9, 18, 109, 122, 127 and 142 are not significantly different, the approach taken in this part of the analysis is to recode fire stations and hostels as one combined contract type and bidders 9, 18, 109, 122, 127 and 142 as one combined bidder.

The recoding reduces the number of contract types in the model from five to four and the number of bidders from 15 to 10. Using these four contract types and 10 bidders together with last dummy variables from other contract types and bidders, the regression procedure was repeated to determine if other contract types and bidders can be grouped together. If other contract types and bidders were found to be not significantly different these were recoded as one combined contract type or bidder and the process iterated until all variables displaying non-significant characteristics were found and combined together.

Model 12 in its present transformation was used as the starting point for refining the model. It would seem reasonable to start with this particular model and transformation because, after extensive testing, model 12 is shown in Chapters 7 and 9 to be the best model and the present transformation is shown in Chapter 8 to be one that satisfies all the regression assumptions. At each iteration the regression assumptions were tested. In instances where the model no longer satisfies the assumptions other more suitable transformations were considered.

This chapter comprises three sections. By swapping the last contract type dummy variables and iterating the model, the first section examines the extent to which bidder behaviour differs significantly toward contract type. Whilst adopting the same procedure but swapping the last bidder dummy variables, the second section identifies which groups of bidders do not differ significantly in terms of competitiveness. Competitiveness predictions and reliability of the refined model is presented in the third section.

10.2 Contract type iterations

The following contract type iteration is based on 4 contract types and 10 bidders with fire stations and hostels being recoded as contract type FSH and bidders 9, 18, 109, 122, 127 and 142 being recoded as bidder M. With secondary schools (contract type 713) and bidder 24 being put into the position of last dummy variable, Figure 10.1 shows the regression model summary statistics based on four contract types and 10 bidders. Compared with the previous 5 contract type 15 bidder regression model (see Figure 9.2) it can be seen that there is a slight drop in the adjusted R2 statistic (from .25392 to .24823), however, there is a slight increase in the global F test statistic (from 11.99027, Signif F =.0000 to 12.12594, Signif F =.0000). The reason for the slight increase in this latter statistic is that the variables remaining in the equation has dropped from 24 to 23.

In respect of satisfying the regression assumptions, Figure 10.1 also shows that the multicollinearity assumption is satisfied since none of the variance inflation factors exceed 10. The normality (K-S prob = 0.205) and homoscedasticity assumptions are also satisfied; using Szroeters test for continuous variables and the Bartlett Box test for categorical variables it is found that three variables are heteroscedastic (ie. BID, BID2 and J3BID). The probability of three variables out of 23 being heteroscedastic is 0.079. Since this exceeds the critical value 0.05, the iterated model can be accepted as one that satisfies all the regression assumptions.

The remaining contract type coefficients shown in Figure 10.1 are presented again in Table 10.1, but in a different format to demonstrate more clearly the effect of the contract type coefficients on the regression equation. It can be seen that for fire stations and hostels (coded FSH) the dummy variable J1 and interaction variable J1BID were retained. The competitiveness difference between this variable and the last dummy variable, secondary schools (coded 713), is a vertical shift and change in slope in the regression line. For primary schools (coded 712) the dummy variable J3 was deleted while both the interaction variable J3BID and squared interaction variable J3BID2 were retained in the equation. The deletion of the dummy variable means that the level of competitiveness is not significantly different, however, the slope and shape of the regression line is significantly different. These findings appear to conform with the previous findings reported in Chapter 9 and shown in Figures 9.3 and 9.4.

**** MULTIPLE REGRESSION ****

Equation Number 1 Dependent Variable .. DEP

Variable(s) Removed on Step Number
53.. B3BID

Multiple R	.52013
R Square	.27054
Adjusted R Square	.24823
Standard Error	.05110

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	23	.72818	.03166
Residual	752	1.96341	.00261

F = 12.12594 Signif F = .0000

-- Variables in the Equation --

Variable	B	SE B	Beta	Tolerance	VIF
J3BID2	.004252	8.5180E-04	.332968	.218055	4.586
B1	- .045233	.006123	-.378919	.368721	2.712
B2BID	.006292	.002535	.106966	.522519	1.914
B6BID	.012822	.003607	.168835	.429980	2.326
B5BID	.007944	.003700	.113038	.350015	2.857
B7BID	.011714	.002087	.215761	.656605	1.523
B8	- .037984	.009417	-.149159	.709395	1.410
B7BID2	- .001156	3.1041E-04	-.132903	.761442	1.313
B3	- .051911	.008651	-.231794	.650032	1.538
B1BID	.005856	.001139	.296704	.291020	3.436
B6	- .094035	.011825	-.388346	.406721	2.459
B9	- .051881	.009995	-.197065	.673051	1.486
B5	- .072742	.011809	-.308829	.385894	2.591
B6BID2	.002235	8.4645E-04	.130092	.382862	2.612
J1	.010644	.004256	.089642	.755216	1.324
B2BID2	-8.51008E-04	4.4679E-04	-.081886	.524855	1.905
B4	.031416	.012918	.133379	.322508	3.101
B5BID2	.001602	7.9780E-04	.106040	.347675	2.876
J1BID	.002700	.001027	.114554	.511292	1.956
J3BID	.020160	.004106	.342968	.198836	5.029
B4BID	.014777	.003636	.217743	.337926	2.959
BID2	1.45854E-04	6.0227E-05	.108559	.482729	2.072
BID	- .009313	.001163	-.672248	.137713	7.261
(Constant)	.136352	.005832			

Figure 10.1: Regression model summary at a lambda setting of -4.2, based on 4 contract types and 10 bidders with 713 (secondary schools) and bidder 24 as last dummy variables.

LAST DUMMY VARIABLE: SECONDARY SCHOOLS			
Contract type code	Jn	JnBID	JnBID2
Fire stations and hostels (FSH)	J1	J1BID	-
Police stations (374)	-	-	-
Primary schools (712)	-	J3BID	J3BID2

Table 10.1: Contract type variables remaining in the equation at lambda setting of -4.2, based on 4 contract types and 10 bidders with 713 (secondary schools) and bidder 24 as last dummy variables.

With respect to police stations (coded 374) it can be seen in Table 10.1 that the dummy, interaction and squared interaction variables were all deleted. This means that bidders' competitiveness towards police stations and secondary schools is not significantly different and therefore these two variables can be grouped together in subsequent iterations. This non-significant difference was verified by swapping the last dummy variables with bidders other than bidder 24 and repeating the regression procedure. With every bidder iteration the dummy, interaction and squared interaction variables for police stations were deleted. Also when the last dummy variable for secondary schools was swapped with police stations, the dummy, interaction and squared interaction variables for secondary schools were also all deleted with the resulting regression model summary being identical to that shown in Figure 10.1.

To complete the contract type iterations, primary schools (coded 712) and bidder 24 were placed in the position of last dummy variable. The results were as expected. 28 variables remained in the model (Five more variables than the iteration shown in Figure 10.1). The larger number of variables remaining in the equation is because primary schools was the last dummy variable, and as can be seen in Figures 9.3 and 9.4 bidders' competitiveness towards primary schools is quite different when compared to the other contract types. This greater difference between types leads to more significant coefficients being retained in the model. The model achieved an adjusted R2 of 0.25008 (slightly higher than that shown in Figure 10.1) and a global F test statistic of 10.22995, Signif F =.0000 (slightly lower than that shown in Figure 10.1). The model failed to satisfy the regression assumption of multicollinearity (largest VIF for a variable in the model is 175.05) but passed the assumptions of normality (K-S prob = .218) and homoscedasticity (Two out of 28 variables are heteroscedastic). The likely reason why this iteration failed the assumption of multicollinearity is that of the larger number of variables remaining in the equation which creates excessive interdependency between the independent variables.

The foregoing results indicate that the original five contract types can be broken down into three contract type competitiveness groupings of (1) fire stations and hostels, (2) police stations and secondary schools and (3) primary schools. It seems the formation of these three groupings is primarily due to the different means and distribution of contract sizes for each contract type. These appear to fall into three distinct contract size bands. This can be seen in Table 10.2 which illustrates a contract size by contract type breakdown table for this 15 bidder data sub-set. Observe that primary schools has the smallest mean bid value and standard deviation, fire stations and hostels has the second and third smallest mean bid value and standard deviation while police stations and secondary schools have the second largest and largest mean bid values and standard deviation. The findings in Chapters 7 and 9 indicate that contract size is more important than contract type. The formation of the contract type groupings appear to be dictated by the size and distribution of contracts within the contract type.

Contract type	Mean bid value (HK$million)	Standard Deviation	Cases
Primary schools (712)	12.79	6.38	125
Fire stations (372)	14.72	9.82	133
Hostels (848)	20.26	18.09	206
Police stations (374)	28.51	27.26	149
Secondary schools (713)	35.61	21.23	163
Overall	22.92	20.38	766

Table 10.2 : Breakdown tables; contract size by contract type

For subsequent iterations the number of contract types in the model was reduced from four to three with the combined variable of police stations and secondary schools being recoded as PSS.

10.3 Bidder iterations

It was established in Chapter 9 that six of the 15 bidders' competitiveness toward contract type and size does not differ significantly from each other. This part of the analysis focuses on determining which of the other bidders are not significantly different. The first round of iterations is based on 3 contract types (ie. FSH, 712 and PSS) and 10 bidders (ie. bidders 20, 24, 45, 52, 69, 71, 96, 142 and M).

10.3.1 First round of bidder iterations

With FSH as the last contract type dummy variable, 10 different bidder iterations were computed, each with a different bidder as the last dummy variable. Table 10.3 shows the model utility statistics resulting from these iterations. It can be seen that, depending on the last bidder dummy variable, the number of variables remaining in the equation varies from 20 to 29. As expected, those iterations which contain the most number of variables were for bidders with more extreme bidding performances (ie. bidders' 96 and 45). Table 10.4 shows the regression assumption statistics for these iterations. It can be seen that four iterations satisfy all the regression assumptions (ie. where bidders 24, 69, 119 and M were last dummy variables), two failed the assumption of multicollinearity (ie. where bidders 52 and 142 were last dummy variables) and four failed the assumptions of both multicollinearity and homoscedasticity (ie. where bidders 20, 96, 71 and 45 were last dummy variables).

LAST BIDDER DUMMY VARIABLE	24	69	20	119	96
No. of variables in equation Adjusted R2 F / Signif F	24/751 0.25046 11.79/0.000	21/754 0.24711 13.11/0.000	27/748 0.25385 10.77/0.000	20/755 0.24717 13.72/0.000	29/746 0.25160 9.98/0.000
LAST BIDDER DUMMY VARIABLE	52	142	71	45	M
No. of variables in equation Adjusted R2 F / Signif F	27/748 0.25275 10.71/0.000	26/749 0.25451 11.17/0.000	27/748 0.25283 10.71/0.000	29/746 0.25215 10.01/0.000	23/752 0.25442 12.50/0.000

Table 10.3 : Model utility statistics at lambda setting of -4.2, based on 3 contract types and 10 bidders

LAST BIDDER DUMMY VARIABLE	24	69	20	119	96
Largest VIF K-S prob No. of hetro vari/prob	8.984 0.411 2/0.223	8.949 0.376 1/0.358	103.435 0.265 4/0.034	8.938 0.293 1/0.377	128.083 0.086 5/0.011
LAST BIDDER DUMMY VARIABLE	52	142	71	45	M
Largest VIF K-S prob No. of hetro vari/prob	111.341 0.229 3/0.107	36.540 0.229 3/0.100	41.625 0.107 4/0.034	47.375 0.160 5/0.011	8.778 0.241 2/0.215

Table 10.4 : Regression assumption statistics at lambda setting of -4.2 based on 3 contract types and 10 bidders

Table 10.5 shows the bidder variables remaining in the equation with each bidder being in the position of last dummy variable. Consider the iteration where bidder 24 was the last dummy variable and compare the bidder coefficients remaining in the equation for each of the other bidders. Under this iteration it can be seen that the bidding performances of each of the other bidders differ significantly in some way to that of bidder 24. Also the bidders whose bidding performances were most similar to bidder 24 were bidders 119, 69 and 20, where the only difference between bidding performances was a vertical shift in the dummy variable. When seen in the light of the competitiveness predictions shown in Figures 9.3 and 9.4 this would seem reasonable with the exception of bidder 20 who, in Chapter 9, was classed as a bidder who has a preferred contract size range for smaller contracts.

It appears that under this previous iteration bidder 20 may be wrongly classified. The suspected reason for this apparent misclassification is that bidder 20 has only bid over a comparatively small range of contracts (this can be seen in Figures 9.3 and 9.4 where dashed lines show the regression curve extrapolated outside the data values) thereby making the predictor coefficients less reliable. The bidders whose bidding performances were most dissimilar to bidder 24 were bidders 52 and 96. For these bidders the dummy, interaction and interaction squared variables were all retained in the equation.

LAST DUMMY VARIABLE 24			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	-
142	-	B2BID	B2BID2
119	B3	-	-
45	B4	B4BID	-
52	B5	B5BID	B5BID2
96	B6	B6BID	B6BID2
71	-	B7BID	B7BID2
69	B8	-	-
20	B9	-	-

LAST DUMMY VARIABLE 69			
Bidder code	Bn	BnBID	BnBID2
M	-	B1BID	-
142	B2	-	-
119	-	-	-
45	B4	B4BID	-
52	B5	B5BID	B5BID2
96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2
24	B8	-	-
20	-	-	-

LAST DUMMY VARIABLE 20			
Bidder code	Bn	BnBID	BnBID2
M	B1	-	B1BID2
142	B2	-	B2BID2
119	-	B3BID	B3BID2
45	B4	-	B4BID2
52	B5	-	-
96	B6	B6BID	-
71	B7	B7BID	B7BID2
69	B8	B8BID	B8BID2
24	B9	B9BID	B9BID2

LAST DUMMY VARIABLE 119			
Bidder code	Bn	BnBID	BnBID2
M	-	B1BID	-
142	B2	-	-
24	B3	B3BID	-
45	B4	B4BID	-
52	B5	-	-
96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2
69	-	-	-
20	-	-	-

LAST DUMMY VARIABLE 96			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	B1BID2
142	B2	B2BID	B2BID2
119	B3	B3BID	B3BID2
45	B4	-	B4BID2
52	B5	-	-
24	B6	B6BID	B6BID2
71	B7	-	B7BID2
69	B8	B8BID	B8BID2
20	B9	-	-

LAST DUMMY VARIABLE 52			
Bidder code	Bn	BnBID	BnBID2
M	B1	-	B1BID2
142	B2	-	B2BID2
119	B3	B3BID	B3BID2
45	B4	-	B4BID2
24	B5	B5BID	B5BID2
96	-	B6BID	-
71	B7	B7BID	B7BID2
69	B8	B8BID	B8BID2
20	B9	-	-

LAST DUMMY VARIABLE 142			
Bidder code	Bn	BnBID	BnBID2
M	B1	-	B1BID2
24	-	B2BID	-
119	B3	B3BID	B3BID2
45	B4	-	B4BID2
52	B5	-	B5BID2
96	B6	B6BID	B6BID2
71	-	B7BID	-
69	B8	B8BID	B8BID2
20	B9	-	B9BID2

LAST DUMMY VARIABLE 71			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	B1BID2
142	-	B2BID	-
119	B3	B3BID	B3BID2
45	B4	-	-
52	B5	-	B5BID2
96	B6	-	B6BID2
24	-	B7BID	B7BID2
69	B8	B8BID	B8BID2
20	B9	-	B9BID2

LAST DUMMY VARIABLE 45			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	B1BID2
142	B2	B2BID	-
119	B3	B3BID	B3BID2
24	B4	B4BID	B4BID2
52	B5	-	B5BID2
96	B6	-	B6BID2
71	B7	-	-
69	B8	B8BID	B8BID2
20	B9	-	B9BID2

LAST DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2
24	B1	B1BID	-
142	B2	-	B2BID2
119	-	B3BID	-
45	B4	B4BID	-
52	B5	-	B5BID2
96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2
69	-	B8BID	-
20	-	-	B9BID2

Table 10.5: Bidder variables remaining in the equation at lambda setting of -4.2 based on 3 contract types and 10 bidders

Moving on to the iterations where bidders 69, 119 and 20 were placed in the position of last dummy variable, it can be seen in Table 10.5 that for bidder 69 the dummy, interaction and interaction squared variables for bidders 119 and 20 were all deleted. This deletion was reciprocated where bidder 119 was the last dummy variable whereby the same three variables pertaining to bidders 69 and 20 were deleted. However, where bidder 20 was the last dummy variable, some of the dummy and iteration variables were retained in the equation. The suspected reason for bidder 20's variables not being consistent with bidders 69 and 119 was explained in the last paragraph (ie. bidder 20 has only bid over a comparatively small range of contracts thereby making the coefficients for this bidder less reliable). On balance, however, with all the variables pertaining to bidder 20 being deleted where bidders 69 and 119 were the last dummy variables, there appears to be sufficient evidence and justification to group these three bidders together in the next round of iterations.

In respect of the remaining iterations, where bidders 96, 52, 142, 71, 45 and M are the last dummy variables it can be seen in Table 10.5 that the results are similar to that of bidder 24 in that the bidding performances of each of the other nine bidders is significantly different in someway to that of the other bidders. The first round of iterations indicate that there is not further scope to group any more bidders together other than bidders 20, 69 and 119.

10.3.2 Second round of bidder iterations

For the second round of bidder iterations, bidders 20, 69 and 119 were recoded and combined as bidder 'N', thereby reducing the number of bidders remaining in the model from ten to eight. Tables 10.6 and 10.7 show the respective model utility statistics and regression assumption statistics. Both these tables display the models as having similar characteristics as those contained in the corresponding iterations described in the previous round of iterations. In respect of the regression assumption statistics note that three iterations satisfy all the regression assumptions (ie. where bidders 24, M and N were last dummy variables), two failed the multicollinearity assumption (ie. where bidders 52 and 142 were last dummy variables) and three failed the assumptions of both multicollinearity and homoscedasticity (ie. where bidders 96, 71 and 45 were last dummy variables).

LAST BIDDER DUMMY VARIABLE	24	96	52	45
No. of variables in equation Adjusted R2 F / Signif F	22/753 0.25070 12.78/0.000	25/750 0.25044 11.35/0.000	23/752 0.25052 12.26/0.000	24/751 0.25092 11.82/0.000
LAST BIDDER DUMMY VARIABLE	142	71	M	N
No. of variables in equation Adjusted R2 F / Signif F	21/754 0.25316 13.51/0.000	21/754 0.24992 13.30/0.000	21/754 0.25369 13.55/0.000	20/755 0.24717 13.72/0.000

Table 10.6 : Model utility statistics at lambda setting of -4.2, based on 3 *contract types and 8 bidders*

LAST BIDDER DUMMY VARIABLE	24	96	52	45
Largest VIF K-S prob No. of hetro vari/prob	8.951 0.335 1/0.375	160.348 0.268 5/0.006	151.615 0.273 3/0.079	47.251 0.259 6/0.001
LAST BIDDER DUMMY VARIABLE	142	71	M	N
Largest VIF K-S prob No. of hetro vari/prob	36.413 0.193 2/0.198	38.376 0.289 5/0.003	8.792 0.303 2/0.198	8.938 0.293 1/0.377

Table 10.7 : Regression assumption statistics at lambda setting of -4.2 based on 3 contract types and 8 bidders

Table 10.8 identifies the bidder variables remaining in the equation in which each bidder was placed in the position of last dummy variable. It can be seen that the bidding performance of each bidder was significantly different. Although there appears not to be further scope for grouping more bidders together, this may be because of the current transformation setting (ie. where lambda is set at -4.2 and the x-variable is set at 2/3) which restricts further groupings. However, a new transformation setting may enable more bidders to be grouped together. For example, consider bidders 142 and 71. Figures 9.3 and 9.4 show the bidding performances of both of these bidders as being very similar and as such they fall into the same competitiveness grouping (ie. they are classed as bidders who are more competitive on larger contracts). It can be seen in Table 10.8 that where bidder 142 was the last dummy variable, the dummy variable and interaction term of bidder 71 were retained in the model. Likewise where bidder 71 was the last dummy variable the interaction term of bidder 142 were retained in the model. Under the current transformation, where bidders 142 and 71 were last dummy variables, these iterations fail one or more of the regression assumptions. Perhaps when a suitable transformation is found to satisfy the all the regression assumptions for both models, the transformed version of the models will show that the competitiveness of these bidders are not significantly different.

LAST DUMMY VARIABLE 24			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	-
N	B2	-	-
142	B3	B3BID	B3BID2
45	B4	B4BID	-
52	B5	B5BID	B5BID2
96	B6	B6BID	B6BID2
71	-	B7BID	B7BID2

LAST DUMMY VARIABLE 96			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	B1BID2
N	B2	B2BID	B2BID2
142	B3	B3BID	B3BID2
45	B4	-	B4BID2
52	B5	-	-
24	B6	B6BID	B6BID2
71	B7	-	B7BID2

LAST DUMMY VARIABLE 52			
Bidder code	Bn	BnBID	BnBID2
M	B1	-	B1BID2
N	B2	B2BID	B2BID2
142	B3	-	B3BID2
45	B4	-	B4BID2
24	B5	B5BID	B5BID2
96	-	B6BID	-
71	B7	B7BID	B7BID2

LAST DUMMY VARIABLE 45			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	B1BID2
N	B2	B2BID	B2BID2
142	B3	B3BID	-
24	B4	B4BID	B4BID2
52	B5	-	B5BID2
96	B6	-	B6BID2
71	B7	-	-

LAST DUMMY VARIABLE 142			
Bidder code	Bn	BnBID	BnBID2
M	B1	-	B1BID2
N	B2	B2BID	B2BID2
24	-	B3BID	B3BID2
45	B4	-	-
52	B5	-	B5BID2
96	B6	B6BID	B6BID2
71	B7	B7BID	-

LAST DUMMY VARIABLE 71			
Bidder code	Bn	BnBID	BnBID2
M	B1	B1BID	-
N	B2	B2BID	-
142	-	B3BID	-
45	B4	-	-
52	B5	-	B5BID2
96	B6	-	B6BID2
24	-	B7BID	-

LAST DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2
N	-	B1BID	-
24	B2	B2BID	-
142	B3	-	B3BID2
45	B4	B4BID	-
52	B5	-	B5BID2
96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2

LAST DUMMY VARIABLE N			
Bidder code	Bn	BnBID	BnBID2
M	-	B1BID	-
24	B2	B2BID	-
142	B3	-	-
45	B4	B4BID	-
52	B5	-	-
96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2

Table 10.8: Bidder variables remaining in the equation at lambda setting of -4.2 based on 3 contract types and 8 bidders.

This was tested with bidders 142 and 71 in the position of last dummy variables. To correct excessive multicollinearity, in accordance with previous procedures, the x-variable (ie. contract size) was transformed according to various exponential functions including natural log. It can be seen from Table 10.9 that the best x-variable transformation was at the setting of natural log. The largest variance inflation factor (VIF) remaining in the equation was only 2.089 and 6.703 for bidders 142 and 71 respectively. Since both these values are less than the critical VIF value of 10, the multicollinearity assumption appears to be satisfied for both models.

	**0.90	**0.75	**2/3	**0.5	**1/3	**0.25	**0.1	Natural Log
Bidder 71	57.604	43.761	38.376	31.524	8.422	8.570	15.017	6.703
Bidder 142	55.255	42.090	36.413	26.401	2.177	1.959	3.473	2.089

Table 10.9: Largest variance inflation factor (VIF) remaining in the equation after (1) centering the independant continuous variable (2) using backwards stepwise regression and (3) transforming the x-variable according to exponential functions of 0.90, 0.75, 2/3, 0.5, 1/3, 0.25, 0.1 and natural log at lambda setting of -4.2

The model utility statistics are shown in Table 10.10. For bidders 142 and 71 it can be seen that *the number of variables remaining in the equation has dropped from* each having 21 variables (see Table 10.6) to 16 and 17 respectively. Likewise the adjusted R2 has dropped from 0.25316 and 0.24992 to 0.23736 and 0.23760 respectively. Turning to the regression assumption statistics, as can be seen in Table 10.11, that apart from multicollinearity both the normality and homoscedasticity assumptions were satisfied. This new transformation therefore appears to satisfy all the regression assumptions. However, when looking at the bidder variables remaining in the equation, as shown in Table 10.12, it can be seen that the interaction coefficient remained in the equation where bidder 142 was last dummy variable and similarly where bidder 71 was last dummy variable. Since this signifies that the equation slopes for each bidder are significantly different, these bidders cannot be grouped together.

LAST BIDDER DUMMY VARIABLE	142	71
No. of variables in equation Adjusted R2 F / Signif F	16/759 0.23736 16.08/0.000	17/758 0.23760 15.21/0.000

Table 10.10: Model utility statistics at lambda setting of -4.2 and x-variable at natural log based on 3 contract types and 8 bidders

LAST BIDDER DUMMY VARIABLE	142	71
Largest VIF K-S prob No. of hetro vari/prob	2.089 0.260 2/0.157	6.703 0.268 2/0.132

Table 10.11 : Regression assumption statistics at lambda setting of -4.2 and x-variable at natural log based on 3 contract types and 8 bidders

LAST DUMMY VARIABLE 142				LAST DUMMY VARIABLE 71			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
M	B1	-	-	M	B1	B1BID	-
N	B2	B2BID	-	N	B2	B2BID	-
71	-	B3BID	-	142	-	B3BID	-
45	B4	B4BID	-	45	B4	-	-
52	B5	-	B5BID2	52	B5	-	B5BID2
96	B6	-	B6BID2	96	B6	-	B6BID2
24	-	B7BID	-	24	-	B7BID	-

Table 10.12: Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at natural log based on 3 contract types and 8 bidders

When trying further transformations with other bidders as last dummy variables similar results to that described above were also found. No further instances of the dummy, interaction and interaction squared variables being deleted for reciprocating bidders could be found. It appears, therefore, that the regression model cannot be refined any further through swapping the last dummy variables.

10.4 Competitiveness predictions and reliability of the refined model

The regression summary of the final refined model based on three contract types (ie. contract types coded FSH, 712, PSS) and eight bidders (ie. bidders M, N, 24, 45, 52, 71, 96, 142) is presented in Figure 10.2 with the corresponding SPSS-X

**** MULTIPLE REGRESSION ****

Equation Number 1 Dependent Variable .. DEP

Variable(s) Removed on Step Number
37.. B1BID2

Multiple R	.52337
R Square	.27392
Adjusted R Square	.25369
Standard Error	.05091

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	21	.73727	.03511
Residual	754	1.95432	.00259

F = 13.54519 Signif F = .0000

-- Variables in the Equation --

Variable	B	SE B	Beta	Tolerance	VIF
J2BID2	.003906	9.0375E-04	.305869	.192297	5.200
B6BID	.006639	.003482	.087418	.458021	2.183
B4BID	.008388	.003465	.123593	.369494	2.706
B2	.054024	.010120	.209863	.623056	1.605
B5BID2	.001369	6.6094E-04	.090630	.502894	1.988
B3	.045184	.008532	.209540	.615057	1.626
B7	.043526	.011626	.179754	.417727	2.394
B1BID	- .004733	.001009	-.154231	.891480	1.122
J1	- .011910	.004314	-.099153	.746465	1.340
B7BID	.005666	.002028	.104357	.689836	1.450
B2BID	- .008636	.002279	-.149086	.622063	1.608
B6	- .048907	.010811	-.201977	.483113	2.070
J2	- .024061	.009034	-.150185	.302876	3.302
J1BID	- .003782	9.1729E-04	-.201389	.403524	2.478
B5	- .028459	.010364	-.120823	.497360	2.011
B7BID2	- .001120	3.9312E-04	-.128780	.471308	2.122
B6BID2	.002351	8.5783E-04	.136848	.386143	2.590
B3BID2	-7.91501E-04	4.0932E-04	-.076160	.620797	1.611
B4	.076707	.011999	.325666	.371063	2.695
J1BID2	1.78966E-04	6.7822E-05	.118438	.478003	2.092
J2BID	.011411	.005408	.194122	.113744	8.792
(Constant)	.103502	.003314			

Figure 10.2: Regression model summary at lambda setting of -4.2, based on 3 contract types and 8 bidders with FSH (Fire stations and hostels) and bidder M (bidders 9, 18, 109, 122, 127 and 148) as last dummy variables

Chunk	Variable	SPSS-X Code	Description
T	b_1T_1	J1	Police Stations and Secondary Schools
	b_2T_2	J2	Primary Schools
	b_3T_3	J3	Fire Stations and Hostels
B	b_4B_1	B1	Bidder N
	b_5B_2	B2	Bidder 24
	b_6B_3	B3	Bidder 142
	b_7B_4	B4	Bidder 45
	b_8B_5	B5	Bidder 52
	b_9B_6	B6	Bidder 96
	$b_{10}B_7$	B7	Bidder 71
	$b_{11}B_8$	B8	Bidder M

Figure 10.3 : SPSS-X coding of dummy variables for refined model at lambda setting of -4.2, based on three contract types and eight bidders with FSH (Fire stations and hostels) and bidder M (bidders 9, 18, 109, 122, 127 and 148) as last dummy variables

codes of the dummy variables shown in Figure 10.3. So that direct comparisons can be made between the model before refinement shown in Chapter 9 and the refined model, fire stations and hostels (FSH) and bidder M were placed in the position of last dummy variables. The estimates of the final refined model (shown in Figure 10.2) can be substituted into the equation as follows:

$$\begin{aligned}\hat{y} = [(-4.2)\ [\ & 0.103502 - 0.011910T_1 - 0.024061T_2 + 0.054024B_2 \\ & + 0.045184B_3 + 0.076707B_4 - 0.028459B_5 - 0.048907B_6 \\ & + 0.043526B_7 - 0.003782T_1\ (x^{2/3}-7.68) \\ & + 0.000178966T_1\ (x^{2/3}-7.68)^2 + 0.011411T_2\ (x^{2/3}-7.68) \\ & + 0.003906T_2\ (x^{2/3}-7.68)^2 - 0.004733B_1\ (x^{2/3}-7.68) \\ & - 0.008636B_2\ (x^{2/3}-7.68) - 0.000791501B_3\ (x^{2/3}-7.68)^2 \\ & + 0.008388B_4\ (x^{2/3}-7.68) + 0.001369B_5\ (x^{2/3}-7.68)^2 \\ & + 0.006639B_6\ (x^{2/3}-7.68) + 0.002351B_6\ (x^{2/3}-7.68)^2 \\ & + 0.005666B_7\ (x^{2/3}-7.68) - 0.001120B_7\ (x^{2/3}-7.68)^2]+1]^{-1/4.2}\end{aligned}$$

where

$\hat{y}$ = predicted competitiveness

x = contract size

T = contract type

B = bidder

By substituting the appropriate values of the contract *type and bidder variables* into the equation and combining like terms, the prediction equation for each contract type and bidder can be found. For example:

Police Stations and Secondary Schools ($T_1 = 1$, $T_2 = 0$, $T_3 = 0$)
Bidder N ($B_1 = 1$, $B_2 = 0 \ldots B_8 = 0$)

$$\hat{y} = [(-4.2)\ [\ 0.103502 - 0.011910T_1 - 0.003782T_1\ (x^{2/3}-7.68) + 0.000178966T_1\ (x^{2/3}-7.68)^2 - 0.004733B_1\ (x^{2/3}-7.68)]+1]^{-1/4.2}$$

In comparing the model utility statistics of the model before refinement (see Figure 9.2) with the refined model it can be seen that the adjusted R2 is almost identical (from 0.25392 to 0.25369). The biggest difference is the drop in the variables remaining in the equation (from 24 to 21) which produced an increase in the global F test statistic (from F = 11.99027, Signif F = 0.0000 to F = 13.54519, Signif F = 0.0000).

There is also a slight overall improvement in the regression assumption statistics. In respect of multicollinearity, the largest variance inflation factor remaining in the equation is approximately equal (from 8.777 to 8.792). For the normality assumption there is a slight improvement in the normality probability statistic (from K-S prob = 0.160 to K-S prob = 0.303). The number of heteroscedastic variables remaining in the equation has also dropped from three to two (the probability of 3 out of 24 variables being heteroscedastic is 0.086, whilst the probability of 2 out of 21 variables being heteroscedastic is 0.198).

Table 10.13 compares the contract type and bidder variables remaining in the equation for the model before refinement and the refined model. In making an overall comparison between the these models, it can be seen that the number of non-significant contract type and bidder coefficients has dropped from 30 to 6. In respect of the contract type variables, it can be seen that all the coefficients for the refined model are now retained. This indicates that the level of competitiveness, slope and degree of curvature of the regression line of the three remaining contract types are significantly different. Regarding the bidder variables, with the exception of bidder N, more than one coefficient is retained in the refined model which also indicates quite significant competitive differences between these eight remaining bidders.

CONTRACT TYPE VARIABLES REMAINING IN THE EQUATION							
UNREFINED MODEL (Last dummy variable 848)				REFINED MODEL (Last dummy variable FSH)			
Contract type code	Jn	JnBID	JnBID2	Contract type code	Jn	JnBID	JnBID2
372	-	-	-	PSS	J1	J1BID	J1BID2
374	J2	J2BID	J2BID2	712	J2	J2BID	J2BID2
712	J3	J3BID	J3BID2				
713	J4	-	-				

BIDDER VARIABLES REMAINING IN THE EQUATION							
UNREFINED MODEL (Last dummy variable 9)				REFINED MODEL (Last dummy variable M)			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
18	-	-	-	N	-	B1BID	-
142	B2	-	B2BID2	24	B2	B2BID	-
119	-	B3BID	-	142	B3	-	B3BID2
127	-	-	-	45	B4	B4BID	-
148	-	-	-	52	B5	-	B5BID2
122	-	-	-	96	B6	B6BID	B6BID2
45	B7	B7BID	-	71	B7	B7BID	B7BID2
52	B8	-	B8BID2				
96	B9	B9BID	B9BID2				
71	B10	B10BID	B10BID2				
109	-	-	-				
69	-	B12BID	-				
24	-	-	B13BID2				
20	B14	B14BID	-				

Table 10.13: Unrefined and refined model comparison of contract type and bidder variables remaining in the equation at lambda setting of -4.2

10.4.1 Competitiveness of bidders toward contract type and size

The competitiveness predictions of the refined model according to contract type is presented in Figure 10.4 (The coefficients upon which these competitiveness predictions are based are scheduled according to contract type and bidder in Table 10.14). The essential difference between this and the model before refinement (see Figure 9.3) is that, in addition to the model before refinement finding of bidders' competitiveness toward fire stations and hostels not being significantly different, the process of refining the model reveals that bidders' competitiveness toward police stations and secondary schools are also not significantly different. In the discussion of the model before refinement it is suggested that there are two major contract type groupings (see Section 9.3.4). However, the process of refining model identifies more clearly that the competitiveness of bidders towards the five contract types may in fact be classified into three contract type groupings. The formation of these type groupings appear to be dictated by the size and distribution of contracts within the contract type.

In considering the refined model, it can be seen in Figure 10.3 that the level of competitiveness, slope and degree of curvature of the regression lines for (1) fire stations and hostels, (2) police stations and secondary schools and (3) primary schools are significantly different. However, consider the overall shape of the regression lines for (1) fire stations and hostels and (2) police stations and secondary schools. Although they are shown to be significantly different they do appear to be somewhat similar in shape. The probable reason for this similarity is that in using the chunkwise algorithm (see Chapter 7) the major contract type - bidder interaction chunks (ie. TB and STB) are deleted, also both of these contract type groupings contain small and large contracts. As observed in Chapter 9 primary schools appear to be the most dissimilar contract type simply because they do not contain any large contracts and judging from the narrow distribution of bidding attempts between contracts, appear to be highly standardised in terms of contract size. This apparent standardisation has led to an overall increase in bidders' competitiveness towards this type when compared with the other types. Of the remaining two types, bidders

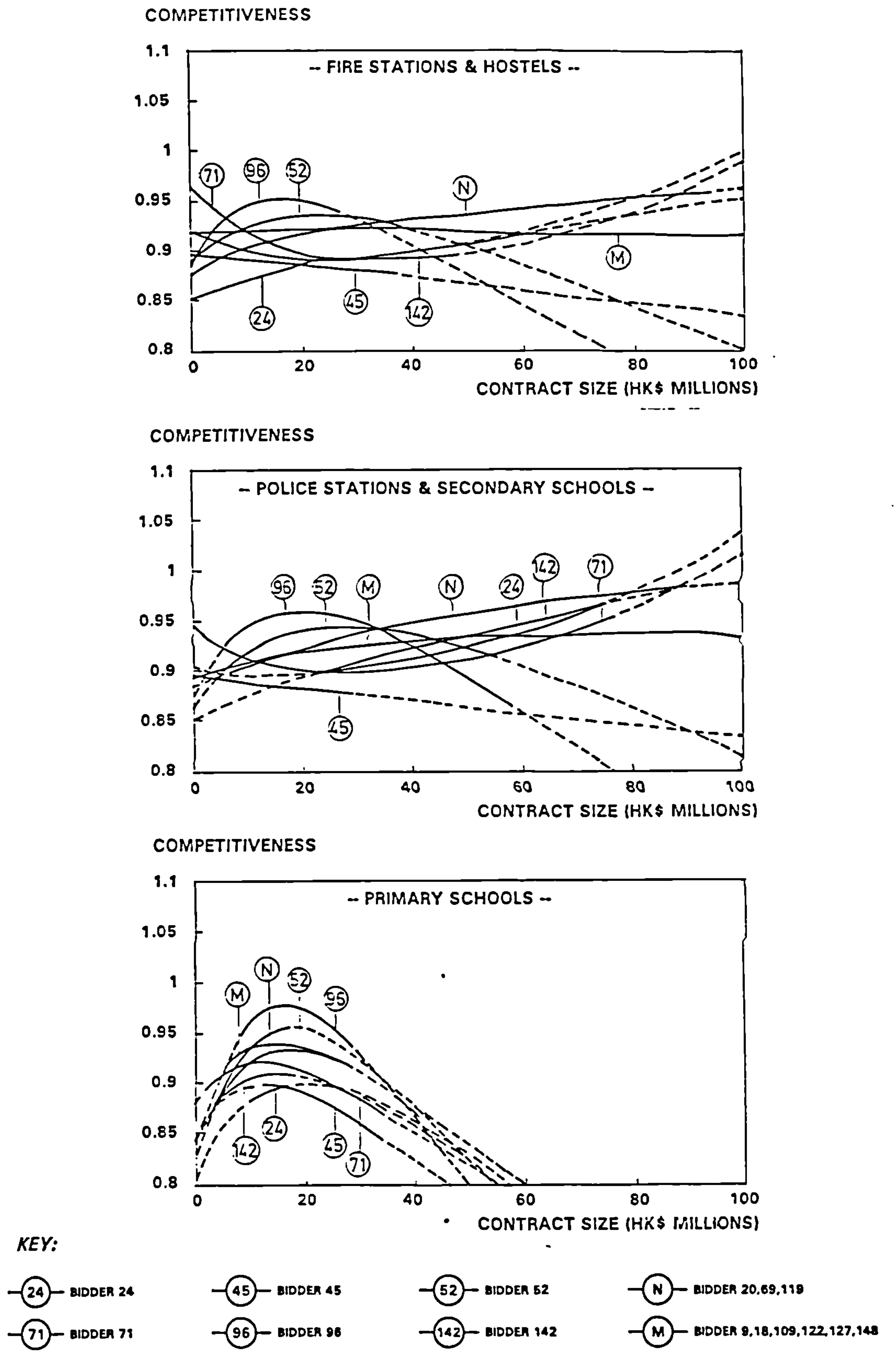


Figure 10.4: Refined model competitiveness predictions according to contract type

POLICE STATIONS AND SECONDARY SCHOOLS		BIDDER							
CHUNK	SPSS-X CODE	B1	B2	B3	B4	B5	B6	B7	B8
Constant		.103502	.103502	.103502	.103502	.103502	103502	103502	.103502
T	J_1	-011910	-011910	-011910	-.011910	-011910	-011910	-011910	-011910
B	B_8		054024	.045184	076707	-028459	-048907	043526	
ST	J_1BID J_1BID2	-003782 1 78966E-4	-003782 1 78966E-4	-003782 1 78966E-4	-003782 1 78966E-4	-003782 1.78966E-4	-003782 1 78966E-4	-.003782 1 78966E-4	-003782 1 78966E-4
SB	B_8BID B_8BID2	-004733	-008636	 -7 9150E-4	008388	 001369	006639 002351	.005666 -001120	

PRIMARY SCHOOLS		BIDDER							
CHUNK	SPSS-X CODE	B1	B2	B3	B4	B5	B6	B7	B8
Constant		103502	103502	103502	103502	.103502	103502	103502	103502
T	J_2	-024061	-024061	-024061	-024061	-.024061	-024061	-024061	-024061
B	B_8		054024	045184	076707	-.028459	-.048907	043526	
ST	J_2BID J_2BID2	011411 003906	011411 003906	011411 003906	011411 003906	011411 003906	.011411 003906	011411 003906	011411 .003906
SB	B_8BID B_8BID2	-004733	-008636	 -7 9150E-4	008388	 001369	006639 002351	.005666 -.001120	

FIRE STATIONS AND HOSTELS		BIDDER							
CHUNK	SPSS-X CODE	B1	B2	B3	B4	B5	B6	B7	B8
Constant		.103502	103502	103502	103502	103502	103502	.103502	.103502
T	J_3								
B	B_8		054024	045184	076707	-028459	-048907	.043526	
ST	J_3BID J_3BID2								
SB	B_8BID B_8BID2	-004733	-008636	 -7 9150E-4	008388	 .001369	.006639 .002351	005666 -001120	

Table 10.14: Regression coefficient breakdown for refined model according to contract type and bidder

appear to be more competitive toward police stations and secondary schools than fire stations and hostels. This apparent difference may be explained by the fact that there are a greater number of larger police station and secondary school contracts than fire station and hostel contracts. It would seem, therefore, that bidders are more competitive on larger contracts than smaller contracts (These competitiveness differences between types may be seen more clearly in Figure 10.5 which shows the bidding performances individual bidders towards these types).

The above findings therefore provide evidence that bidders competitiveness towards contract type is affected by (1) the degree of contract type standardisation and (2) the sizes of contract contained within a contract type. The greater the degree of contract type standardisation and also the larger the sizes of contract within the contract type, the greater the likely competitiveness of bidders towards the contract type and *vice versa.*

10.4.2 Competitiveness of bidders

The competitiveness predictions of the refined model according to bidder is presented in Figure 10.5. In addition to the finding in Chapter 9 of bidders 9, 18, 109, 122, 127 and 148 competitive bidding performances not being significantly different, the process of refining the model reveals that the competitive bidding performances of bidders 20, 69 and 119 are also not significantly different.

When comparing the model before refinement (see Figure 9.4) with the refined model it can be seen that the competitiveness predictions of the bidders are similar for all bidders with the exception of bidder 20. The model before refinement shows bidder 20 being classified as a contractor who has a preferred contract size range for smaller contracts. However, during the process of refining the model (see Section 10.3.1) it was shown that bidder 20 may be wrongly classified and there appears to be sufficient evidence to reclassify this bidder as one who has a preferred contract size range for larger contracts. The reclassification of this one bidder does not affect the original five bidder competitiveness groupings identified in Chapter 9. The refined model shows the 15 bidders falling into the following competitiveness groupings:

(1) bidders who, in terms of competitiveness, have a preferred contract size range for smaller contracts (ie. bidder 96 and 52);
(2) bidders who, in terms of competitiveness, have a preferred contract size for larger contracts (ie. bidder 20, 24, 69 and 119);
(3) bidders who are more competitive on the larger contracts (ie. bidders 71 and 142);

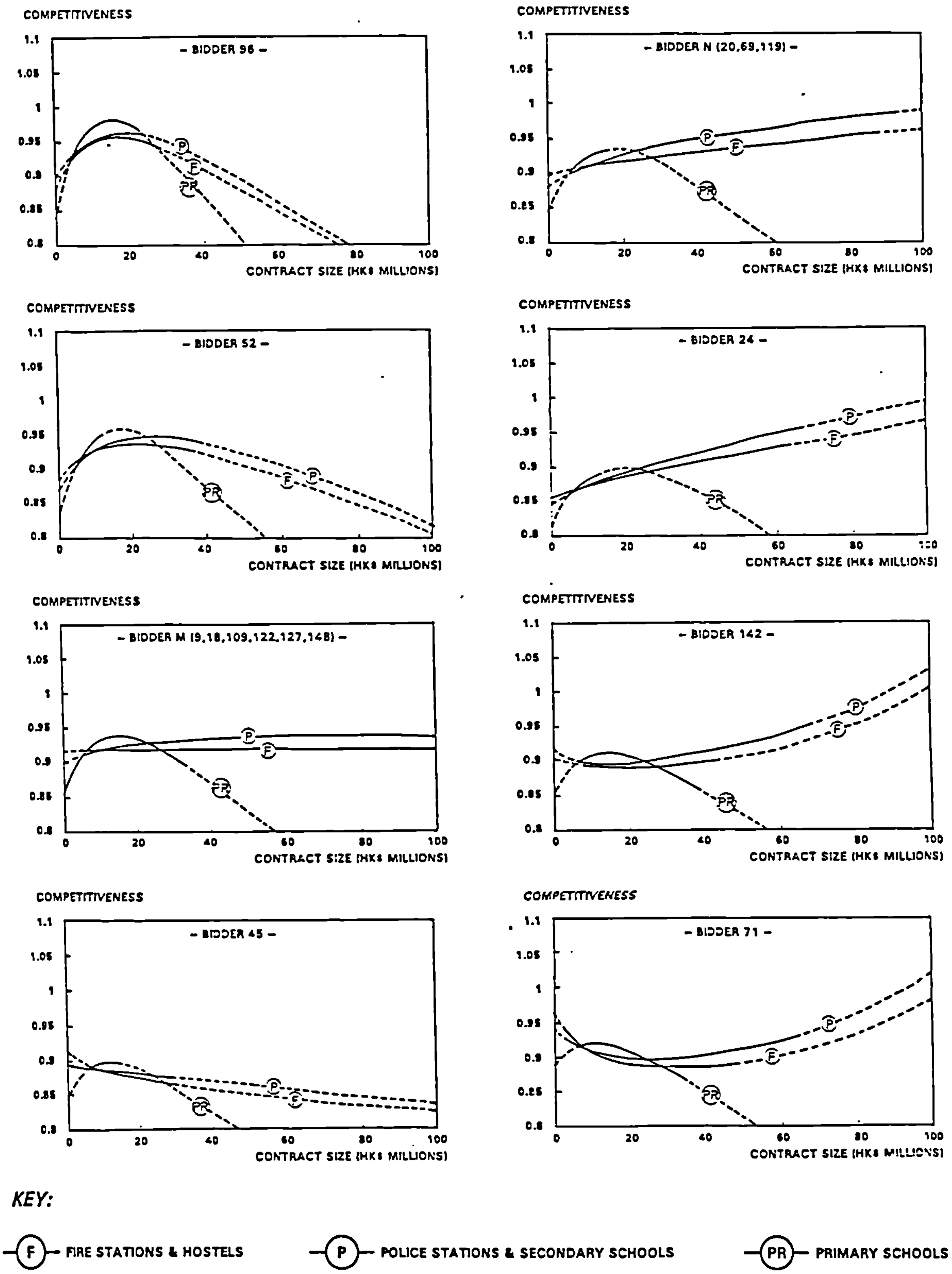


Figure 10.5: Refined model competitiveness predictions according to bidder

(4) bidders whose competitiveness is largely unaffected by size (ie. bidders 9, 18, 109, 122, 127 and 148);
(5) bidders who are less competitive on the larger contracts (ie. bidder 45).

In considering the bidding performances of bidders who fall into the same competitiveness grouping but whose competitiveness performance is significantly different it can be seen that of the two contractors who have a preferred contract size range for smaller contracts bidder 96 appears to be significantly more competitive than bidder 52. Likewise in respect of contractors who have a preferred contract size range for larger contracts bidders 20, 69 and 119 appear to be significantly more competitive than bidder 24. In respect of the two bidders who are more competitive on the larger contracts the essential difference seems to be that bidder 71 is more competitive than bidder 142 at the smaller end of the contract size continuum whereas bidder 142 looks to be more competitive at the larger end of the contract size continuum.

10.4.3 Reliability of the refined model

The predicted values together with the 95% upper and lower prediction intervals according to contract type and bidder is presented in Figure 10.6. The degree of reliability is almost identical to that of the model before refinement (see Figure 9.5).

The extent to which the reliability differs between the refined and unrefined model can be more clearly seen in Table 10.15 which shows five typical cases which extracted from the data. For example, case number 1 shows the competitiveness prediction of bidder 148 for secondary schools with a contract size of HK$17.37 million (in the refined model bidder 148 is shown as bidder M and secondary schools are grouped with police stations). The actual competitiveness of this bidder is unity, however, the predicted competitiveness for the unrefined model is 0.9301, yet for the refined model is 0.9253. The upper and lower prediction intervals are 1.0163 and 0.8721 for the refined model and 1.1063 and 0.8687 for the unrefined model.

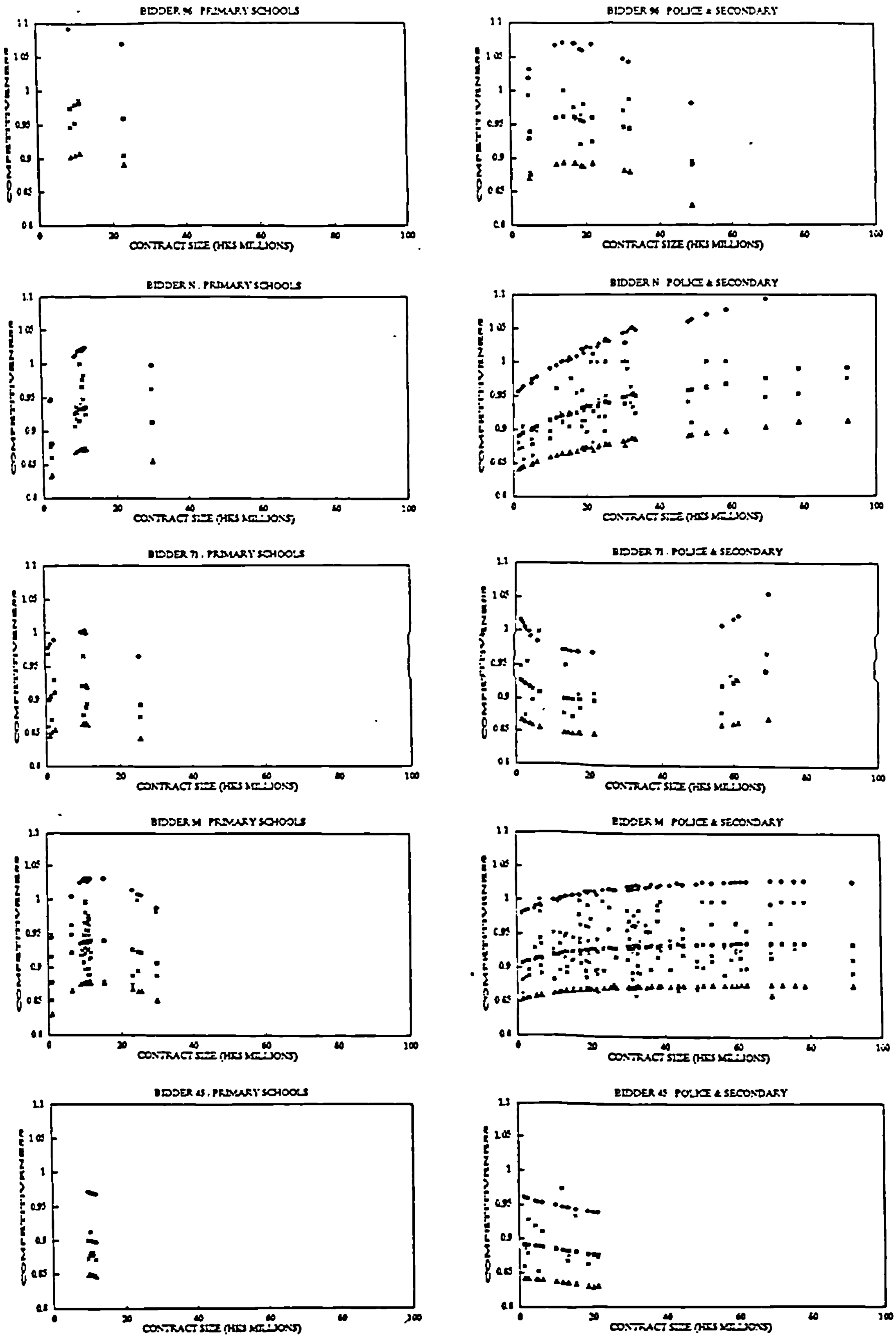


Figure 10.6: Scatterplot of 95% upper and lower prediction intervals, predicted values and actual bidding attempts according to bidder for the refined model

Case No.	1		2		22		183		333	
Model	Unrefined	Refined	Unrefined	Refined	Unrefined	Refined	Unrefined	Refined	Unrefined	Refined
Contract type	713	PSS	712	712	848	FSH	374	PSS	372	FSH
Bidder	148	M	18	M	69	N	45	45	96	96
Contract size (HK$)	17.37	17.37	10.13	10.13	20.05	20.05	5.20	5.20	13.83	13.83
Actual competitiveness	1	1	0.9189	0.9189	0.9119	0.9119	0.8522	0.8522	0.9660	0.9660
Predicted competitiveness	0.9301	0.9253	0.9388	0.9387	0.9205	0.9199	0.8867	0.8887	0.9549	0.9555
Upper prediction interval	1.0163	1.0086	1.0303	1.0302	1.0010	1.0001	0.9520	0.9548	1.0588	1.0599
Lower prediction interval	0.8721	0.8687	0.8782	0.8781	0.8652	0.8648	0.8396	0.8412	0.8887	0.8891

Table 10.15: Competitiveness prediction and reliability comparison of unrefined and refined models using selected cases

In comparing the five cases overall it can be seen that the competitiveness predictions are almost identical. As expected the biggest differences in the predicted competitiveness between refined and unrefined models occur where either bidders and/or contract types have been grouped together. Also as expected in some cases the unrefined model shows a better competitiveness prediction whilst in other cases the refined model shows a better competitiveness prediction.

10.5 Summary

The competitiveness model in the previous chapter shows that bidders' competitiveness towards fire stations and hostels are not significantly different. Likewise, the competitiveness of bidders coded 9, 18, 109, 122, 127 and 148 are also not significantly different. This non-significant difference is due to all the regression coefficients pertaining to these contract types and bidders being deleted from the equation. The reason why these particular contract type and bidder coefficients are deleted from the equation is the result of inverting the regression matrix on the last dummy variables of hostels and bidder 9, using the chunkwise algorithm (to delete non-significant chunks) and backward stepwise procedure (to delete non-significant variables).

The competitiveness model was refined by iterating the regression analysis on the last dummy variables of other contract types and bidders to identify which other contract types and bidders are also not significantly different from each other. Since a fundamental goal of model building is to find the best prediction model containing the least number of predictor variables the contract types and bidders which were not significantly different were grouped together in subsequent iterations. Model 12 in its present transformation was used as the basis for refinement because this model appears to be the best model and the present transformation is one that satisfies all the regression assumptions.

Iterating the competitiveness model on the last dummy variable of *different contract* types shows, that in addition to fire stations and hostels, bidders' competitiveness towards police stations and secondary schools is not significantly different. The five original contract types appear to fall into the three significantly different competitiveness groupings of (1) fire stations and hostels, (2) police stations and secondary schools and (3) primary schools. It seems the formation of these three groupings is primarily due to the different means and distribution of contract sizes for each contract type which appear to fall into three contract size bands.

The level of competitiveness, slope and degree of curvature of the regression line of the three remaining contract types appear to be significantly different. Although they are shown to be significantly different the overall shape of the regression lines for (1) fire stations and hostels and (2) police stations and secondary schools do not appear to be too dissimilar. The reason for this appears to be that both these groupings contain both small and large contracts. Primary schools appears to be the most dissimilar contract type simply because it does not contain any large contracts and judging by the narrow distribution of bidding attempts between contracts would seem to be highly standardised in terms of size. This apparent standardisation has lead to an increase in bidders competitiveness towards this type when compared with the other types. Bidders appear to be more competitive toward police stations and secondary schools than fire stations and hostels. The apparent difference may be explained by the fact that there are a greater number of larger police station and primary school contracts than fire station and hostel contracts. It would appear, therefore, that bidders are more competitive on larger contracts than smaller contracts.

These findings indicate that bidders' competitiveness towards a contract type is affected by (1) the degree of contract type standardisation and (2) the sizes of contract contained within a contract type. The greater the degree of contract type standardisation and also the larger the sizes of contract within a contract type, the greater the likely competitiveness of bidders towards the contract type and vice versa.

Iterating the competitiveness model on the last dummy variable of different bidders shows that in addition to bidders 9, 18, 109, 122, 127 and 148, bidders 20, 69 and 119 are also not significantly different. By running two sets of iterations the number of bidders is reduced from 15 to eight. During the process of refining the model it is shown that bidder 20 may be wrongly classified and there appears to be sufficient evidence to reclassify this bidder as a contractor who has a preferred contract size range for larger contracts. The reclassification of this one bidder does not affect the original five bidder competitiveness groupings identified in Chapter 9. The final refined model shows the 15 bidders falling into the following competitiveness groupings:

(1) bidders who, in terms of competitiveness, have a preferred contract size range for smaller contracts (ie. bidder 96 and 52);
(2) bidders who, in terms of competitiveness, have a preferred contract size for larger contracts (ie. bidder 20, 24, 69 and 119);
(3) bidders who are more competitive on the larger contracts (ie. bidders 71 and 142);
(4) bidders whose competitiveness is largely unaffected by size (ie. bidders 9, 18, 109, 122, 127 and 148);
(5) bidders who are less competitive on the larger contracts (ie. bidder 45).

In comparing the model utility and regression assumption statistics of the refined model with the model before refining, the refined model looks to be a slightly better model overall. Since this improvement is only very marginal the degree of reliability as shown by the prediction intervals is almost identical to that of the unrefined model.

CHAPTER 11

Adding new bidders to the model

11 ADDING NEW BIDDERS TO THE MODEL

11.1 Introduction

The refined model in the previous chapter is based on the bidding performances of 15 bidders towards five contract types. Through refining the model it is shown that of the five contract types, bidders' competitiveness towards three contract types is significantly different. Likewise, eight out of 15 bidders appear to be significantly different in terms of competitiveness. The analysis also shows that the bidding performance of the 15 bidders can be classified into five competitiveness groupings.

Using the refined model as the starting point, this chapter explores the effect of progressively adding new bidders to the model in an attempt to find other competitiveness groupings. In accordance with previous procedures bidders were selected on the basis of number of bidding attempts. Two iterations were carried out for each new bidder entered into the equation. First, where the new bidder is the last dummy variable to see the effect on the bidder variables left in the equation. Second where bidder M is the last dummy variable so that direct comparisons can be made with the refined model.

Although the transformation was the same as the refined model (ie. lambda is -4.2 and the x-variable at 2/3), for the purposes of centering the x-variable at zero, where a new bidder was entered into the analysis, the x-variable was re-centered to account for the difference in the mean bid value. Also since the number of cases in the model was increased, new confidence intervals were calculated for the purposes of applying Szroeter's test to identify the number of heteroscedastic variables.

11.2 Adding the 16th bidder to the model

Bidder 150 was first added into the analysis since this bidder has the 16th largest number of bidding attempts in the sample (ie. 36 bidding attempts). The x-variable was re-centered by deducting the sample mean bid value of HK$ 7.76 million (at the exponential function of 2/3).

Tables 11.1 and 11.2 show the model utility statistics where this bidder was the last dummy variable and also where bidder M was the last dummy variable. It can be seen that there is little difference in the statistics between this and the refined model.

LAST BIDDER DUMMY VARIABLE	150	M
No. of variables in equation Adjusted R2 F / Signif F	22/789 0.24832 13.18/0.000	23/788 0.25529 13.08/0.000

Table 11.1: Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set with (1) bidder 150 and (2) bidder M as last dummy variables

LAST BIDDER DUMMY VARIABLE	150	M
Largest VIF K-S prob No. of hetro vari/prob	9.993 0.324 4/0.	9.796 0.262 4/0.132

Table 11.2: Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set with (1) bidder 150 and (2) bidder M as last dummy variables

Table 11.3 shows the bidder variables remaining in the equation. It can be seen that where bidder 150 was the dummy variable all the three variables for bidder N were deleted from the equation. It seems, therefore, that the competitiveness of bidder 150 is not significantly different from bidder N (ie. a bidder, who in terms of competitiveness, has a preferred range for large contracts).

LAST DUMMY VARIABLE 150				LAST DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	-	-	-	N	-	B1BID	-
24	B2	-	-	24	B2	B2BID	-
142	B3	B3BID	-	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	B5BID	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2	71	B7	B7BID	B7BID2
M	-	B8BID	-	150	-	B8BID	B8BID2

Table 11.3: Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set with (1) bidder 150 and (2) bidder M as last dummy variables

Bidder 150 was, therefore, pooled with bidder N. The model utility statistics, regression assumption statistics and bidder variables remaining in the equation can be seen in Tables 11.4, 11.5 and 11.6 respectively. Note that where bidder 150 was the last dummy variable, the regression model was identical before pooling (ie. in Tables 11.1 to 11.3) and after pooling (ie. in Tables 11.4 to 11.6). The reason for this is that all three variables were deleted before pooling.

LAST BIDDER DUMMY VARIABLE	N	M
No. of variables in equation	22/789	21/790
Adjusted R2	0.24832	0.25296
F / Signif F	13.18/0.000	14.08/0.000

Table 11.4: Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with (1) bidder 150 and (2) bidder M as last dummy variables

LAST BIDDER DUMMY VARIABLE	N	M
Largest VIF	9.993	9.791
K-S prob	0.324	0.318
No. of hetro vari/prob	4/0.	3/0.066

Table 11.5: Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with (1) bidder 150 and (2) bidder M as last dummy variables

LAST BIDDER DUMMY VARIABLE N				LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
M	-	B1BID	-	N	-	B1BID	-
24	B2	-	-	24	B2	B2BID	-
142	B3	B3BID	-	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	B5BID	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2	71	B7	B7BID	B7BID2

Table 11.6: Bidder variables remaining in the equation at lambda setting of - 4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with (1) bidder 150 and (2) bidder M as last dummy variables

Compare the refined model based on 15 bidders (see Tables 10.6 - 10.8, where bidder M is the last dummy variable) and 16 bidders (see Tables 11.4 - 11.6 where bidder M is the last dummy variable). It can be seen that the number of variables remaining in the equation are identical. There is a only slight decrease in the adjusted R2 (from 0.25369 to 0.25296). However, the global F test statistic has increased. (The reason for this is that the data set is increased from 776 cases to 812 cases). Turning to the regression assumption statistics, it can be seen that despite there a slight deterioration in terms of multicollinearity (largest VIF remaining in the equation has increased from 8.792 to 9.791) and homoscedasticity (the number of heteroscedastic variables has increased from 2, probability of 0.198, to 3, probability of 0.066) the new model based 16 bidders satisfies all the regression assumptions. The same transformation can therefore be kept for when the 17th bidder is added into the regression model.

11.3 Adding the 17th bidder to the model

Bidder 40, ranked 17th in terms of number of bidding attempts, is now added to the model. When comparing the model utility statistics based on 16 bidders (see Table 11.4) and 17 bidder (see Table 11.7), overall it can be seen that there was a slight deterioration in terms of the model utility statistics. The 17 bidder model also failed the assumptions of multicollinearity and homoscedasticity (see Table 11.8).

LAST BIDDER DUMMY VARIABLE	40	M
No. of variables in equation	21/826	23/824
Adjusted R2	0.24410	0.24721
F / Signif F	14.03/0.000	13.09/0.000

Table 11.7: Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set with (1) bidder 40 and (2) bidder M as last dummy variables

LAST BIDDER DUMMY VARIABLE	40	M
Largest VIF	10.158	10.177
K-S prob	0.419	0.261
No. of hetro vari/prob	4/[illegible]	4/[illegible]

Table 11.8: Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set with (1) bidder 40 and (2) bidder M as last dummy variables

When referring to the bidder variables left in the equation (see Table 11.9) it can be seen that all the variables were deleted for bidder M where bidder 40 was the last dummy variable and likewise where M was the last dummy variable. It seems therefore that bidder 40 is a bidder whose competitiveness is largely unaffected by contract size and can therefore be grouped with those bidders pooled into bidder M.

LAST BIDDER DUMMY VARIABLE 40				LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	-	B1BID	-	N	B1	B1BID	B1BID2
24	B2	B2BID	-	24	B2	B2BID	-
142	B3	-	B3BID2	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	-	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2	71	B7	B7BID	B7BID2
M	-	-	-	40	-	-	-

Table 11.9: Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set with (1) bidder 40 and (2) bidder M as last dummy variables

Tables 11.10 shows the model utility statistics where bidder 40 was pooled into bidder M. Compared with the refined model based on 16 bidders (see Table 11.4) it can be seen that there is slight deterioration in terms of the model utility statistics. Likewise when referring to the model utility statistics in Table 11.11 it can be seen that this model fails the assumptions of multicollinearity and homoscedasticity signifying that a new transformation is needed. The probable reason for the failure of these regression assumptions is the affect of increasing the number of cases contained in the data set, thereby changing the character of the data set. Table 11.12 shows the competitiveness of each bidder being significantly different after pooling.

LAST BIDDER DUMMY VARIABLE	M
No. of variables in equation	23/824
Adjusted R2	0.24721
F / Signif F	13.09/0.000

Table 11.10: Model utility statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable

LAST BIDDER DUMMY VARIABLE	M
Largest VIF	10.177
K-S prob	0.261
No. of hetro vari/prob	4/0.

Table 11.11: Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable

LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2
N	B1	B1BID	B1BID2
24	B2	B2BID	-
142	B3	-	B3BID2
45	B4	B4BID	-
52	B5	-	B5BID2
96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2

Table 11.12: Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3 based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable

To correct multicollinearity the x-variable is changed from 2/3 to 0.5 and re-centered accordingly. The first transformation shows lambda at the original setting of -4.2, the second transformation shows lambda at a new setting of -4.4. Tables 11.13 - 11.15 illustrate the model utility statistics, regression assumption statistics and bidder variables remaining in the equation. It can be seen that the number of variables remaining in the equation has dropped to 19. There is, however, a further deterioration in the adjusted R2 statistic. It can be seen that in changing the x-variable the multicollinearity and normality assumptions are both satisfied. However, both transformations fail the homoscedasticity assumption as four out of 19 variables are heteroscedastic.

LAST BIDDER DUMMY VARIABLE	M (Lambda=-4.2\x-variable=**0.5)	M (Lambda=-4.4\x-variable=**0.5)
No. of variables in equation	19/828	19/828
Adjusted R2	0.23808	0.23606
F / Signif F	14.93/0.000	14.77/0.000

Table 11.13: Model utility statistics at (1) lambda setting of -4.2 and x-variable at 0.5 (2) lambda setting of -4.4 with x-variable at 0.5, based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable

LAST BIDDER DUMMY VARIABLE	M (Lambda=-4.2\ x-variable=**0.5)	M (Lambda=-4.4\ x-variable=**0.5)
Largest VIF	5.714	5.714
K-S prob	0.123	0.090
No. of hetro vari/prob	4/0.	4/0.

Table 11.14: Regression assumption statistics at lambda setting of -4.2 and x-variable at (1) lambda setting of -4.2 and x-variable at 0.5 (2) lambda setting of -4.4 with x-variable at 0.5, based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable

LAST BIDDER DUMMY VARIABLE M (Lambda=-4.2\x-variable=**0.5)				LAST BIDDER DUMMY VARIABLE M (Lambda=-4.4\x-variable=**0.5)			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	-	B1BID	-	N	-	B1BID	-
24	B2	B2BID	-	24	B2	B2BID	-
142	B3	-	B3BID2	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	-	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	-	B7BID2	71	B7	-	B7BID2

Table 11.15: Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at (1) lambda setting of -4.2 and x-variable at 0.5 (2) lambda setting of -4.4 with x-variable at 0.5, based on 17 bidder/3 contract type data set and bidder 40 pooled into bidder M with bidder M as last dummy variable

Other lambda transformations were tried on a trial and error basis in an attempt to find a suitable transformation that satisfies all the regression assumptions. At lambda settings less than -4.2 a greater proportion of the variables were found to be heteroscedastic. At settings greater than -4.7 the model failed the normality assumption. In addition other x-variable transformations were tested where the x-variable exponential is less than 0.5. It was found that in doing this the number of x-variables remaining in the equation were reduced, resulting in a lower adjusted R2 statistic.

It appears therefore that the maximum number of bidders that can be retained in a model which usefully satisfies the regression assumptions is 16 bidders. Figure 11.1 shows the regression model summary based on 16 bidders.

11.4 An alternative approach

Since it appears not to be possible to proceed further with the approach of combining all the bidders in the one model, another approach was used to identify the bidding performance of bidders who were ranked 16th or below. Using the 15 bidder/5 contract type refined model shown in Chapter 10 as the starting point, a series of iterations are undertaken by adding each of the new bidders into the model separately as the 16th bidder. In other words, each of the new bidders was entered

* * * * M U L T I P L E   R E G R E S S I O N * * * *

Equation Number 1 Dependent Variable .. DEP

Variable(s) Removed on Step Number
37.. B1BID2

Multiple R	.52183
R Square	.27230
Adjusted R Square	.25296
Standard Error	.05082

Analysis of Variance

	DF	Sum of Squares	Mean Square
Regression	21	.76340	.03635
Residual	790	2.04009	.00258

F = 14.07703 Signif F = .0000

--- Variables in the Equation --

Variable	B	SE B	Beta	Tolerance	VIF
J2BID2	.003924	9.0172E-04	.312681	.178370	5.606
B6BID	.006943	.003544	.091008	.426737	2.343
B4BID	.008371	.003457	.123191	.355884	2.810
B2	.054130	.009972	.206306	.637660	1.568
B5BID2	.001335	6.4643E-04	.088979	.495994	2.016
B3	.046185	.008541	.210273	.609165	1.642
B7	- .044810	.011655	.181598	.412896	2.422
J1	- .011416	.004187	-.095336	.753406	1.327
B1BID	- .004771	9.1074E-04	-.167943	.896080	1.116
B7BID	.005502	.002006	.100060	.692386	1.444
B2BID	- .008653	.002274	-.144874	.635674	1.573
J2	- .022431	.009270	-.138665	.280517	3.565
B6	- .047628	.010833	-.193018	.477968	2.092
J1BID	- .003791	8.9884E-04	.198241	.416879	2.399
B5	- .027852	.010388	-.116047	.491692	2.034
B7BID2	- .001127	3.9222E-04	-.127452	.467803	2.138
B3BID2	-8.10711E-04	4.1722E-04	-.075303	.613325	1.630
B6BID2	.002350	8.5620E-04	.137680	.366102	2.731
B4	.078126	.012176	.325519	.357921	2.794
J1BID2	-1.80858E-04	6.7328E-05	.116415	.490450	2.039
J2BID	.012142	.005505	.209482	.102135	9.791
(Constant)	.102369	.003186			

Figure 11.1: Regression model summary at lambda setting of -4.2 and x-variable at 2/3 based on 16 bidder/3 contract type data set and bidder 150 pooled into bidder N with bidder M as last dummy variables

into the analysis as if it were the 16th bidder. Although it is recognised that this approach is inferior to the previous approach in that all the new bidders are not incorporated into the one model, the bidding performance of each of the new bidders can at least be seen and identified to determine the competitiveness grouping of the new bidder.

Five bidders (ie. bidder 150, 40, 43, 48 and 140), ranked 16th to 20th in terms of number of bidding attempts, were considered in this part of the analysis. Table 11.16 shows the that there is very little variability in terms of the model utility statistics between the bidders.

Table 11.17 shows the regression assumption statistics for each of bidders. Where each of these new bidders are the last dummy variables, it can be seen that of the five bidders, three fail the assumption of multicollinearity (ie bidders 43, 48 and 140) and three fail the assumption of homoscedasticity (ie. bidders 150, 43 and 48). Where bidder M was the last dummy variable one bidder just fails the assumption of multicollinearity (ie. bidder 140), however, four bidders fail the assumption of homoscedasticity.

LAST BIDDER DUMMY VARIABLE	150	40	43	48	140
No. of variables in equation Adjusted R2 F / Signif F	22/789 0.24832 13.18/0.000	21/790 0.24473 13.51/0.000	24/786 0.24252 11.81/0.000	21/788 0.23495 12.83/0.000	22/787 0.24496 12.93/0.000
LAST BIDDER DUMMY VARIABLE	M	M	M	M	M
No. of variables in equation Adjusted R2 F / Signif F	23/788 0.25529 13.09/0.000	21/790 0.24473 13.51/0.000	23/787 0.24837 12.64/0.000	21/788 0.23930 13.12/0.000	23/786 0.24977 12.71/0.000

Table 11.16: Model utility statistics at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder 3 contract type data set with (1) bidder 150 and bidder M, (2) bidder 40 and bidder M, (3) bidder 43 and bidder M, (4) bidder 48 and bidder M and (5) bidder 140 and bidder M as last dummy variables

LAST BIDDER DUMMY VARIABLE	150	40	43	48	140
Largest VIF K-S prob No. of hetro vari/prob	9.993 0.324 4/0.	9.220 0.386 3/0.	103.435 0.265 6/0.	30.355 0.205 5/0.	10.210 0.197 2/0.
LAST BIDDER DUMMY VARIABLE	M	M	M	M	M
Largest VIF K-S prob No. of hetro vari/prob	9.796 0.262 4/0.	9.220 0.386 3/0.	8.465 0.404 5/0.	8.747 0.232 5/0.	10.06 0.267 4/0.

Table 11.17: Regression assumption statistics at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder 3 contract type data set with (1) bidder 150 and bidder M, (2) bidder 40 and bidder M, (3) bidder 43 and bidder M, (4) bidder 48 and bidder M and (5) bidder 140 and bidder M as last dummy variables

Table 11.18 shows the bidder variables remaining in the equation. Where bidder 150 was the last variable it can be seen that all the bidder N variables were deleted from the equation. However, where bidder M was the last dummy variable it can be seen that two variables for bidder *150 were retained in the equation. Judging* from these results it would seem that bidder 150 can be at least classified as one who has a preferred contract size for larger projects.

Where bidder 40 was the last dummy variable it can be seen that all the bidder M variables are deleted from the equation. Likewise where bidder M is the last dummy variable all the bidder 40 variables are deleted from the equation. This suggests that bidder 40 can be classified as a bidder whose competitiveness is unaffected by contract size.

Where bidder 43 and bidder M was the last dummy variable at least one variable is retained in the equation for each of the bidders. The closest bidder appears to be bidder N, however one variable is retained in both iterations. On balance it would seem that bidder 43's competitiveness is significantly different from all the other bidders considered so far.

The results of bidder 48 are very similar to that of bidder 40, it would seem,

LAST BIDDER DUMMY VARIABLE 150				LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	-	-	-	N	-	B1BID	-
24	B2	-	-	24	B2	B2BID	-
142	B3	B3BID	-	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	B5BID	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2	71	B7	B7BID	B7BID2
M	-	B8BID	-	150	-	B8BID	B8BID2

LAST BIDDER DUMMY VARIABLE 40				LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	-	B1BID	-	N	B1	B1BID	-
24	B2	B2BID	-	24	B2	B2BID	-
142	B3	-	B3BID2	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	-	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2	71	B7	B7BID	B7BID2
M	-	-	-	40	-	-	-

LAST BIDDER DUMMY VARIABLE 43				LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	-	-	B1BID2	N	-	B1BID	-
24	B2	-	B2BID2	24	B2	B2BID	-
142	B3	B3BID	B3BID2	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	B5BID	-	52	B5	-	B5BID2
96	B6	B6BID	-	96	B6	B6BID	B6BID2
71	B7	B7BID	B7BID2	71	B7	B7BID	B7BID2
M	-	B8BID	B8BID2	43	-	B8BID	B8BID2

LAST BIDDER DUMMY VARIABLE 48				LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	-	B1BID	B1BID2	N	-	B1BID	-
24	B2	B2BID	B2BID2	24	B2	B2BID	-
142	B3	-	-	142	B3	-	B3BID2
45	B4	-	-	45	B4	B4BID	-
52	B5	-	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	B7BID	-	71	B7	B7BID	B7BID2
M	-	-	B8BID2	48	-	-	-

LAST BIDDER DUMMY VARIABLE 140				LAST BIDDER DUMMY VARIABLE M			
Bidder code	Bn	BnBID	BnBID2	Bidder code	Bn	BnBID	BnBID2
N	B1	-	-	N	-	B1BID	-
24	B2	B2BID	-	24	B2	B2BID	-
142	-	-	-	142	B3	-	B3BID2
45	B4	B4BID	-	45	B4	B4BID	-
52	B5	B5BID	B5BID2	52	B5	-	B5BID2
96	B6	B6BID	B6BID2	96	B6	B6BID	B6BID2
71	B7	B7BID	-	71	B7	B7BID	B7BID2
M	-	B8BID	-	140	B8	B8BID	-

Table 11.18: Bidder variables remaining in the equation at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder 3 contract type data set with (1) bidder 150 and bidder M, (2) bidder 40 and bidder M, (3) bidder 43 and bidder M, (4) bidder 48 and bidder M and (5) bidder 140 and bidder M as last dummy variables

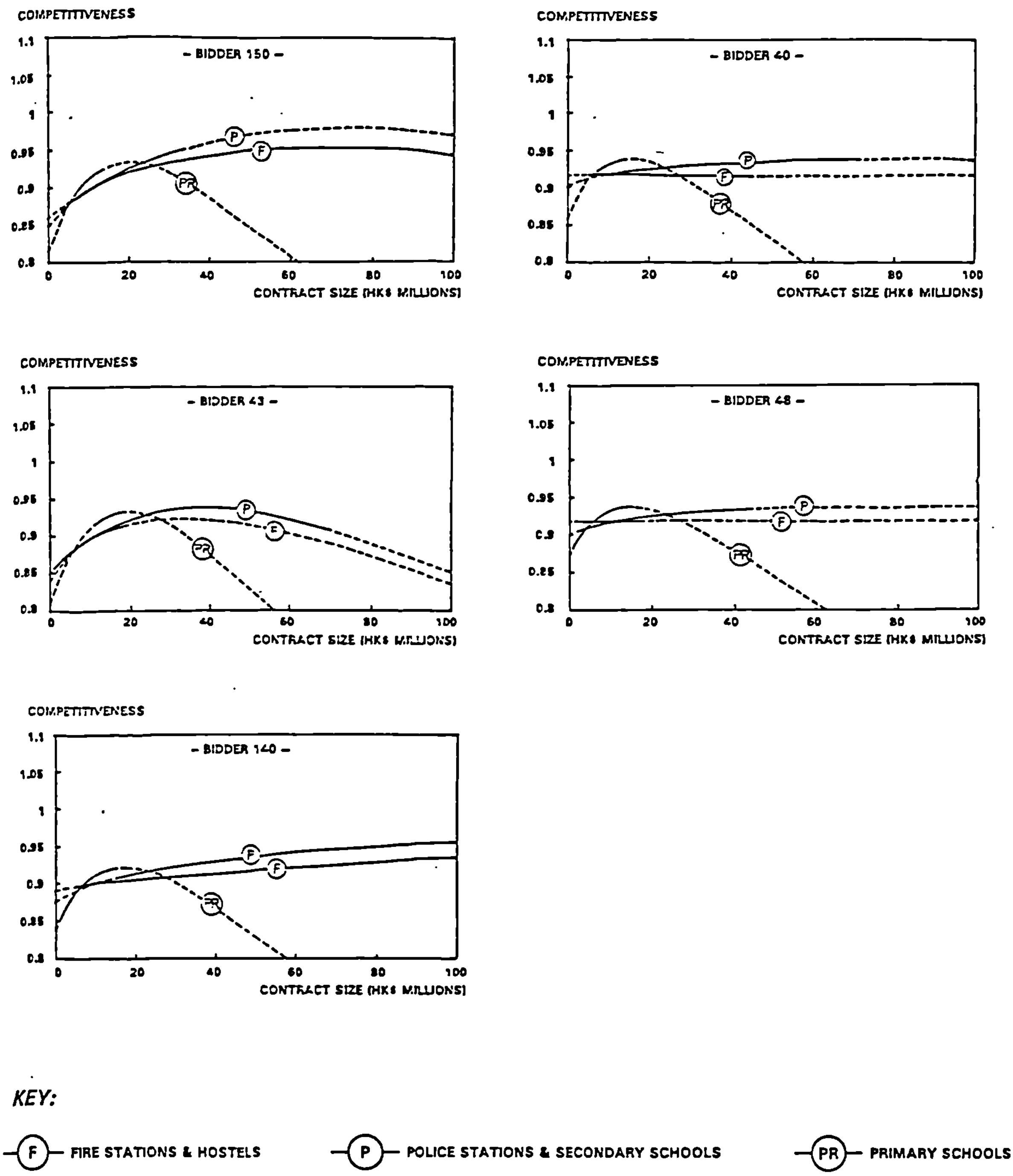


Figure 11.2: Competitiveness predictions according to (1) bidder 150, (2) bidder 40, (3) bidder 43, (4) bidder 48 and (5) bidder 140 at lambda setting of -4.2 and x-variable at 2/3, based on 16 bidder/3 contract type data set with bidder M as last dummy variables

therefore, that bidder 48 can be classified as a bidder whose competitiveness is unaffected by contract size.

Where bidder 140 was the last dummy variable all the bidder 119 variables are deleted from the equation. However, where bidder M was the last dummy variable two of bidder 142's variables were retained in the equation. On balance it would seem that this bidder is a bidder who is more competitive on the larger contracts.

Figure 11.2 shows the competitiveness predictions for each of these bidders according to type. It can be seen that no new competitiveness grouping were found. The competitiveness of these bidders fall into four of the five groupings as before described ie.

(1) bidders who in terms of competitiveness have a preferred contract size range for smaller contracts (ie. bidder 43);
(2) bidders who in terms of competitiveness have a preferred contract size range for larger contracts (ie. bidder 150);
(3) bidders who are more competitive on the larger contracts (ie. bidder 140);
(4) bidders whose competitiveness is largely unaffected by contract size (ie. bidders 40 and 48).

11.5 Summary

Using the 15 bidder refined model as the starting point, this chapter explored the effect of progressively adding new bidders to the refined model.

When the 16th bidder (ie. bidder 150) was added to the model this increased the number of cases from 776 to 812. Although there was a slight deterioration in the overall regression assumption statistics, the refined model transformation was still able to satisfy all of the regression assumptions. The bidding performance of this bidder was not significantly different from bidder N (ie. a bidder who, in terms of competitiveness, has a preferred range for large contracts). This bidder was, therefore, grouped with bidder N.

When the 17th bidder was added to the model, this increased the number of cases from 812 to 848. It was found that the transformation no longer satisfied all the regression assumptions. Although other transformations were tried in an attempt to find a suitable transformation. No satisfactory transformations could be found. The probable reason for the failure of these regression assumptions is the effect of incrementally increasing the number of cases contained in the data set, thereby changing the character of the data set. It appears, therefore, that the maximum number of bidders that can be retained in a model which usefully satisfies the regression assumption is 16 bidders.

Since it appears not to be possible to proceed further with the approach of combining all the bidders in one model, an alternative approach was used to identify the bidding performances of five bidders ranked 16th to 20th (ie. bidder 150, 40, 43, 48 and 20). Each of these bidders was entered into the analysis as if it were the 16th bidder. Although it is recognised that this approach is inferior to the previous approach in that all the new bidders are not incorporated into the one model, the bidding performance of each of the new bidders can at least be seen and identified to determine the competitiveness grouping of the new bidder. No new competitiveness groupings were found. These five new bidders fell into four of the five groupings as before described ie.

(1) bidders who, in terms of competitiveness, have a preferred contract size range for smaller contracts (ie. bidder 43);

(2) bidders who, in terms of competitiveness, have a preferred contract size range for larger contracts (ie. bidder 150);

(3) bidders who are more competitive on the larger contracts (ie. bidder 140);

(4) bidders whose competitiveness is largely unaffected by contract size (ie. bidders 40 and 48).

PART 3

SUMMARY AND CONCLUSIONS

CHAPTER 12

Summary and conclusions

12 SUMMARY AND CONCLUSIONS

12.1 Introduction

By considering the relationships of bids submitted to the client, this thesis focuses on the bidding behaviour of contractors who are in competition with each other for various packages of construction work. The aim of this work is to demonstrate through statistical modelling that competing contractors are influenced, to varying degrees, by contract type and contract size and that a competitiveness relationship exists between contractor size and contract size.

A brief review of management and economic theory indicates that management theory is more comprehensive at modelling strategic behaviour within construction firms, while economic theory seems to be more developed at modelling competitive performance between construction firms. Since competitive relationships between firms are based on the outcome of management decisions that have taken place within a firm, the approach taken in the theoretical development of this research is to view the bidding behaviour of construction firms as the outcome of strategic management decisions undertaken in an economic setting.

The construction industry environment within which contractors operate is seen to consist of general environmental factors as well as competitive environmental factors. Since contracting is demand driven the competitive environment can be defined in terms of markets. Definitions of the construction market indicate that it exists in three main dimensions: (1) contract type and nature (2) contract size and complexity (3) geographic area. The total number of firms interested in undertaking construction work according to these three dimensions is affected by prevailing and perceived future market conditions.

The type and nature of construction work undertaken within the construction market is diverse, producing a series of market sectors within which contractors compete for work. Contract size and complexity is an important dimension in the construction market because of the wide range of contract sizes that exists within the construction market. Contract size is regarded as the major determinant of the number of firms able to undertake the work. A readily available measure that reflects, to a degree, both contract size and complexity is the bid price submitted by the contractor.

The nature and form of the competitive arena for the contractor in construction contracting is largely determined by the client and/or advisors. The choice of bidding system coupled with bidder selection practices has a direct bearing on the degree of competition since it affects both the number and identities of bidders competing for a particular contract. An addition in numbers of bidders above four or five has only a marginal impact on competitiveness. The identities of individual bidders are important since different bidders are able to achieve different levels of competitiveness.

Contractors respond to the construction market by making strategic decisions at different levels and stages of the strategic process. Strategic decisions define the boundary between the firm and the external environment. At the corporate strategy level contractors define a strategic domain. The strategic domain establishes the market dimensions within which contractors plan to operate and compete for work. Larger contractors are likely to develop a larger strategic domain than smaller contractors. Contractors make decisions on which contracts to bid for at the business strategy level. If opting to bid, the baseline estimate is formulated at the operational strategy level and then fed back to the business strategy level where senior management decides the appropriate bid level at an adjudication meeting. The bid, which can be regarded as the outcome of the strategic decision process, is then submitted to the client.

A contractor's strategic domain can be defined according to a number of contract types and may comprise undertaking all or specialising in certain contract types within one or more sectors of the construction market. The strategic domain may also include undertaking new build work or alteration work or both. A contractor's strategic domain can also be defined according to the range of contract sizes it wishes to undertake. Strategic domain differences in terms of geographic area are likely to become less apparent in smaller, more densely populated countries. In Hong Kong for example, the influence of geographic area seems to be minimal since most contractors operate territory wide with the exception of undertaking work on some of Hong Kong's more remote islands. Hong Kong's construction market, therefore, appears to exist largely according to two main market dimensions, that of contract type and size.

Contract bidding, like all other forms of pricing, is essentially about contractors making strategic decisions in respect of which contracts to bid for and the bid levels necessary to secure them. In the course of running the construction firm it is at the business strategy level where contractors are given numerous opportunities to bid or work both within and outside of the strategic domain. Job desirability is influenced by many factors including favoured contract types within the bidder's expertise area.

In deciding to bid contractors are likely to consider both their current workload and future available work in the construction market. Economic theory of the firm suggests firms operate most efficiently when they are operating just under capacity of their total resources. If the firm attempts to operate beyond this point the firm may run into assorted bottlenecks making it less competitive. Achieving optimum efficiency therefore becomes an issue of balancing the resources in hand with the size of contract. Management (and not fixed capital) is regarded as the most important determinant of the capacity as well as the capability of construction firms. Managerial skills capacity gives the contractor greater flexibility in the work it undertakes. Contractors do not attach too much importance to availability of resources since resource constraints can be overcome by obtaining extra resources from alternative sources.

If the contractor opts to submit the bid, the pricing of the bid normally consists of a two stage formulation process comprising baseline estimate and mark-up. The baseline estimate is combined with a mark-up to form the bid. Bidding strategy is concerned with setting the mark-up level to a value that is likely to provide the best pay-off.

As part of their bidding strategy, different bidders will have different degrees of preference towards the individual contract characteristics such as size, type and location. Those who are more selective concentrate on particular contract characteristics such as type and size. Those who are less selective place less emphasis on contract characteristics than on other factors such as workload or resources available. Bidders who carefully select contracts for which they enter serious bids may be regarded as 'market' or 'preference driven'. Those bidders who place most emphasis on workload may be regarded as 'resource' or 'constraint driven'. These categories are neither exhaustive nor mutually exclusive and some bidders may place equally high or low emphasis on market and resource factors.

Bidding performance is concerned with the competitive relationships between bids submitted to the client. Since a bid is an estimate of the (unknown) market price, most bidders submitting a genuine bid are attempting to submit a bid which is low enough to win the contract but high enough to make a profit. At the time of submitting the bid the maximum level of competitiveness can be taken to be the lowest bid. All other bids, in terms of competitiveness, are relative to the lowest bid.

There appears to be a gap between theory and reality and bidding models do not seem to be much used or considered outside research circles. It appears that the failure, weaknesses and limitations of bid models stem from the complexities and uncertainties inherent in the bid process itself. Part of the problem lies in the fact that many factors, other than pure economic, are considered in bidding strategy decisions. Much of bidding research is concerned with modelling bidding behaviour by considering competitiveness relationships. Competitiveness in bidding can be modelled by analysing (1) entire bid distributions, (2) competitiveness within bids and (3) competitiveness between bids.

This thesis focuses on the bidding performance of bidders by comparing competitiveness relationships between bids. For most practical purposes it is sufficient to consider bids in relation to a baseline. Baselines include the designer's estimate, a bidder's baseline estimate, or the mean, median or lowest of the bids entered for a contract. Of these measures the lowest bid appears to be the best measure of competitiveness between bids, since when submitted the lowest bid represents maximum competitiveness.

The approach to the methodology is to develop a particular study undertaken by Flanagan and Norman (Flanagan and Norman 1982b). Data from tender reports was collected from the Hong Kong Government on the basis of Flanagan and Norman's study and divided into 5 contract types (ie. fire stations, police stations, primary schools, secondary schools and hostels) according to the CI/Sfb classification.

12.2 Replicating Flanagan and Norman's (1982b) study

Flanagan and Norman (1982b) compared the bidding performance of three different UK contractors who were classified as being small, medium and large, and labelled A, B and C respectively. In replicating Flanagan and Norman's study, three Hong Kong bidders were selected according to Flanagan and Norman's rationale and some similarities are found when comparing the bidding performance of three Hong Kong contractors with three UK contractors.

UK bidder A, a small contractor only bid for one contract type, namely schools, and was found to be very successful. By comparison none of the three Hong Kong contractors restricted their bidding to just one type, although in terms of successes, Hong Kong bidder A's only two successes are restricted to one type (ie. police station alteration contracts) while all eight of Hong Kong bidder B's (a medium contractor) successes are for new works. Six of these are for primary school contracts. This inclination towards schools by both a UK and Hong Kong contractor may be due to the fact that Government schools are very similar in design. It would seem, therefore, that experience is a key factor influencing competitiveness. In contrast, Hong Kong's bidder C's (a large contractor) five successes are spread over three contract types and are for contracts which are diverse in size. Three successes are for new works contracts and the remaining two for alteration contracts. This bidder, similar to UK bidder B, appears to show no particular bidding trend. Unlike UK bidder C (a large contractor), none of the three Hong Kong contractors appear to be more competitive on larger contracts.

Flanagan and Norman's conclusions on the bidding performance of bidders appear to rest largely on the relationship between size of bidders and their success rates relative to size and type of contract. Since success is a discrete variable and success rates are based on a nominal scale, the distance between values in terms of competitiveness, is not known. The bidding performances of the bidders is also measured by expressing each competitors bid as a percentage of the bidders bid. Using each bidder's bid as a baseline has a disadvantage when comparing the bidding performance between bidders in that each bidders baseline is likely to be different. Although this gives an overall picture of a contractor's bidding performance it is difficult to observe and compare the relative degree of competitiveness between each bidder.

12.3 Competitiveness and variability in bidding

Bidding performance analysis is concerned with the relationships between bids entered by contractors in competition. As bidding performance is the product of bidding for contracts of different types and sizes, a suitable comparative measure is needed to reflect the competitiveness of bids between contracts.

In developing Flanagan and Norman's study a preferred alternative competitiveness measure is offered. Competitiveness (C) is measured by the ratio of the lowest bid. Each bidder's mean competitiveness (C') is determined from a series of past competitions. Bidding variability is measured using the standard deviation (C"). Smaller standard deviations indicate smaller variability in bidding (and, therefore, greater consistency) and vice versa.

In using this measure it is found that of the three Hong Kong contractors, bidder B, appears to be the most competitive bidder and is least variable in bidding. In contrast, bidder A is the least competitive and is also the most variable in bidding. This suggests that there is a correlation between mean competitiveness C' and the corresponding standard deviation C". It would seem logical to suggest that there is a relationship between bidding competitiveness and variability in bidding since a bidder who is consistently competitive is by definition less variable in bidding. It follows that less competitive bidders are likely to be more variable in their bidding otherwise they would fail to get any work. Conversely, a bidder who is very competitive and highly variable in bidding would eventually become bankrupt. Based on this logic, a four way classification system is proposed in which bidders are classified (from a client's perspective) as *Sensible* (high C' and low C" values), *Suicidal* (high C' and C" values), *Non-serious* (low C' and C" values) and *Silly* (low C' and high C" values). Bidders are analysed according to this classification system by initially comparing the bidding performance of bidders over all five contract types and then according to each building type.

The most frequent bidders (ie. those who bid ten times or more in the sample), are selected for analysis as it is considered that the results obtained would be more representative of the bidders' bidding behaviour. The C' and C" values of this subset of 75 bidders are found to have a strong negative correlation of -0.6290 (n=75, p=0.000). The significant correlation between competitiveness and consistency leads to most bidders being classified as *Sensible* or *Silly*. More extreme cases of *Sensible* and *Silly* bidders were found than in the *Suicidal* and *Non-serious* categories, where bidders are not so clearly differentiated.

The average success ratios for the four groups of bidders indicated that the *Suicidal* bidders had the most success in winning contracts. This was followed, as expected, by the *Sensible*, *Silly*, and *Non-Serious* groups. Analysis of the *Sensible* group, identified bidders who are consistently *Sensible* (ie. unfocused cost leaders) over *all* contract types, and bidders who are *Sensible* (ie. focused cost leaders) over *only some* contract types. The latter group consists of specialists whose competitiveness is likely to have been developed over a period. Specialists are distinguished by their unequal distribution of successes across different contract types. Specialists who had been successful more than once for a particular contract type were found to exist for all the five contract types under study. The position of these bidders in the *Sensible* quadrant suggested the existence of an unfocused-focused continuum and this was used to identify further unfocused bidders. Bidders classed as *Suicidal* were also thought to be focused but, as implied by the class name, rather more risky in their bidding. Some evidence of focusing was also found in the *Non-Serious* and *Silly* groups, but on a much reduced scale.

Bidders who met with five or more successes for a particular contract type were invariably classified as *Sensible* for that type. Bidders classified as *Silly* or *Non-Serious* were, with one exception, restricted to one or two successes per contract type. An interesting inference from this observation might be that those *Sensible* bidders winning more than one contract for a particular type did so more by judgement than luck. *Silly* bidders winning more than one contract for a particular type, on the other hand, could be said to do so more by luck than judgement.

A major disadvantage of using this particular approach is that it does not account for different size contractors bidding to different ranges of contract size. Since this measure of competitiveness will produce greater ratio differences for smaller contracts, it is likely to show smaller contractors to be less competitive than the larger contractors and also more variable in their bidding simply because they are more likely to have bid over a narrower range of contracts. One approach in reducing this problem may be to divide the contracts up into different bands of contract sizes and recalculating the competitiveness of bidders according to each contract size band. Eliminating this problem may be accomplished by modelling the competitiveness of bidders using regression analysis with bidder size as the continuous independent variable. One of the regression analysis assumptions is that the independent variables have a constant variance. If this assumption is violated the competitiveness model is required to be transformed in order to satisfy this assumption.

12.4 The effect of contract type and contract size

When Flanagan and Norman (1982b) examined the competitiveness of three bidders they found that when bidding (1) one bidder considered contract size and type, (2) one bidder was more successful in bidding for large contracts and (3) one bidder's competitiveness was not related to either contract type or size. Flanagan and Norman's study suggests that competing contractors are influenced to varying degrees by contract type and size.

To measure the effect of contract type and contract size on competitiveness in bidding, 15 bidders were selected for analysis on the basis of most bidding attempts and a suitable regression methodology developed. 22 candidate models were proposed and the best model found using a forward chunkwise sequential variable algorithm based on the F-test to determine the best model. Model 12 was found to be the best model and the robustness of this model was tested extensively before transforming the model to satisfy the regression assumptions. The best model, transformed to satisfy the regression assumptions, was then also retested against other transformed candidate models and was found still to be the best model. The prediction equations were then estimated and the reliability of the model tested by checking the coefficients and constructing 95% prediction intervals around the prediction equations.

Although Flanagan and Norman's findings neatly link together the variables of contract type and contract size, there is no indication of the relative effect of these relationships. The regression model in this analysis not only shows this effect but also provides a powerful technique for predicting competitiveness and testing the reliability of the competitiveness predictions. The best model is found to be statistically useful as indicated by the global F test statistics ($F_{.05}$ = 13.55, p = .0000, df= 21, 754) and adjusted R square statistic of 0.25369.

The analysis in this thesis clearly indicates that, in terms of competitiveness, contract size is more influential than contract type. In other words, differences in competitiveness are greater for different contract sizes than different contract types. Evidence of this can be seen by reviewing the findings firstly in the predictor selection process and secondly in the competitiveness predictions themselves.

The selection of predictor variables is in two stages. A chunkwise approach was used in the first stage to determine the best candidate model. In the second stage backwards stepwise regression was used and the best model was refined by iterating the regression analysis on the last dummy variables of each contract type and bidder to identify which contract types and bidders are not significantly different from each other. Since a fundamental goal of model building is to find the best prediction model containing the least number of variables, those contract types and bidders that were found not to be significantly different were pooled together in subsequent iterations.

The chunkwise approach eliminated the two principal bidder-contract type interaction variables (ie. TB and STB). The deletion of these variables indicates that the contract type-bidder interactions are less influential than the contract size-contract type and contract size-bidder interactions (ie. ST and SB).

Backwards stepwise regression eliminated the insignificant variables remaining in the equation. In using backwards stepwise regression and iterating the model on the last dummy variable of each contract type it was found that bidders' competitiveness did not differ significantly between fire stations and hostels and also between police stations and secondary schools. The original five contract types were therefore grouped into the three significantly different competitiveness groupings of (1) fire stations and hostels, (2) police stations and secondary schools and (3) primary schools. It seems the formation of these groupings is primarily influenced by the different means and distribution of contract sizes for each contract type which appear to fall into three contract size bands. Primary schools had the smallest mean bid value and standard deviation and in ascending rank order this was followed by fire stations and hostels, police stations and secondary schools.

Of the five contract types, competitiveness towards primary schools appeared to differ the most. A major factor appears to be that the sample of primary schools does not contain any large contracts and judging by the narrow distribution of bid values seems to be highly standardised in terms of contract size. This apparent standardisation has lead to an increase in bidders' competitiveness towards this type when compared with other types. Bidders appear to be more competitive toward police stations and secondary schools than fire station and hostel contracts. The apparent difference may be explained by the fact that there are a greater number of larger police station and secondary school contracts than fire station and hostel contracts. This indicates that bidders are more competitive on larger contracts than smaller contracts.

These findings indicate that bidders' competitiveness towards a contract type is affected by (1) the degree of contract type standardisation and (2) the sizes of contract contained within a contract type. The greater the degree of contract type standardisation and also the larger the sizes of contract within a contract type, the greater the likely competitiveness of bidders towards the contract type and *vice versa.*

The three contract type groupings appear to be part of the same market sector since it is the same bidders who have preferred contract sizes for the smaller contracts in all groupings. It seems those bidders who have a preferred contract size range for larger contracts or are more competitive towards larger contracts do not appear to be competitive toward primary schools simply because there are no large contract sizes pertaining to this type. Perhaps it is not surprising to find that contract size is more important than contract type in this analysis, since a Flanagan and Norman criterion (Flanagan and Norman 1982b) was that the data was made up of similar contract types.

Of the 15 bidders, eight were found to be significantly different in terms of competitiveness. The notion that bidders have preferred size ranges at which they are more competitive appears to hold as the shape of regression lines are mostly the expected convex shape. The exceptions tend to be with bidders who are less competitive. The effect of contract size on bidder's competitiveness varies considerably between some bidders. The analysis shows that the competitiveness of the 15 bidders can be classified into five distinct groupings:

(1) bidders who, in terms of competitiveness, have a preferred contract size range for smaller contracts (ie. bidders 52 and 96);
(2) bidders who, in terms of competitiveness, have a preferred contract size range for larger contracts (ie. bidders 20, 24, 69, 119);
(3) bidders who are more competitive on the larger contracts (ie. bidders 71 and 142);
(4) bidders who are less competitive on larger contracts (ie. bidder 45);
(5) bidders whose competitiveness is largely unaffected by contract size (ie. bidders 9, 18, 109, 122, 127 and 148);

The distinction between (3) and (4) is in the shape of the competitiveness curves which are convex and concave respectively. A simplified representation of these five competitiveness groupings is shown in Figure 12.1. With the exception of bidder groupings (4) and (5), the shapes of the competitiveness lines are shown as convex. This conforms to the notion that bidders have a preferred contract size at which they are more competitive.

In addition to the 15 bidders, the bidding performances of five other bidders were also examined to see if other competitiveness groupings could be identified. However, no new groupings could be identified.

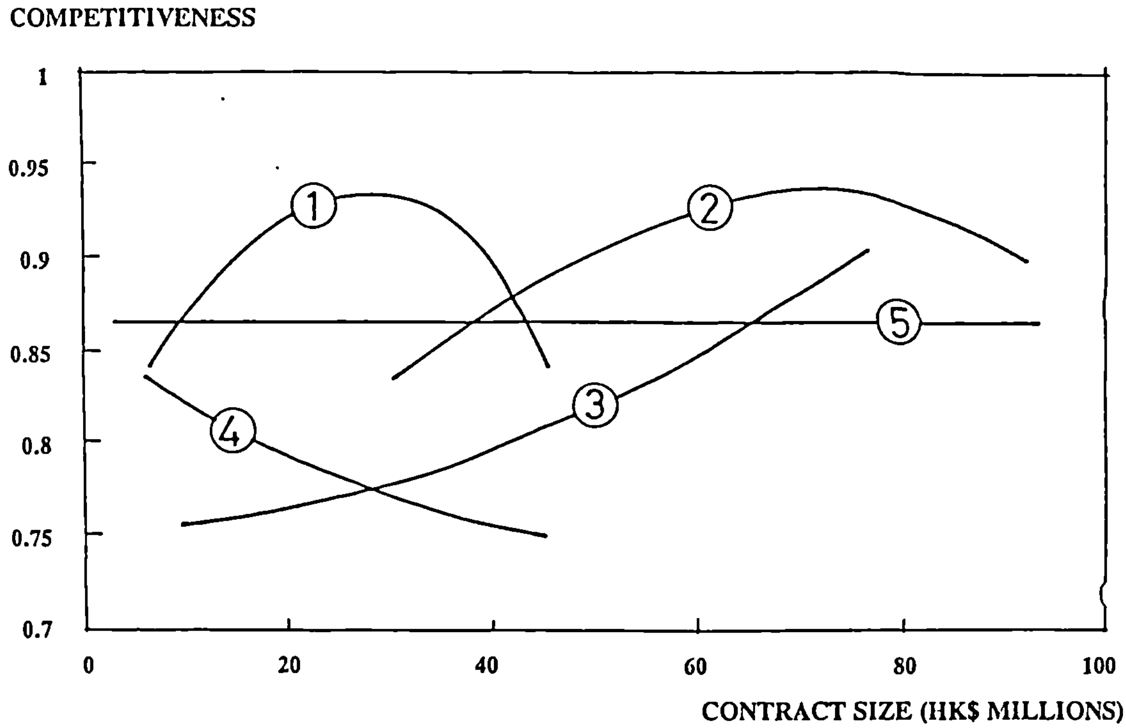


Figure 12.1: Simplified representation of competitiveness groupings

Flanagan and Norman (1982b) found in their study that one bidder was more competitive on larger contracts while another bidder's competitiveness was largely unaffected by contract size. Bidders displaying the same characteristics are found in this analysis ie. in groups (3) and (5). In addition it can be seen that three new competitiveness groupings are identified ie. (1), (2) and (4). The most competitive bidders appear to be those who have preferred contract sizes, either for smaller or larger contracts ie. those bidders who appear in groups (1) and (2).

Flanagan and Norman (1982b) also concluded that one of the bidders they analysed was influenced by both contract size and type. However, the relative influence of contract size and type was not reported. The analysis in this thesis indicates that contract size is more influential than contract type. A suggested reason why contract type differences do not greatly influence competitiveness is because all the five contract types are from the same market sector.

The results indicate that contractors, in terms of competitiveness, are influenced to varying degrees by contract size and contract type. Although the 95% prediction intervals reveal that the model is somewhat limited at predicting competitiveness, the best model does, at least, give an indication of whether a bidder's competitiveness is likely to be above, below or average in relation to other bidders.

12.5 The effect of bidder size

When Flanagan and Norman (1982b) examined the bidding performance of a large contractor they found that the large bidder was more successful in bidding for large contracts. This suggests that there is a relationship between bidder size and contract size.

The effect of bidder size on competitiveness can be measured using the same regression analysis methodology as for individual bidders, except that bidders are grouped according to size (ie. small, medium and large) and the size behaviour observed. Since bidder size is a qualitative variable, a single prediction equation for each bidder size can be found by creating a dummy variable for bidder size.

Flanagan and Norman measured bidder size according to area of operation. Given that Hong Kong only comprises approximately 400 square miles it is not really feasible to adopt this measure. Since Flanagan and Norman's rationale behind the bidder size measure is that 'in most instances they would be tendering in project value ranges' the measure of bidder size adopted in this analysis is based on the Hong Kong Government classification system. Contractors are classified as small, medium and large. Although data on other bidder size classifications could have been collected, it was decided to base this part of the analysis solely on the bidder size classification according to Government criteria. The decision to do this was influenced by the work of Hillebrandt and Cannon (1990) who conclude that the shift towards the high use of subcontracting within the construction industry means there is no satisfactory measure of the size of firms. Since bidder sizes are known for all bidders, the whole data set is included in the first part of this analysis.

The best model is found to be statistically useful as indicated by the global F test statistics ($F_{.05}$ = 8.35, p = .0000, df= 41, 2354) and adjusted R square statistic of 0.11. The chunkwise approach only eliminated the contract size - bidder interaction variable (ie. SB). As only one of the interaction variables has been deleted from the best model, this would tend to suggest that different size bidders do not behave competitively in a similar way. Further evidence of this can be seen by referring to the adjusted R square statistic which implies that only 11% of the sample variation is attributable to, or explained by, the independent variable x.

The best model from the grouped bidder performance was compared with the individual bidder performance to find the best overall competitiveness model. To make the data sets identical for comparative purposes, the same 15 bidders were grouped into small, medium and large and the best model found. It was perhaps no surprise to find that the individual best model was substantially better than the grouped best model.

The likely reason for the poor results of the grouped bidder model is that the individual bidders contained within each bidder size group have different performance patterns. Evidence of this can be seen in the previous section in which it is shown that the individual bidders appear to fall into five distinct competitiveness groupings. Another possible reason for the poor results may be that the data set comprised contracts that were nearly all small to medium in size, thereby restricting the competitiveness range of the large contractors.

These results in this analysis therefore indicate that there is little difference in terms of competitiveness between small, medium and large bidders and that a better competitiveness model is obtained by analysing the competitiveness according to individual bidding behaviour rather than that of grouped behaviour. In other words, the results appear to be inconclusive in providing evidence that large contractors are more competitive on larger contracts and *vice versa.*

12.6 Possible connotations for the construction industry

A fundamental goal of any bidding system is to obtain a competitive bid and reveal the identity of the entity submitting the bid. It is contended that a bidding system is operating at maximum efficiency when the optimal bid is found from the optimal bidder under an optimal level of competition. The optimum bid has been defined by Merna and Smith (1990) as 'the lowest priced evaluated bid which has undergone a process of assessment to identify and, where necessary, to price the consequences inherent in the submission'. The optimum bidder may be defined as one who is not only capable of fulfilling clients' requirements in terms of time, quality and risk, but also in respect of cost is willing and able to submit a bid lower than any competitor. The optimal level of competition may be taken to be engaging the minimum number of bidders to obtain a genuine competitive bid.

Improving the efficiency of construction contract bidding systems essentially rests with the clients and/or advisors of the construction industry as they set up the competition which includes determining the number and identity of contractors. It is usually assumed that the mere existence of a free market will automatically ensure competitive bidding. As a result, large numbers of contractors are often encouraged to enter bids to guarantee a fully competitive competition. The ideal number of contractors for competition has been the subject of much debate. The arguments for increasing the number of bidders include pressure from contractors who want to be included on the tender lists to compete for work and the assumption that the greater number of bidders, the higher the chances of obtaining a low price. In addition, since many bids are predominantly made up of subcontractor quotations, to which the contractor adds an oncost, the actual cost of preparing the bid is spread between the main contractor and subcontractors. The counter argument is that bidding is expensive[1], time consuming and that there is a quantifiable cost associated with every bid which will ultimately be recovered from the construction industry clients. More specifically, procuring bids from too many contractors is likely to result in contractors having (1) to make more bids to reach target turnover, (2) higher bidding overheads, (3) less control over the work they really want to undertake, (4) less accuracy in tender pricing and (5) a greater chance of making an error of omission.

Conclusions reached from empirical research findings are that competitions comprising four to five bidders will ensure a genuine competitive bid with the addition in the number of contractors above four or five only having a marginal impact on competitiveness. Rather than increasing the number of competitors, Flanagan and Norman (1985) point out that improvement in information is likely to be a more efficient method for increasing the competitiveness of bids. They propose that one relatively costless method of improving the information base of bidders can be accomplished by selecting contractors with experience of the contract type.

The competitiveness models presented in this thesis may be used as part of a more informed approach in selecting contractors for competition. It is suggested that Flanagan and Norman's proposal can be taken a stage further by urging clients and/or advisors to select contractors on the basis of likely competitiveness, particularly toward type and size of contract. Information on contractor competitiveness will enable the selection of contractors who are potentially more competitive over those who are likely to be less competitive. This should alleviate the need for clients to select such large numbers of contractors for competition, thereby improving the efficiency of the whole bidding process.

---

[1]For example, UK contractors expend between 0.7 - 1.0% turnover in the handling and preparation of tender documentation (Flanagan and Norman 1989).

The competitiveness models can also be developed as part of a more systematic approach in prequalifying contractors. Russell and Skibniewski (1988), for example, propose a bidder selection model based on composite decision factors such as references, financial stability, status of current work programme, technical expertise and project specific criteria. This rationale is used to construct a knowledge based system (Russell and Skibniewski 1990). Their model and knowledge based system could be further developed by attempting to account for a bidder's likely competitiveness since their is little point in selecting a bidder who is unable to submit a competitive bid.

Contractors can use the competitiveness models in attempts to become more cost efficient and so be in a better competitive position. For example, contractors may consider developing their strategic domain according to their competitiveness level. Also if the information is available, undertake competitor analysis to determine the likely competitiveness of rival contractors and identify key competitors. Such information is likely to be useful to contractors in deciding which future contracts to bid for and, if opting to bid, the bid level. In addition contractors may consider using such competitiveness models in the selection of their subcontractors.

12.7 Suggestions for further research

Further research could be undertaken by refining the models or developing similar models in related areas (Since the following number of suggestions is quite extensive, for the sake of brevity this is shown in list form). The models presented in this thesis could be refined by:

(1) adding one or more important variables (eg. market conditions or bidder's workload) to the models;

(2) using different type or market sector groupings (eg. commercial, educational and residential buildings and/or new and alteration work)[2];

[2]A Flanagan and Norman (1982b) criterion was that the buildings were of a similar building type. A better model might arise from a data set of dissimilar types or market sectors.

(3) using a wider range of contract sizes to explore further the notion that bidders have preferred size ranges at which they are competitive;
(4) selecting bidders for analysis according to other bidding behaviour criteria, for example, according to bidding strategy rather than on the basis of most bidding attempts;
(5) modelling competitiveness in bidding using data collected from contractors rather than from clients[3];
(6) modelling competitiveness in bidding using data collected from a different time frame;
(7) selecting only the serious bids and/or more competitive bidders for analysis;
(8) using competitiveness baselines other than lowest bid (eg. second lowest bid, mean bid, cost estimate);
(9) using a non-chunkwise approach with which to model competitiveness;
(10) using other tests to examine violations of the regression assumptions;
(11) developing and using other approaches to correct regression assumption violations;
(12) testing further the transformed versions of candidate models against the best model;
(13) exploring further the weighted least squares approach;
(14) exploring other regression approaches to modelling competitiveness in bidding (eg. generalised least squares, non-linear regression);
(15) exploring other approaches to modelling competitiveness (eg. other multivariate methods, fuzzy set theory, neural nets).

Many of the research limitations can be identified in the above list. Work relating to contract type and size could further be extended by modelling the competitive behaviour of subcontractors within a main contractor's bid and also, perhaps, by considering the competitive behaviour of contractors from an international and/or

[3]The data was collected for this analysis from Government tender reports. Bidders' competitiveness is, therefore, only being assessed from the perspective of a single client. Also no distinction is made between serious and non-serious bids.

joint venture perspective. So as to have a better understanding of the sequential effect of competitiveness, McCaffer's longitudinal study (McCaffer 1976) on the bidding behaviour of contractors according to contract type could also be extended to take into account contract size.

Models based on similar methodology could also be developed using data collected from a bidder to assess a bidder's competitive positioning relative to rival bidders according to various types and sizes of contract. The competitiveness relationship between cost estimate and bid can also be explored in an attempt to determine which areas of the market are most profitable by using lowest bid/bid ratio and lowest bid/cost estimate ratios. Models showing differences between the lowest bid and cost estimate for a particular contract size could be analysed as part of a more objective approach to determine mark-up levels for future competitions.

The notion that bidders have a range of preferred contract sizes arising from possible economies of scale between contract size and bidder size has been accounted for in the model by the inclusion of a quadratic term and bidder size has been measured according to Hong Kong Government classification criteria. It would be useful to explore this notion further by using a wider range of contract sizes than that contained in this data set and analyzing the individual and grouped competitive behaviour of bidders in terms of bidder size (eg. small, medium or large), according to different measures of size (eg. turnover, number of employees and market share).

The relationship between competitiveness in bidding and market share would also be an interesting area to explore since market share and experience appear to be directly related.

REFERENCES

Abdel-Razek, R.H. and McCaffer, R. (1987) A change in the UK construction industry structure: implications for estimating, *Construction Management and Economics*, **5**, 227-242.

Ahmad, I. and Minkarah, I. (1988) Questionnaire survey on bidding in construction, *Journal of Management in Engineering, American Society of Civil Engineers*, **4** (3), 229-43.

Andrews, K.R. (1987) *The concept of corporate strategy*, Third edition, Dow Jones-Irwin Inc, Homewood, Illinois.

Andrews, J. (1990) Building strategy - how to win, structure and manage projects, paper presented at the *First ASEAN International Symposium on Construction and Development*, 7-8 May, Kuala Lumpur, Malaysia.

Ansoff, H.I. (1987) *Corporate Strategy*, Revised edition, Penguin Books, London.

AQUA Group (1992) *Pre-contract practice for the building team*, 8th Edition, BSP Professional Books, Oxford.

Azzaro, D., Hubbard, J. and Robertson, D. (1987) *Contractors' estimating procedures; an overview*, Technical Paper, Surveyors Publications, The Royal Institution of Chartered Surveyors, London.

Ball, M. (1988) *Rebuilding construction: economic change in the British construction industry*, Routledge, London.

Baker, M.J. (1985) *Marketing: an introductory text*, 4th edition, Macmillan, Basingstoke.

Baker, M.J. and Hart, S.J. (1989) *Marketing and competitive success*, Philip Allen, Hemel Hempstead.

Bannock G., Baxter R.E. and Davis, E. (1987) *Dictionary of economics*, 4th edition, Penguin Books, London.

Barnard, R.H. (1981) A strategic planning appraisal for small firms, *Building Technology and Management*, (Sept) 21-4.

Barnes, M. (1980) Comparison of Friedman and Gates competitive bidding models - discussion, *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, **106** (CO2), 227.

Barnes, N.M.L. (1972) *On getting paid - the right amount*, Paper presented to the Builders Conference, 4 Oct.

Barnes, N.M.L. and Lau, K.T. (1974) Bidding strategies and company performance in process plant contracting, In *Transactions*, Third International Cost Engineering Symposium, Association of Cost Engineers.

Benes, J. and Diepeveen, W.J. (1985) Flexible planning in construction firms, *Construction Management and Economics*, **3** 25-31.

Beeston, D.T. (1983) *Statistical methods for building price data*, E & FN Spon, London.

Bell, R. (1981) *Marketing and the larger construction firm*, Chartered Institute of Building Occasional paper No. 22, Chartered Institute of Building, Ascot.

Benjamin, N.B.H. (1969) *Competitive bidding for building construction contracts*, PhD dissertation, Stanford University.

Betts, M. (1990) Methods and data used by large building contractors in preparing tenders, *Construction Management and Economics*, **8**, 399-414.

Betts, M. and Ofori, G. (1992) Strategic planning for competitive advantage in construction, *Construction Management and Economics*, **10**, 511-32.

Bon, R. (1993) *Whither global construction ? : 1992 and 1993 ECERU Opinion Surveys*, European Construction Economics Research Unit, Department of Construction Management and Engineering, University of Reading.

Briscoe, G. (1988) *The economics of the construction industry*, Mitchell, London.

Broemser, G.M. (1968) *Competitive bidding in the construction industry*, PhD dissertation, Stanford University.

Cannon, J. and Hillebrandt, P.M. (1989a) Theories of the firm, In *The Management of Construction Firms: Aspects of Theory* (edited by Hillebrandt P.M. and Cannon J.) Macmillan, London, 1-7.

Cannon, J. and Hillebrandt, P.M. (1989b) Diversification, In *The Management of Construction Firms: Aspects of Theory* (edited by Hillebrandt P.M. and Cannon J.) Macmillan, London, 31-42.

Cannon, J. and Hillebrandt, P.M. (1989c) Financial Strategy, In *The Management of Construction Firms: Aspects of Theory* (edited by Hillebrandt P.M. and Cannon J.) Macmillan, London, 57-73.

Carr, R.I. (1983) Impact of number of bidders on competition, *Journal of Construction Engineering and Management*, Proceedings of the American Society of Civil Engineers **109** (1), 61-73.

Carr, R.I. and Sandahl, J.W. (1978) Bidding strategy using multiple regression, *Journal of the Construction Division, American Society of Civil Engineers* **104** (CO1), 15-26.

Carson, D.J. (1985) The evolution of marketing in small firms, *European Journal of Marketing*, 19 (5), 7-16.

Chan, K.C. and Pau, K.T. (1980) *A study into the labour subcontracting system as practised by the building services contractor in Hong Kong*, Dissertation submitted in partial fulfillment of MBA programme at the Chinese University, Hong Kong.

Channon, D.F. (1973) *The strategy and structure of British enterprise*, Boston, Division of Research, Graduate School of Business Administration, Harvard University.

Chartered Institute of Building, (1983) *Code of Estimating Practice* The Chartered Institute of Building, Ascot.

Cook, A.E. (1991) *Construction Tendering*, B.T. Batsford Ltd., London.

Couzens, A.C. (1991) *Preliminary analysis of an empirical study of contractors' strategic tendering decisions*, Department of Surveying, University of Salford.

Cryer, J.D. and Miller, R.B. (1991) *Statistics of business: data analysis and modelling*, PWS-Kent Publishing Company, Boston.

Cusack, M.M. (1981) *Time cost models: their use in decision making in the construction industry with particular reference to the use of the microcomputer*, PhD thesis, University of Bath

Cyert, R.M. and March, J.G. (1963) *A behavioral theory of the firm*, Prentice-Hall, Englewood Cliffs, New Jersey.

Czepiel, J.A. (1992) *Competitive marketing strategy*, Prentice-Hall International Inc., Englewood Cliffs, New Jersey.

Davis, Langdon and Seah International (1994) *Asia Pacific construction costs handbook*, E & FN Spon, London.

Department of Environment (1985) *Housing and Construction statistics*, H.M.S.O., London.

Department of Environment (1992) *Housing and Construction statistics*, H.M.S.O., London.

Dielman, T.E. (1991) *Applied regression analysis for business and economics*, PWS-Kent Publishing Company, Boston.

Douglas, E.J. (1989) *Managerial economics: analysis and strategy*, Prentice-Hall International, Englewood Cliffs, New Jersey.

Drew, D.S. and Skitmore, R.M. (1990) Analysing bidding performance; measuring the influence of contract size and type, *Building Economics and Construction Management; Management of the building firm*, International Council of Construction Research Studies and Documentation, CIB W-65 Sydney, Australia, 129-39.

Drew, D.S. and Skitmore, R.M. (1992) Competitiveness in bidding: a consultant's perspective, *Construction Management and Economics*, **10**, 227-47.

Drew, D.S. and Skitmore, R.M. (1993) Prequalification and C-competitiveness, *OMEGA International Journal of Management Science*, **21**, 363-75.

Drew, D.S., Skitmore, R.M. and Lo, H.P. (1993) Competitiveness in bidding: analysing the influence of competitors, *Organisation and management of construction - the way forward*, International Council of Construction Research Studies and Documentation, CIB W-65 Port of Spain, Trinidad, 417-26.

Edwards, C. (1968) *The large conglomerate firm: a critical appraisal*, In Monopoly power and economic performance ed. by Edwin Mansfield, W.W. Norton & Co. Inc., New York.

Engelbrecht-Wiggans, R. (1980) Auctions and bidding models: a survey, *Management Science* **26**, 119-142.

Farrow, J.J. (1976) *Tendering - an applied science*, Chartered Institute of Building Occasional paper No. 1, Chartered Institute of Building, Ascot, UK.

Fellows, R.F. (1992) *Marketing and the construction client*, Chartered Institute of Building, Ascot, UK.

Fellows, R.F., Langford, D.A., Newcombe, R. and Urray, S.A. (1983) *Construction Management in practice,* Construction Press, Longman, Harlow.

Ferry, D.J. and Brandon, P.S. (1984) *Cost Planning of buildings*, Granada, London.

Fine, B. (1970) *Analysis of building division performance data*, unpublished paper.

Fine, B. (1974) Tendering Strategy *Building*, 25 Oct. 115-21.

Fine, B. (1975) Tendering Strategy, *Aspects of the economics of construction*, In Turin D.A. (ed), Godwin, 203-221.

Fisher, N. (1986) *Marketing for the construction industry*, Longman, Harlow.

Flanagan, R. (1990) Making international comparisons in the global construction market, *Building Economics and Construction Management; International Comparisons*, International Council of Construction Research Studies and Documentation, CIB W-65 Sydney, Australia, 230-46.

Flanagan, R. and Norman, G. (1982a) Making good use of low bids, *Chartered Quantity Surveyor* **4** (March), 226-227.

Flanagan, R. and Norman, G. (1982b) An examination of the tendering pattern of individual building contractors, *Building Technology and Management* **28** (April), 25-28.

Flanagan, R. and Norman, G. (1985) Sealed bid auctions: an application to the building industry, *Construction Management and Economics*, **3**, 145-61.

Flanagan, R. and Norman, G. (1989) Pricing Policy In *The Management of Construction Firms: Aspects of Theory* (edited by Hillebrandt P.M. and Cannon J.) Macmillan, London, 129-53.

Fox, P.W. (1989) *A study of the Hong Kong Construction Industry using a systems approach*, M.Sc. Thesis, University of Salford.

Franks, J. (1970) An exercise in cost (price?) estimating, *Building*, 12 June, 133-4

Friedman, L. (1956) A competitive bidding strategy, *Operations Research*, **1** (4), 104-12.

Fryer, B.G. (1990) *The practice of construction management*, Second edition, BSP Professional Books, Oxford.

Furest, M. (1976) Bidding models: truths and comments, *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, **102** (CO1), 169-177.

Fuerst, M. (1977) Theory for competitive bidding, *Journal of the Construction Division, American Society of Civil Engineers*, **103** (CO1), 139-152.

Gabor, A. (1977) *Pricing: principles and practice*, Gower, Brookfield, Vermont.

Ganesan, S. (1982) *Management of small construction firms: a case study of Sri Lanka, Singapore, Hong Kong, Thailand, the Philippines and Japan*, Asian Productivity Organisation, Tokyo.

Gates, M. (1967) Bidding strategies and probabilities, *Journal of the Construction Division, Proccedings of the American Society of Civil Engineers*, **93,** 75-107.

Gates, M. (1976) Gates' bidding model - a Monte Carlo experiment, *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers* **102** (CO1), 669-680.

Gates, M. (1983) A bidding strategy based on ESPE, *Cost Engineering,* **25** (6), 27-35.

Glantz, S.A. and Slinker, B.K. (1990) *Primer on applied regression and analysis of variance*, McGraw-Hill Inc., New York.

Gray, C. and Flanagan, R. (1989) *The changing role of specialist and trade contractors*, Chartered Institute of Building, Ascot.

Green, S.D. (1989) Tendering : optimization and rationality, *Construction Management and Economics*, **7**, 53-73.

Griffith, A. (1992) *Small building works management*, Macmillan, Basingstoke.

Griffiths, W.E. and Surekha, K. (1986) A Monte Carlo evaluation of the power of some tests for heteroscedasticity, *Journal of Econometrics*, **31**, 219-231.

Grinyer, P.H. (1972) Systematic strategic planning for construction firms, *Building Technology and Management*, **10** (Sept.), 8-14.

Grinyer, P.H. and Whittaker, J.D. (1973) Managerial judgment in a competitive bidding model, *Operational Research Quarterly*, **24** (2), 181-191.

Harris, F. and McCaffer, R. (1989) *Modern construction management*, 3rd edition, BSP Professional Books, Oxford.

Harrison, R.S. (1981) *Estimating and tendering - some aspects of theory and practice*, Estimating Information Service No. 41, Chartered Institute of Building, Ascot.

Harvey, J.R. (1979) *Competitive bidding on Canadian public construction projects stochastic analysis for optimisation*, PhD. dissertation, School of Business Administration, University of Western Ontario.

Hayward, A.L. and Sparkes, J.J. (1986) *Oxford concise dictionary*, Omega Books, Ware, Hertfordshire.

Henderson, B. (1981) Understanding the forces of strategic and natural competition, *Journal of Business strategy*, **1** (3), 11-15.

Henderson, B. (1983) The anatomy of competition, *Journal of Marketing*, **47**, 7-11.

Henderson, B. (1984) *The logic of business strategy*, Ballinger, Cambridge, Mass.

Hillebrandt, P.M. (1985) *Economic theory and the construction industry*, 2nd edition, Macmillan, Basingstoke.

Hillebrandt, P.M. and Cannon, J. (1990) *The modern construction firm*, Macmillan, London.

Hong Kong Government (1980) *Rules for the administration of the Public Works Department list of approved contractors*, Hong Kong Government.

Hong Kong Government (1990) Prequalification of tenderers for public works contracts Works Branch, *Technical Circular 12/90*, Hong Kong Government.

Hong Kong Government (1988) *Survey of Building Construction and Real Estate Sectors*, Census and Statistics Department, Hong Kong Government.

Hong Kong Government (1991) *Survey of Building Construction and Real Estate Sectors*, Census and Statistics Department, Hong Kong Government.

Jarman, R.J. (1978) *Building production in a capitalist economy, the response of a sample of building companies to changing market conditions*, MSocSc thesis, University of Birmingham.

Johnson, G.J. and Scholes, K. (1993) *Exploring corporate strategy*, Third Edition, Prentice-Hall International, Hemel Hempstead.

Kast, F.E. and Rosenzweig, J.E. (1985) *Organisation and management: a systems and contingency approach*, Fourth Edition, McGraw-Hill, New York.

Kelting, H. (1979) An investigation of factors affecting the sale of condominium units, In *A second course in business statistics* by Mendenhall W. and Sinich T., Third edition, 1989. Dellen Publishing Company, San Francisco 655-79

Kerlinger, F.N. (1986) *Foundations of behavioral research*, 3rd edition, Holt, Rinehart and Winston, New York.

Kempner, T. (1980) *A handbook of management*, Penguin Books, Harmondsworth.

Kenkel, J.L. (1989) *Introductory statistics for management and economics*, Third edition, PWS-Kent Publishing Company, Boston.

Kerin, R.A., Mahajan, V. and Varadarajan, P.R. (1990) *Contemporary perspectives on strategic market planning*, Allyn and Bacon, Needham Heights, Mass.

Klienbaum, D.G., Kupper, L.L. and Muller, K.E. (1988) *Applied regression analysis and other multivariate methods*, PWS-Kent Publishing Company, Boston.

King, D. (1990) *Project cost increases due to risk and need to work premiums: an empirical study of bidding in the construction industry*, MSc dissertation, Massachusetts Institute of Technology, Cambridge, Mass.

King, M. and Mercer, A. (1988) Recurrent competitive bidding, *European Journal of Operational Research*, **33**, 2-16.

Kortanek, K.O., Soden, J.V. and Sodaro, D. (1973) Profit analyses and sequential bidding models, *Management Science*, **20**, 396-417.

Kotler, P. (1988) *Marketing management : analysis, planning, implementation and control*, 6th Edition, Prentice-Hall International, Englewood Cliffs, New Jersey

Lai, M.Y. (1987) *A Review of the Subcontracting Systems in the Hong Kong Construction Industry*, M.Sc. thesis, University of Hong Kong.

Langford, D.A. and Male, S. (1991) *Strategic management in construction*, Gower, Aldershot.

Lansley, P. (1983) *Case studies of the constraints to the application of construction management research*, Department of Construction Management, University of Reading.

Lansley, P. Quince, T. and Lea, E. (1979) *Flexibility and efficiency in construction management*, The final Report on a research project with *financial support of the* DoE. Building Industry Group, Ashbridge Management Research Unit (unpublished)

Lansley, P. Quince, T. and Lea, E. (1980) Flexibility and efficiency in construction management, *Building Technology and Management*, (Dec.) 42-3

Levett and Bailey (1990) *Tender price indices, 1990*, Levett and Bailey, Hong Kong.

Male, S. (1991a) Strategic management for competitive strategy and advantage, In Male S. and Stocks R. (eds.), *Competitive advantage in construction*, Butterworth - Heinemann Ltd., Oxford, 1-4.

Male, S. (1991b) Strategic management in construction: conceptual foundations, In Male S. and Stocks R. (eds.), *Competitive advantage in construction*, Butterworth - Heinemann Ltd., Oxford, 5-44.

Male, S. (1991c) Strategic management and competitive advantage, In Male S. and Stocks R. (eds.), *Competitive advantage in construction*, Butterworth - Heinemann Ltd., Oxford, 45-104.

Marsh, P. (1987) *The Art of Tendering*, Gower, Aldershot.

Masterman, J.W.E. (1992) *An introduction to building procurement systems*, E & FN Spon, London.

McCaffer, R. (1976) *Contractors' bidding behaviour and tender price prediction*, PhD thesis, Loughborough University of Technology.

McCall, F.E. (1977) Pricing for profits *World Construction*, **30** (5), 65, 68, 70-1.

Mendenhall, W. and McClave, J.T. (1981) *A second course in business statistics : regression analysis*, Dellen Publishing Co., San Francisco.

Mendenhall, W. and Sinich, T. (1993) *A second course in business statistics: regresssion analysis*, Fourth Edition, Macmillan Publishing Company, New York.

Merna, A. and Smith, N.J. (1990) Bid evaluation for UK public sector construction contracts, In *Proceedings*, Institution of Civil Engineers, Part 1, **88** (Feb.), 91-105

Milgrom, P.R. (1981) Rational expectations information acquisition and competitive bidding, *Econometrica*, **49** (4), 921-43.

Milne, J.A. (1980) *Tendering and Estimating Procedures*, George Godwin Ltd., London.

Mohanty, R.P. (1992) Project selection by a multiple-criteria decision-making method: an example from a developing country, *International Journal of Project Management*, **10** (1), 31-8.

Morin, T.L. and Clough, R.H. (1969) OPBID: competitive bidding strategy model, *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, **95** (CO1), 85-106.

Morrison, N. and Stevens, S. (1980) *Construction cost data base*, 2nd annual report of research project by Dept. of Construction Management, University of Reading, for Property Services Agency, Directorate of Quantity Surveying Services, DoE.

National Economic Development Office (1978) *How flexible is construction?: a study of resources and participants in the construction process*, Report of the Structural Analysis Committee, H.M.S.O., London.

Naoum, S.G. (1991) *Procurement and project performance*, Chartered Institute of Building Occasional paper No. 45, Chartered Institute of Building, Ascot, UK.

Neter, J., Wasserman, W. and Kutner, M.H. (1983) *Applied linear regression models*, Irwin, Homewood, Illinois.

Newcombe, R. (1976) *The evolution and structure of the construction firm*, MSc Thesis, University College, London.

Newcombe, R., Langford, D. and Fellows R. (1990a) *Construction Management 1 : Organisation Systems*, Mitchell, London.

Newcombe, R., Langford, D. and Fellows R. (1990b) *Construction Management 2 : Management Systems*, Mitchell, London.

Neufville de R.D., Hani E.N. and Lesage Y. (1977) Bidding model: effects of bidders' risk aversion, *Journal of the Construction Division, American Society of Civil Engineers*, **103** (C01), 57-70.

Neufville, de R.D. and King, D. (1991) Risk and need-for-work premiums in contractor bidding, *Journal of the Construction Engineering and Management, American Society of Civil Engineers*, **117** (4), 659-73.

National Joint Consultative Committee (1989) *Code of procedure for single stage selective tendering*, NJCC Publications, National Joint Consultative Committee for Building, London.

Norris, K. (1984) *Small building firms - their origins, characteristics and development needs*, Chartered Institute of Building Occasional paper No. 32, Chartered Institute of Building, Ascot, UK.

Norusis, M.J. (1988) *SPSS-X Introductory statistics guide for release 3*, SPSS Inc., Chicago.

Odusote, O.O. and Fellows, R.F. (1992) An examination of the importance of resource considerations when contractors make project selection decisions, *Construction Management and Economics*, **10**, 137-51.

Park, W.R. (1966) *The strategy of contracting for profit*, Prentice-Hall, Englewood Cliffs, New Jersey.

Pearce, J.A. and Robinson, R.B. (1991) *Strategic management practice*, Irwin, Boston.

Pilcher, R. (1985) *Project cost control in construction*, Collins, London.

Porter, M.E. (1979) How competitive forces shape strategy, *Harvard Business Review*, March-April, 137-46.

Porter, M.E. (1980) *Competitive strategy: techniques for analyzing competitors*, The Free Press, New York.

Porter, M.E. (1985) *Competitive advantage: creating and sustaining superior performance*, Macmillan, London.

Porter, M.E. (1990) *The competitive advantage of nations*, Macmillan, London.

Raftery, J. (1991) *Principles of building economics*, BSP Professional Books, Oxford.

Raftery, J. (1994) *Risk analysis in project management*, E & FN Spon, London.

Ramsay W. (1989), Business objectives and strategy, In *The Management of Construction Firms: Aspects of Theory* (edited by P.M. Hillebrandt and J. Cannon), Macmillan, London, 9-29.

Ray-Jones, A. and Clegg, D. (1976) *CI/SfB Construction Indexing Manual*, 3rd Revised edition, RIBA Publications Ltd, London.

Rothkopt, D. (1980) On multiplicative bidding strategies, *Operations Research*, **28** (3), 570-7.

Robbins, S.P. (1983) *Organization theory*, Prentice-Hall Inc., Englewood Cliffs, New Jersey.

Russell, J.S. and Skibniewski, M.J. (1988) Knowledge engineering in a knowledge-based system for contractor prequalification, In Proceedings, *Microcomputer knowledge based expert systems in Civil Engineering*, American Society of Civil Engineers 169-85.

Russell, J.S. and Skibniewski, M.J. (1990) Qualifier-2 : Knowledge-based systems for contractor prequalification, *Journal of Construction Engineering and Management*, American Society of Civil Engineers, **116** (1), 157-71.

Schweizer, U. and Ungern-Sternberg, T.V. (1983) Sealed bid auction and the search for better information, *Econometrica* **50**, 79-86.

Seigal, A.F. (1988) *Statistics and data analysis*, John Wiley and Sons, New York

Seymour, H. (1987) *The multinational construction industry*, Croom Helm, London.

Seymour, H. (1989) International contracting, In *The Management of Construction Firms: Aspects of Theory* (edited by P.M. Hillebrandt and J. Cannon), Macmillan, London, 44-55.

Shaffer, L.R. and Micheau, T.W. (1971) Bidding with competitive strategy models, *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, **97** (CO1), 113-139.

Shash, A.A. (1993) Factors considered in tendering decisions by top UK contractors, *Construction Management and Economics*, **11**, 111-118.

Shepherd, W.G. (1990) *The economics of industrial organization*, Prentice-Hall International, Englewood Cliffs, New Jersey.

Shutt, R.C. (1988) *Economics for the construction industry*, Second edition, Longman Scientific and Technical, Harlow.

Sidwell, A. (1984) Management of opportunities, *Building Technology and Management*, **22** (6), 21-2.

Skitmore, R.M. (1981) Why do tenders vary?, *Chartered Quantity Surveyor*, **4**, 128-9.

Skitmore, R.M. (1982) A bidding model, *Building cost techniques: new directions*, In Brandon P.S. (ed.), E & FN Spon, London, 278-289.

Skitmore, R.M. (1986) *A model of the construction project selection and bidding decision*, PhD thesis, The University of Salford.

Skitmore, R.M. (1987a) *Construction prices: market effect*, Department of Civil Engineering, University of Salford.

Skitmore, R.M. (1987b) The distribution of construction bids, Paper presented at the *4th International Symposium on Building Economics*, International Council for Construction Research Studies and Documentation CIB W-55, Copenhagen, Denmark, 171-83.

Skitmore, R.M. (1988) *Fundamental research in bidding for estimating*, Paper presented to the International Council for Construction Research Studies and Documentation CIB W-55, Haifa, Israel.

Skitmore, R.M. (1989) *Contract Bidding in Construction*, Longman, Harlow.

Skitmore, R.M. (1991a) Contract price forecasting and bidding strategies, In Brandon, P S (ed.) *Quantity surveying techniques; new directions,* BSP Professional Books, Oxford.

Skitmore, R.M. (1991b) An introduction to bidding strategy, In Male S. and Stocks R. (eds.) *Competitive advantage in construction*, Butterworth - Heinemann Ltd., Oxford, 139-162.

Smith, R.C. (1986) *Estimating and tendering for building work*, Longman, London.

Spooner, J.E. (1971) Bidding with competitive strategy models - discussion, *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers*, **100** (CO1), 65-77.

Stanlake G.F. (1988) *Introductory economics*, 4th Edition, Longman, Harlow.

Stocks R.K. (1984) *The building team : an organisation of organisations*, MSc thesis, Heriot-Watt University.

Stark, R.M. and Rothkopf, M.H. (1978) Competitive bidding: a comprehensive bibliography, *Operations Research*, **27** (2), 364-390.

Stocks (1991) Strategic marketing management, In Male S and Stocks R (eds.) *Competitive advantage in construction*, Butterworth - Heinemann Ltd., Oxford, 105-127.

Stone, P.A. (1983) *Building Economy*, Pergamon Press, Oxford.

Sykes, J.B. (1978) *The pocket Oxford dictionary of current English*, Oxford University Press, Oxford.

Thompson, A.A. (1989) *Economics of the firm: theory and practice*, 5th edition, Prentice-Hall, Englewood Cliffs, New Jersey.

Thorpe, A. and McCaffer, R. (1991) Competitive bidding and tendering policies, In Male S. and Stocks R. (eds.) *Competitive advantage in construction*, Butterworth - Heinemann Ltd., Oxford, 163-194.

Upson, A. (1987) *Financial Management for Contractors*, BSP Professional Books, Oxford.

Wade, R.L. and Harris, R.B. (1976) LOMARK: a bidding strategy, *Journal of the Construction Division, Proceedings of the American Society of Civil Engineers* **102** (CO1) 197-211.

Walker, A. and Rowlinson, S.M. (1990) *The building of Hong Kong*, Hong Kong University Press.

Whittaker, J.D. (1970) *A study of competitive bidding with particular reference to the construction industry* PhD thesis, City University, London.

Wilson, O.D., Atkins, A.S., Sharpe, K. and Kenley, R. (1987) Competitive tendering: the ideal number of tenders, In *Managing Construction Worldwide* edited by P.R. Lansley and P.A. Marlow, E & FN Spon, London, 175-86

Wilson, R. (1979) A bidding model of perfect competition, *Review of Economic Studies*, **44**, 511-18.

Wong, C. (1978) *Bidding strategy in the building industry* MSc Thesis, Brunel University.

APPENDIX A

Original data set (in chronological order)

Record No.	Rank	Bid	Pct.	Type (CI/Sfb)	Bidder Code	Size	Date	New/ Alt.	Alt. Type
1145	1	1314658	0.00	374	52	2	8101	1	4
1146	2	1454463	10.63	374	99	2	8101	1	4
1147	3	1469140	11.75	374	118	1	8101	1	4
1148	4	1575984	19.88	374	139	1	8101	1	4
1149	5	1792079	36.32	374	114	2	8101	1	4
1541	1	6330507	0.00	712	84	2	8101	1	7
1542	2	6556127	3.56	712	52	2	8101	1	7
1543	3	6560000	3.63	712	40	2	8101	1	7
1544	4	6680000	5.52	712	175	2	8101	1	7
1545	5	6696733	5.79	712	136	2	8101	1	7
1546	6	6758000	6.75	712	126	2	8101	1	7
1547	7	6925304	9.40	712	119	3	8101	1	7
1548	8	6930960	9.49	712	68	2	8101	1	7
1549	9	6946080	9.72	712	20	2	8101	1	7
1550	10	7002435	10.61	712	79	2	8101	1	7
1551	11	7090806	12.01	712	127	2	8101	1	7
1552	12	7212313	13.93	712	170	1	8101	1	7
1553	13	7228054	14.18	712	69	3	8101	1	7
1554	14	7440006	17.53	712	43	2	8101	1	7
1555	15	7486245	18.26	712	138	2	8101	1	7
1556	16	7528221	18.92	712	149	2	8101	1	7
1557	17	7941634	25.45	712	37	2	8101	1	7
1558	18	8140353	28.59	712	156	2	8101	1	7
1559	19	9269428	46.42	712	91	3	8101	1	7
2061	1	12946707	0.00	713	140	3	8101	1	8
2062	2	13031884	0.66	713	148	3	8101	1	8
2063	3	15554426	20.14	713	150	3	8101	1	8
2064	4	18236878	40.86	713	24	3	8101	1	8
2644	1	13528825	0.00	848	8	3	8101	1	15
2645	2	13892691	2.69	848	148	3	8101	1	15
2646	3	14215874	5.08	848	124	3	8101	1	15
2647	4	14715007	8.77	848	51	3	8101	1	15
2648	5	14942379	10.45	848	105	3	8101	1	15
2649	6	15275364	12.91	848	28	3	8101	1	15
2650	7	15780610	16.64	848	24	3	8101	1	15
2651	8	17367764	28.38	848	150	3	8101	1	15
2652	9	19718357	45.75	848	135	3	8101	1	15
2653	1	18200082	0.00	848	150	3	8101	1	15
2654	2	20446649	12.34	848	119	3	8101	1	15
2655	3	20607788	13.23	848	69	3	8101	1	15
2656	4	21967257	20.70	848	24	3	8101	1	15
2657	5	21978549	20.76	848	109	3	8101	1	15
2658	6	22789799	25.22	848	146	3	8101	1	15
2659	7	23165511	27.28	848	51	3	8101	1	15
2660	8	26024567	42.99	848	148	3	8101	1	15
1523	1	6040829	0.00	712	149	2	8103	1	7
1524	2	6429670	6.44	712	141	2	8103	1	7
1525	3	6487647	7.40	712	96	2	8103	1	7
1526	4	6490000	7.44	712	40	2	8103	1	7
1527	5	6542417	8.30	712	136	2	8103	1	7
1528	6	6660190	10.25	712	52	2	8103	1	7
1529	7	6660787	10.26	712	126	2	8103	1	7
1530	8	6759157	11.89	712	48	1	8103	1	7
1531	9	6890364	14.06	712	127	2	8103	1	7
1532	10	7148228	18.33	712	119	3	8103	1	7
1533	11	7294641	20.76	712	79	2	8103	1	7
1534	12	7382801	22.22	712	143	3	8103	1	7
1535	13	7432734	23.04	712	175	2	8103	1	7
1536	14	7568023	25.28	712	68	2	8103	1	7
1537	15	7687510	27.26	712	157	3	8103	1	7
1538	16	7773323	28.68	712	104	2	8103	1	7
1539	17	8350085	38.23	712	99	2	8103	1	7
1540	18	13291675	120.03	712	50	2	8103	1	7
2065	1	10076427	0.00	713	119	3	8103	1	8
2066	2	11778530	16.89	713	148	3	8103	1	8
2067	3	12396568	23.03	713	140	3	8103	1	8
2068	4	12944163	28.46	713	24	3	8103	1	8
2069	1	17615000	0.00	713	162	3	8103	1	9
2070	2	19102148	8.44	713	119	3	8103	1	9
2071	3	19388000	10.07	713	46	3	8103	1	9
2072	4	23018244	30.67	713	140	3	8103	1	9
2073	5	23416342	32.93	713	51	3	8103	1	9
2074	6	23439573	33.07	713	124	3	8103	1	9

2075	7	23743836	34.79	713	28	3	8103	1	9
2076	8	24116962	36.91	713	148	3	8103	1	9
2077	9	24210255	37.44	713	24	3	8103	1	9
2661	1	3717109	0.00	848	96	2	8103	1	14
2662	2	4145166	11.52	848	149	2	8103	1	14
2663	3	4338000	16.70	848	40	2	8103	1	14
2664	4	4464930	20.12	848	138	2	8103	1	14
2665	5	4738181	27.47	848	143	3	8103	1	14
2666	6	4791888	28.91	848	118	1	8103	1	14
2667	7	4887348	31.48	848	68	2	8103	1	14
2668	8	4958545	33.40	848	126	2	8103	1	14
2669	9	4992050	34.30	848	136	2	8103	1	14
2670	10	5570788	49.87	848	43	2	8103	1	14
2671	11	5986328	61.05	848	79	2	8103	1	14
2672	12	6246654	68.05	848	45	2	8103	1	14
2673	13	7222361	94.30	848	15	2	8103	1	14
598	1	8697186	0.00	372	60	3	8104	1	3
599	2	9632319	10.75	372	148	3	8104	1	3
600	3	10156913	16.78	372	105	3	8104	1	3
601	4	11213972	28.94	372	140	3	8104	1	3
602	5	11276985	29.66	372	27	3	8104	1	3
1140	1	14220004	0.00	374	51	3	8104	1	5
1141	2	15177141	6.73	374	178	3	8104	1	5
1142	3	15402269	8.31	374	37	2	8104	1	5
1143	4	16173135	13.74	374	28	3	8104	1	5
1144	5	16367808	15.10	374	27	3	8104	1	5
2052	1	13280000	0.00	713	175	2	8104	1	8
2053	2	13997626	5.40	713	140	3	8104	1	8
2054	3	14388217	8.35	713	148	3	8104	1	8
2055	4	14692914	10.64	713	119	3	8104	1	8
2056	1	11881826	0.00	713	148	3	8104	1	8
2057	2	12394748	4.32	713	150	3	8104	1	8
2058	3	12602443	6.06	713	119	3	8104	1	8
2059	4	13274000	11.72	713	46	3	8104	1	8
2060	5	13291991	11.87	713	140	3	8104	1	8
2078	1	15818862	0.00	713	119	3	8104	1	8
2079	2	17316810	9.47	713	124	3	8104	1	8
2080	3	18293459	15.64	713	27	3	8104	1	8
2081	4	18971076	19.93	713	135	3	8104	1	8
2082	1	10772000	0.00	713	46	3	8104	1	8
2083	2	11072394	2.79	713	119	3	8104	1	8
2084	3	11770390	9.27	713	36	3	8104	1	8
2085	4	12547683	16.48	713	140	3	8104	1	8
2086	5	12578711	16.77	713	24	3	8104	1	8
2087	6	13354911	23.98	713	146	3	8104	1	8
2615	1	1302956	0.00	848	118	1	8104	1	14
2616	2	1451863	11.43	848	68	2	8104	1	14
2617	3	1508292	15.76	848	139	1	8104	1	14
2618	4	1530201	17.44	848	132	1	8104	1	14
2619	5	1720135	32.02	848	154	2	8104	1	14
2620	6	1837950	41.06	848	92	1	8104	1	14
2621	7	2121909	62.85	848	97	1	8104	1	14
2622	1	15276156	0.00	848	36	3	8104	1	15
2623	2	16101903	5.41	848	18	3	8104	1	15
2624	3	23405797	53.22	848	119	3	8104	1	15
2630	1	13713919	0.00	848	150	3	8104	1	15
2631	2	15284374	11.45	848	8	3	8104	1	15
2632	3	15567720	13.52	848	105	3	8104	1	15
2633	4	15583903	13.64	848	51	3	8104	1	15
2634	5	15642578	14.06	848	24	3	8104	1	15
2635	6	15808806	15.28	848	119	3	8104	1	15
2636	7	15976986	16.50	848	69	3	8104	1	15
2637	8	19498552	42.18	848	113	3	8104	1	15
2674	1	4195950	0.00	848	96	2	8104	2	14
2675	2	4354250	3.77	848	27	3	8104	2	14
2676	3	4396400	4.78	848	68	2	8104	2	14
2677	4	4501050	7.27	848	118	1	8104	2	14
2678	5	4610400	9.88	848	151	2	8104	2	14
2625	1	15139709	0.00	848	109	3	8105	1	15
2626	2	17448297	15.25	848	51	3	8105	1	15
2627	3	17454582	15.29	848	146	3	8105	1	15
2628	4	17999545	18.89	848	36	3	8105	1	15
2629	5	22218176	46.75	848	24	3	8105	1	15
1481	1	1696000	0.00	712	68	2	8106	2	7
1482	2	1870373	10.28	712	44	1	8106	2	7
1483	3	1885605	11.18	712	71	1	8106	2	7
1484	4	2152748	26.93	712	92	1	8106	2	7

1485	5	2354383	38.82	712	114	2	8106	2	7
1486	6	2792236	64.64	712	119	3	8106	2	7
1518	1	1106869	0.00	712	115	2	8106	2	7
1519	2	1154231	4.28	712	154	2	8106	2	7
1520	3	1505773	36.04	712	39	1	8106	2	7
1521	4	1610642	45.51	712	71	1	8106	2	7
1522	5	1709924	54.48	712	92	1	8106	2	7
2556	1	27896535	0.00	848	150	3	8107	1	15
2557	2	28393323	1.78	848	135	3	8107	1	15
2558	3	30893333	10.74	848	148	3	8107	1	15
2559	4	32533671	16.62	848	24	3	8107	1	15
2560	5	32863948	17.81	848	51	3	8107	1	15
2561	6	33048869	18.47	848	36	3	8107	1	15
2562	7	36956654	32.48	848	146	3	8107	1	15
2563	8	37143301	33.15	848	10	3	8107	1	15
2638	1	9616259	0.00	848	150	3	8107	1	13
2639	2	10419689	8.35	848	69	3	8107	1	13
2640	3	12383149	28.77	848	140	3	8107	1	13
2641	4	12856737	33.70	848	105	3	8107	1	13
2642	5	13423154	39.59	848	4	3	8107	1	13
2643	6	18184424	89.10	848	24	3	8107	1	13
2564	1	18836970	0.00	848	69	3	8108	1	14
2565	2	20242585	7.46	848	150	3	8108	1	14
2566	3	20877450	10.83	848	37	2	8108	1	14
2567	4	20951318	11.22	848	146	3	8108	1	14
2568	5	21122845	12.14	848	134	3	8108	1	14
2569	6	22449564	19.18	848	124	3	8108	1	14
2570	7	22784862	20.96	848	135	3	8108	1	14
2571	8	23369559	24.06	848	51	3	8108	1	14
2572	9	24496675	30.05	848	133	3	8108	1	14
2573	10	30099623	59.79	848	10	3	8108	1	14
2583	1	2755406	0.00	848	154	2	8108	1	15
2584	2	3036873	10.22	848	136	2	8108	1	15
2585	3	3386996	22.92	848	118	1	8108	1	15
2586	4	3522134	27.83	848	141	2	8108	1	15
2587	5	3628617	31.69	848	16	2	8108	1	15
2588	6	3865186	40.28	848	79	2	8108	1	15
2589	7	3970485	44.10	848	96	2	8108	1	15
2590	8	4975051	80.56	848	149	2	8108	1	15
2591	9	6458343	134.39	848	114	2	8108	1	15
2600	1	7147568	0.00	848	96	2	8108	1	14
2601	2	7663399	7.22	848	43	2	8108	1	14
2602	3	7772951	8.75	848	2	2	8108	1	14
2603	4	8055309	12.70	848	52	2	8108	1	14
2604	5	8089235	13.17	848	154	2	8108	1	14
2605	6	8428000	17.91	848	40	2	8108	1	14
2606	7	8682741	21.48	848	122	2	8108	1	14
2607	8	8842348	23.71	848	114	2	8108	1	14
2608	9	8954801	25.28	848	45	2	8108	1	14
2609	10	9126190	27.68	848	18	3	8108	1	14
2610	11	9287699	29.94	848	68	2	8108	1	14
2611	12	9390499	31.38	848	175	2	8108	1	14
2612	13	9411115	31.67	848	136	2	8108	1	14
2613	14	9552049	33.64	848	99	2	8108	1	14
2614	15	10481303	46.64	848	20	2	8108	1	14
2574	1	3351110	0.00	848	20	2	8109	2	13
2575	2	3478896	3.81	848	65	3	8109	2	13
2576	3	3522194	5.11	848	7	3	8109	2	13
2577	4	3668411	9.47	848	51	3	8109	2	13
2578	5	4204091	25.45	848	148	3	8109	2	13
2579	6	5149581	53.67	848	27	3	8109	2	13
2580	7	6037279	80.16	848	105	3	8109	2	13
2581	8	6445689	92.34	848	43	2	8109	2	13
2582	9	8336021	148.75	848	61	2	8109	2	13
2592	1	4750072	0.00	848	122	2	8109	1	14
2593	2	5292761	11.42	848	68	2	8109	1	14
2594	3	5948965	25.24	848	114	2	8109	1	14
2595	4	6101023	28.44	848	18	3	8109	1	14
2596	5	6422309	35.20	848	154	2	8109	1	14
2597	6	7146029	50.44	848	102	2	8109	1	14
2598	7	9101486	91.61	848	45	2	8109	1	14
2599	8	13626269	186.86	848	10	3	8109	1	14
588	1	4231921	0.00	372	68	2	8110	1	3
589	2	4702131	11.11	372	71	1	8110	1	3
590	3	4928000	16.45	372	40	2	8110	1	3
591	4	5083894	20.13	372	51	3	8110	1	3
592	5	5214108	23.21	372	141	2	8110	1	3

593	6	5250228	24.06	372	61	2	8110	1	3
594	7	5311746	25.52	372	84	2	8110	1	3
595	8	5620172	32.80	372	94	2	8110	1	3
596	9	5641235	33.30	372	20	2	8110	1	3
597	10	7099899	67.77	372	114	2	8110	1	3
1133	1	23698205	0.00	374	27	3	8110	1	5
1134	2	24012625	1.33	374	178	3	8110	1	5
1135	3	24682413	4.15	374	36	3	8110	1	5
1136	4	25331010	6.89	374	133	3	8110	1	5
1137	5	26008849	9.75	374	51	3	8110	1	5
1138	6	26109513	10.18	374	148	3	8110	1	5
1139	7	29998861	26.59	374	24	3	8110	1	5
1487	1	647042	0.00	712	6	1	8110	2	7
1488	2	671762	3.82	712	71	1	8110	2	7
1489	3	720638	11.37	712	179	1	8110	2	7
1490	4	730000	12.82	712	175	2	8110	2	7
1491	5	749000	15.76	712	68	2	8110	2	7
1492	6	767411	18.60	712	38	1	8110	2	7
1493	7	785295	21.37	712	64	1	8110	2	7
1494	8	787323	21.68	712	190	1	8110	2	7
1495	9	834686	29.00	712	21	1	8110	2	7
1496	10	844740	30.55	712	17	1	8110	2	7
1497	11	867300	34.04	712	95	1	8110	2	7
1498	12	878203	35.73	712	39	1	8110	2	7
1499	13	975395	50.75	712	154	2	8110	2	7
1500	14	975461	50.76	712	114	2	8110	2	7
1501	15	987000	52.54	712	130	1	8110	2	7
1502	16	1047941	61.96	712	103	1	8110	2	7
1503	17	1118960	72.93	712	92	1	8110	2	7
1504	18	1316774	103.51	712	18	3	8110	2	7
2545	1	12286672	0.00	848	134	3	8112	1	15
2546	2	13648765	11.09	848	28	3	8112	1	15
2547	3	13895260	13.09	848	119	3	8112	1	15
2548	4	15260701	24.21	848	140	3	8112	1	15
2549	5	16019420	30.38	848	36	3	8112	1	15
2550	6	16671040	35.68	848	51	3	8112	1	15
2551	7	17539554	42.75	848	124	3	8112	1	15
2552	8	18337628	49.25	848	27	3	8112	1	15
2553	9	27641954	124.98	848	105	3	8112	1	15
2554	10	28731955	133.85	848	24	3	8112	1	15
2555	11	29164129	137.36	848	123	3	8112	1	15
1452	1	531110	0.00	712	48	1	8201	2	7
1453	2	644980	21.44	712	6	1	8201	2	7
1454	3	897000	68.89	712	71	1	8201	2	7
1455	4	898935	69.26	712	92	1	8201	2	7
1456	5	899253	69.32	712	114	2	8201	2	7
1457	6	986080	85.66	712	152	3	8201	2	7
1458	7	1018103	91.69	712	64	1	8201	2	7
1459	8	1366300	157.25	712	68	2	8201	2	7
1460	9	1607452	202.66	712	139	1	8201	2	7
2443	1	8197816	0.00	848	68	2	8201	1	14
2444	2	8260000	0.76	848	40	2	8201	1	14
2445	3	8394885	2.40	848	154	2	8201	1	14
2446	4	8538270	4.15	848	9	2	8201	1	14
2447	5	8583424	4.70	848	20	2	8201	1	14
2448	6	8777700	7.07	848	49	2	8201	1	14
2449	7	8800000	7.35	848	175	2	8201	1	14
2450	8	8847171	7.92	848	96	2	8201	1	14
2451	9	9816649	19.75	848	138	2	8201	1	14
2452	10	9855315	20.22	848	114	2	8201	1	14
2453	11	10162754	23.97	848	150	3	8201	1	14
2454	12	10215056	24.61	848	18	3	8201	1	14
2455	13	10602218	29.33	848	149	2	8201	1	14
630	1	1221776	0.00	374	100	1	8202	2	5
631	2	1294470	5.95	374	75	2	8202	2	5
632	3	1307088	6.98	374	71	1	8202	2	5
633	4	1467225	20.09	374	38	1	8202	2	5
634	5	1473129	20.57	374	141	2	8202	2	5
635	6	1680000	37.50	374	68	2	8202	2	5
636	7	1744370	42.77	374	64	1	8202	2	5
2408	1	2005544	0.00	848	45	2	8203	2	14
2409	2	2225587	10.97	848	114	2	8203	2	14
2410	3	2246979	12.04	848	119	3	8203	2	14
2411	4	2272190	13.30	848	99	2	8203	2	14
2412	5	2347134	17.03	848	109	3	8203	2	14
2413	6	2572816	28.29	848	68	2	8203	2	14
2414	7	2611879	30.23	848	149	2	8203	2	14

2415	8	2630588	31.17	848	52	2	8203	2	14
2416	9	2666680	32.97	848	96	2	8203	2	14
2417	10	2926000	45.90	848	40	2	8203	2	14
2418	11	3337394	66.41	848	141	2	8203	2	14
2419	1	5131914	0.00	848	96	2	8204	1	14
2420	2	5288300	3.05	848	52	2	8204	1	14
2421	3	5320615	3.68	848	79	2	8204	1	14
2422	4	5328953	3.84	848	45	2	8204	1	14
2423	5	5830414	13.61	848	140	3	8204	1	14
2424	6	5932795	15.61	848	141	2	8204	1	14
2425	7	5966975	16.27	848	119	3	8204	1	14
2426	8	6090437	18.68	848	148	3	8204	1	14
2427	9	6116288	19.18	848	135	3	8204	1	14
2428	10	6130000	19.45	848	174	2	8204	1	14
2429	11	6321066	23.17	848	126	3	8204	1	14
2430	12	8197953	59.74	848	142	3	8204	1	14
2431	1	1603050	0.00	848	96	2	8205	2	14
2432	2	1649460	2.90	848	7	3	8205	2	14
2433	3	1702500	6.20	848	118	2	8205	2	14
2434	4	1827150	13.98	848	52	2	8205	2	14
2435	5	1842050	14.91	848	41	2	8205	2	14
2436	6	1850750	15.45	848	20	2	8205	2	14
2437	7	1921900	19.89	848	64	1	8205	2	14
2438	8	1927240	20.22	848	48	1	8205	2	14
2439	9	1928050	20.27	848	68	2	8205	2	14
2440	10	2099800	30.99	848	97	1	8205	2	14
2441	11	2325860	45.09	848	92	1	8205	2	14
2442	12	2515500	56.92	848	45	2	8205	2	14
2362	1	22869278	0.00	848	119	3	8206	2	15
2363	2	24036083	5.10	848	135	3	8206	2	15
2364	3	24998835	9.31	848	10	3	8206	2	15
2365	4	25222351	10.29	848	52	2	8206	2	15
2366	5	26347311	15.21	848	150	3	8206	2	15
2367	6	26655452	16.56	848	140	3	8206	2	15
2368	7	27239992	19.11	848	65	3	8206	2	15
2369	8	27885649	21.93	848	133	3	8206	2	15
2370	9	28228484	23.43	848	142	3	8206	2	15
2371	10	28444471	24.38	848	60	3	8206	2	15
2372	11	28585018	24.99	848	8	3	8206	2	15
2373	12	31889467	39.44	848	105	3	8206	2	15
2374	1	3097997	0.00	848	7	3	8207	2	13
2375	2	3321374	7.21	848	178	3	8207	2	13
2376	3	3584591	15.71	848	148	3	8207	2	13
2377	4	3598044	16.14	848	154	2	8207	2	13
2378	5	4748962	53.29	848	122	2	8207	2	13
2379	6	4851571	56.60	848	65	3	8207	2	13
2380	7	5321297	71.77	848	24	3	8207	2	13
2381	1	1177887	0.00	713	118	2	8208	2	8
2382	2	1194127	1.38	713	48	1	8208	2	8
2383	3	1234424	4.80	713	21	1	8208	2	8
2384	4	1279476	8.62	713	99	2	8208	2	8
2385	5	1292423	9.72	713	136	2	8208	2	8
2386	6	1299482	10.32	713	87	1	8208	2	8
2387	7	1370335	16.34	713	64	1	8208	2	8
2388	8	1378999	17.07	713	92	1	8208	2	8
2389	9	1415651	20.19	713	44	2	8208	2	8
2390	10	1459764	23.93	713	55	1	8208	2	8
2391	11	1524780	29.45	713	45	2	8208	2	8
2392	1	2480000	0.00	848	68	2	8208	1	14
2393	2	2492650	0.51	848	2	2	8208	1	14
2394	3	2552885	2.94	848	136	2	8208	1	14
2395	4	2617453	5.54	848	175	2	8208	1	14
2396	5	2619393	5.62	848	118	2	8208	1	14
2397	6	2716000	9.52	848	40	2	8208	1	14
2398	7	2781141	12.14	848	154	2	8208	1	14
2399	8	2832413	14.21	848	149	2	8208	1	14
2400	9	2867476	15.62	848	142	3	8208	1	14
2401	10	2929572	18.13	848	9	2	8208	1	14
2402	11	2931185	18.19	848	52	2	8208	1	14
2403	12	3013968	21.53	848	153	2	8208	1	14
2404	13	3014459	21.55	848	99	2	8208	1	14
2405	14	3119060	25.77	848	96	2	8208	1	14
2406	15	3433445	38.45	848	45	2	8208	1	14
2407	16	3505923	41.37	848	84	2	8208	1	14
652	1	14774821	0.00	374	65	3	8209	1	5
653	2	15533536	5.14	374	148	3	8209	1	5
654	3	15978752	8.15	374	150	3	8209	1	5

655	4	15989324	8.22	374	60	3	8209	1	5
656	5	16512000	11.76	374	98	3	8209	1	5
657	6	16568476	12.14	374	140	3	8209	1	5
658	7	16875594	14.22	374	69	3	8209	1	5
659	8	16966031	14.83	374	134	3	8209	1	5
660	9	17000000	15.06	374	88	3	8209	1	5
661	10	17198834	16.41	374	143	3	8209	1	5
662	11	17257666	16.80	374	126	3	8209	1	5
663	12	17388717	17.69	374	27	3	8209	1	5
664	13	17413372	17.86	374	105	3	8209	1	5
665	14	17465605	18.21	374	24	3	8209	1	5
666	15	17472388	18.26	374	121	3	8209	1	5
667	16	17548714	18.77	374	8	3	8209	1	5
668	17	18108918	22.57	374	119	3	8209	1	5
669	18	20264897	37.16	374	124	3	8209	1	5
670	19	21822165	47.70	374	36	3	8209	1	5
942	1	13883359	0.00	374	148	3	8209	1	5
943	2	14620120	5.31	374	98	3	8209	1	5
944	3	14772029	6.40	374	65	3	8209	1	5
945	4	14999510	8.04	374	69	3	8209	1	5
946	5	15128908	8.97	374	134	3	8209	1	5
947	6	15131236	8.99	374	36	3	8209	1	5
948	7	15424329	11.10	374	150	3	8209	1	5
949	8	15873820	14.34	374	119	3	8209	1	5
950	9	16065000	15.71	374	88	3	8209	1	5
951	10	16117398	16.09	374	60	3	8209	1	5
952	11	16183889	16.57	374	121	3	8209	1	5
953	12	16293163	17.36	374	140	3	8209	1	5
954	13	16385425	18.02	374	37	2	8209	1	5
955	14	16508482	18.91	374	10	3	8209	1	5
956	15	16873856	21.54	374	8	3	8209	1	5
957	16	16980732	22.31	374	169	3	8209	1	5
958	17	17011830	22.53	374	109	3	8209	1	5
959	18	17042993	22.76	374	24	3	8209	1	5
960	19	17118361	23.30	374	105	3	8209	1	5
961	20	17437917	25.60	374	142	3	8209	1	5
962	21	17498200	26.04	374	27	3	8209	1	5
963	22	17782946	28.09	374	126	3	8209	1	5
614	1	18450182	0.00	374	150	3	8210	1	5
615	2	18715000	1.44	374	98	3	8210	1	5
616	3	20348146	10.29	374	69	3	8210	1	5
617	4	20351568	10.31	374	65	3	8210	1	5
618	5	21019122	13.92	374	142	3	8210	1	5
619	6	21372485	15.84	374	140	3	8210	1	5
620	7	21417415	16.08	374	126	3	8210	1	5
621	8	21960473	19.03	374	148	3	8210	1	5
622	9	22815892	23.66	374	109	3	8210	1	5
623	10	23356548	26.59	374	105	3	8210	1	5
624	11	24548164	33.05	374	113	3	8210	1	5
625	12	25473706	38.07	374	135	3	8210	1	5
626	13	25698496	39.29	374	60	3	8210	1	5
627	14	26147576	41.72	374	24	3	8210	1	5
628	15	26198612	42.00	374	27	3	8210	1	5
629	16	26802058	45.27	374	10	3	8210	1	5
1739	1	5660338	0.00	713	136	2	8211	2	8
1740	2	6026740	6.47	713	122	2	8211	2	8
1741	3	6082914	7.47	713	141	2	8211	2	8
1742	4	6182257	9.22	713	79	2	8211	2	8
1743	5	6188120	9.32	713	16	2	8211	2	8
1744	6	6247476	10.37	713	142	3	8211	2	8
1745	7	6247912	10.38	713	68	2	8211	2	8
1746	8	6336029	11.94	713	127	2	8211	2	8
1747	9	6362610	12.41	713	9	2	8211	2	8
1748	10	6380607	12.72	713	154	2	8211	2	8
1749	11	6580584	16.26	713	2	2	8211	2	8
1750	12	6717451	18.68	713	77	2	8211	2	8
1751	13	6797132	20.08	713	60	3	8211	2	8
1752	14	6860578	21.20	713	149	2	8211	2	8
1753	15	6942560	22.65	713	69	3	8211	2	8
1754	16	7280772	28.63	713	45	2	8211	2	8
1755	17	7296924	28.91	713	119	3	8211	2	8
1756	18	7329288	29.48	713	43	2	8211	2	8
1757	19	7457382	31.75	713	18	3	8211	2	8
2292	1	4594950	0.00	848	7	3	8211	2	14
2293	2	4910740	6.87	848	96	2	8211	2	14
2294	3	4928720	7.26	848	118	2	8211	2	14
2295	4	4974320	8.26	848	18	3	8211	2	14

2296	5	5079310	10.54	848	109	3	8211	2	14
2297	6	5090380	10.78	848	68	2	8211	2	14
2298	7	5117070	11.36	848	142	3	8211	2	14
2299	8	5263630	14.55	848	122	2	8211	2	14
2300	9	5368730	16.84	848	119	3	8211	2	14
2301	10	5376320	17.00	848	20	2	8211	2	14
2302	11	5697230	23.99	848	45	2	8211	2	14
2303	12	6160540	34.07	848	2	2	8211	2	14
1700	1	18400910	0.00	713	150	3	8212	1	9
1701	2	18905843	2.74	713	42	3	8212	1	9
1702	3	19033169	3.44	713	65	3	8212	1	9
1703	4	19233724	4.53	713	109	3	8212	1	9
1704	5	19328278	5.04	713	133	3	8212	1	9
1705	6	19374519	5.29	713	105	3	8212	1	9
1706	7	19419610	5.54	713	142	3	8212	1	9
1707	8	19453819	5.72	713	121	3	8212	1	9
1708	9	19460493	5.76	713	126	3	8212	1	9
1709	10	19504340	6.00	713	119	3	8212	1	9
1710	11	19556564	6.28	713	69	3	8212	1	9
1711	12	20090023	9.18	713	10	3	8212	1	9
1712	13	20735295	12.69	713	148	3	8212	1	9
1713	14	20750516	12.77	713	152	3	8212	1	9
1714	15	21123764	14.80	713	60	3	8212	1	9
1715	16	21898598	19.01	713	140	3	8212	1	9
1716	17	22037454	19.76	713	134	3	8212	1	9
1717	18	22180276	20.54	713	124	3	8212	1	9
1718	19	22786833	23.84	713	117	3	8212	1	9
1719	20	22888574	24.39	713	27	3	8212	1	9
1720	21	23449022	27.43	713	4	3	8212	1	9
1721	22	27180235	47.71	713	89	3	8212	1	9
2304	1	2598790	0.00	848	141	2	8212	1	14
2305	2	2778020	6.90	848	7	3	8212	1	14
2306	3	2881990	10.90	848	45	2	8212	1	14
2307	4	2894190	11.37	848	96	2	8212	1	14
2308	5	2958300	13.83	848	27	3	8212	1	14
2309	6	2975280	14.49	848	68	2	8212	1	14
2310	7	3074770	18.32	848	52	2	8212	1	14
2311	8	3074790	18.32	848	119	3	8212	1	14
2312	9	3096900	19.17	848	142	3	8212	1	14
2313	10	3109980	19.67	848	43	2	8212	1	14
2314	11	3111820	19.74	848	20	2	8212	1	14
2315	12	3130150	20.45	848	109	3	8212	1	14
2316	13	3308140	27.30	848	16	2	8212	1	14
2317	14	3315650	27.58	848	2	2	8212	1	14
2318	15	3400620	30.85	848	122	2	8212	1	14
2319	16	3844750	47.94	848	150	3	8212	1	14
2320	1	46032537	0.00	848	69	3	8301	1	15
2321	2	46118929	0.19	848	36	3	8301	1	15
2322	3	47889386	4.03	848	119	3	8301	1	15
2323	4	49429577	7.38	848	7	3	8301	1	15
2324	5	49983171	8.58	848	33	3	8301	1	15
2325	6	50529984	9.77	848	117	3	8301	1	15
2326	7	50571184	9.86	848	10	3	8301	1	15
2327	8	50848277	10.46	848	109	3	8301	1	15
2328	9	51424102	11.71	848	105	3	8301	1	15
2329	10	51999670	12.96	848	134	3	8301	1	15
2330	11	52203675	13.41	848	178	3	8301	1	15
2331	12	52703601	14.49	848	150	3	8301	1	15
2332	13	55213832	19.95	848	140	3	8301	1	15
2333	14	56881073	23.57	848	148	3	8301	1	15
2334	1	4148621	0.00	848	141	2	8301	2	14
2335	2	4300370	3.66	848	2	2	8301	2	14
2336	3	4316699	4.05	848	109	3	8301	2	14
2337	4	4476826	7.91	848	119	3	8301	2	14
2338	5	4780000	15.22	848	68	2	8301	2	14
2339	6	4966231	19.71	848	20	2	8301	2	14
2340	7	4989088	20.26	848	16	2	8301	2	14
2341	8	5142526	23.96	848	7	3	8301	2	14
2342	9	5215572	25.72	848	122	2	8301	2	14
2343	10	5356483	29.11	848	127	2	8301	2	14
2344	11	5389747	29.92	848	45	2	8301	2	14
2345	12	5483155	32.17	848	52	2	8301	2	14
2346	13	5484983	32.21	848	142	3	8301	2	14
2347	14	6165494	48.62	848	115	2	8301	2	14
2348	15	6452752	55.54	848	92	2	8301	2	14
2349	16	8307750	100.25	848	61	2	8301	2	14
1652	1	9583643	0.00	713	16	2	8302	1	8

1653	2	10346623	7.96	713	152	3	8302	1	8
1654	3	10679691	11.44	713	154	2	8302	1	8
1655	4	10734753	12.01	713	52	2	8302	1	8
1656	5	10876064	13.49	713	96	2	8302	1	8
1657	6	10931583	14.07	713	84	2	8302	1	8
1658	7	10972776	14.49	713	115	2	8302	1	8
1659	8	11073768	15.55	713	150	3	8302	1	8
1660	9	11173281	16.59	713	9	2	8302	1	8
1661	10	11273428	17.63	713	22	2	8302	1	8
1662	11	11277697	17.68	713	49	2	8302	1	8
1663	12	11422445	19.19	713	69	3	8302	1	8
1664	13	11741758	22.52	713	109	3	8302	1	8
1665	14	11851814	23.67	713	122	2	8302	1	8
1666	15	11927780	24.46	713	153	2	8302	1	8
1667	16	12060000	25.84	713	40	2	8302	1	8
1668	17	12080356	26.05	713	10	3	8302	1	8
1669	18	12121400	26.48	713	104	2	8302	1	8
1670	19	12685364	32.36	713	142	3	8302	1	8
1671	20	12841437	33.99	713	68	2	8302	1	8
1672	21	13168170	37.40	713	99	2	8302	1	8
1673	22	13270992	38.48	713	61	2	8302	1	8
1674	23	13309448	38.88	713	60	3	8302	1	8
1675	24	13364549	39.45	713	149	2	8302	1	8
1676	25	13583919	41.74	713	127	2	8302	1	8
1677	26	14600791	52.35	713	143	3	8302	1	8
1678	27	15215105	58.76	713	45	2	8302	1	8
1679	28	15714677	63.97	713	92	2	8302	1	8
1680	29	17131187	78.75	713	19	2	8302	1	8
1560	1	9993758	0.00	713	84	2	8303	1	8
1561	2	9995001	0.01	713	104	2	8303	1	8
1562	3	10053937	0.60	713	115	2	8303	1	8
1563	4	10058785	0.65	713	152	3	8303	1	8
1564	5	10195714	2.02	713	141	2	8303	1	8
1565	6	10215562	2.22	713	96	2	8303	1	8
1566	7	10310000	3.16	713	40	2	8303	1	8
1567	8	10406225	4.13	713	52	2	8303	1	8
1568	9	10475459	4.82	713	9	2	8303	1	8
1569	10	10512330	5.19	713	154	2	8303	1	8
1570	11	10647946	6.55	713	150	3	8303	1	8
1571	12	10830436	8.37	713	99	2	8303	1	8
1572	13	10868370	8.75	713	77	2	8303	1	8
1573	14	11183164	11.90	713	119	3	8303	1	8
1574	15	11311111	13.18	713	109	3	8303	1	8
1575	16	11481091	14.88	713	143	3	8303	1	8
1576	17	11625556	16.33	713	20	2	8303	1	8
1577	18	11740083	17.47	713	122	2	8303	1	8
1578	19	11755861	17.63	713	127	2	8303	1	8
1579	20	12197231	22.05	713	92	2	8303	1	8
1580	21	12387017	23.95	713	10	3	8303	1	8
1581	22	13813847	38.22	713	43	2	8303	1	8
1582	1	9674741	0.00	713	84	2	8303	1	8
1583	2	9677712	0.03	713	152	3	8303	1	8
1584	3	9867962	2.00	713	115	2	8303	1	8
1585	4	9878007	2.10	713	104	2	8303	1	8
1586	5	9885876	2.18	713	154	2	8303	1	8
1587	6	9896000	2.29	713	40	2	8303	1	8
1588	7	9949871	2.84	713	99	2	8303	1	8
1589	8	10097424	4.37	713	96	2	8303	1	8
1590	9	10127565	4.68	713	9	2	8303	1	8
1591	10	10204580	5.48	713	69	3	8303	1	8
1592	11	10309509	6.56	713	133	3	8303	1	8
1593	12	10592949	9.49	713	49	2	8303	1	8
1594	13	10686676	10.46	713	77	2	8303	1	8
1595	14	10800000	11.63	713	59	2	8303	1	8
1596	15	10835903	12.00	713	109	3	8303	1	8
1597	16	10837641	12.02	713	150	3	8303	1	8
1598	17	10859917	12.25	713	122	2	8303	1	8
1599	18	10919138	12.86	713	10	3	8303	1	8
1600	19	11245573	16.24	713	20	2	8303	1	8
1601	20	11585937	19.75	713	149	2	8303	1	8
1602	21	11802027	21.99	713	52	2	8303	1	8
1603	22	11913619	23.14	713	94	2	8303	1	8
1604	23	12201661	26.12	713	92	2	8303	1	8
1605	24	12437983	28.56	713	127	2	8303	1	8
1606	25	12706402	31.34	713	143	3	8303	1	8
1607	26	12922819	33.57	713	75	2	8303	1	8
1608	27	13646689	41.05	713	43	2	8303	1	8

1609	28	13735201	41.97	713	61	2	8303	1	8
1610	29	14800773	52.98	713	95	2	8303	1	8
1611	30	16473165	70.27	713	19	2	8303	1	8
2350	1	1650441	0.00	848	118	2	8303	2	14
2351	2	1954091	18.40	848	141	2	8303	2	14
2352	3	2029227	22.95	848	109	3	8303	2	14
2353	4	2124126	28.70	848	145	1	8303	2	14
2354	5	2157955	30.75	848	2	2	8303	2	14
2355	6	2170554	31.51	848	52	2	8303	2	14
2356	7	2186430	32.48	848	45	2	8303	2	14
2357	8	2240410	35.75	848	119	3	8303	2	14
2358	9	2360112	43.00	848	122	2	8303	2	14
2359	10	2582254	56.46	848	25	1	8303	2	14
2360	11	2663179	61.36	848	142	3	8303	2	14
2361	12	2732720	65.58	848	55	1	8303	2	14
234	1	4265195	0.00	372	99	2	8304	1	3
235	2	4498885	5.48	372	102	2	8304	1	3
236	3	4519497	5.96	372	79	2	8304	1	3
237	4	4523800	6.06	372	68	2	8304	1	3
238	5	4608316	8.04	372	122	2	8304	1	3
239	6	4630552	8.57	372	10	3	8304	1	3
240	7	4653078	9.09	372	115	2	8304	1	3
241	8	4665806	9.39	372	9	2	8304	1	3
242	9	4689544	9.95	372	152	3	8304	1	3
243	10	4741767	11.17	372	138	2	8304	1	3
244	11	4757616	11.55	372	49	2	8304	1	3
245	12	4773623	11.92	372	2	2	8304	1	3
246	13	4790202	12.31	372	20	2	8304	1	3
247	14	4844205	13.58	372	77	2	8304	1	3
248	15	4851000	13.73	372	40	2	8304	1	3
249	16	4871748	14.22	372	150	3	8304	1	3
250	17	4904605	14.99	372	95	2	8304	1	3
251	18	4982984	16.83	372	154	2	8304	1	3
252	19	5012784	17.53	372	118	2	8304	1	3
253	20	5031745	17.97	372	127	2	8304	1	3
254	21	5045289	18.29	372	52	2	8304	1	3
255	22	5132056	20.32	372	61	2	8304	1	3
256	23	5195094	21.80	372	112	2	8304	1	3
257	24	5224274	22.49	372	149	2	8304	1	3
258	25	5289183	24.01	372	69	3	8304	1	3
259	26	5295793	24.16	372	141	2	8304	1	3
260	27	5359923	25.67	372	30	2	8304	1	3
261	28	5486549	28.64	372	92	2	8304	1	3
262	29	5554851	30.24	372	45	2	8304	1	3
263	30	5593564	31.14	372	60	3	8304	1	3
264	31	6579684	54.26	372	91	3	8304	1	3
265	32	7083087	66.07	372	43	2	8304	1	3
266	33	8759625	105.37	372	123	3	8304	1	3
1612	1	10327335	0.00	713	152	3	8305	1	8
1613	2	10639991	3.03	713	9	2	8305	1	8
1614	3	10947699	6.01	713	149	2	8305	1	8
1615	4	10958556	6.11	713	49	2	8305	1	8
1616	5	11267000	9.10	713	40	2	8305	1	8
1617	6	11285987	9.28	713	69	3	8305	1	8
1618	7	11328064	9.69	713	150	3	8305	1	8
1619	8	11468127	11.05	713	104	2	8305	1	8
1620	9	11484180	11.20	713	154	2	8305	1	8
1621	10	11485288	11.21	713	122	2	8305	1	8
1622	11	11680299	13.10	713	2	2	8305	1	8
1623	12	12001524	16.21	713	115	2	8305	1	8
1624	13	12116285	17.32	713	79	2	8305	1	8
1625	14	12296999	19.07	713	99	2	8305	1	8
1626	15	12546525	21.49	713	153	2	8305	1	8
1627	16	12584463	21.86	713	77	2	8305	1	8
1628	17	12748039	23.44	713	20	2	8305	1	8
1629	18	13135534	27.19	713	61	2	8305	1	8
1630	19	13549001	31.20	713	142	3	8305	1	8
1631	20	13814636	33.77	713	89	3	8305	1	8
1632	21	13992446	35.49	713	45	2	8305	1	8
1633	22	14650447	41.86	713	118	2	8305	1	8
1634	23	15380106	48.93	713	30	2	8305	1	8
286	1	4632255	0.00	372	7	3	8307	1	3
287	2	4645966	0.30	372	122	2	8307	1	3
288	3	5182842	11.89	372	92	2	8307	1	3
289	4	5328000	15.02	372	68	2	8307	1	3
290	5	5400822	16.59	372	79	2	8307	1	3
291	6	5424954	17.11	372	2	2	8307	1	3

292	7	5688436	22.80	372	119	3	8307	1	3
293	8	5733494	23.77	372	149	2	8307	1	3
294	9	5847350	26.23	372	45	2	8307	1	3
295	10	5937295	28.17	372	150	3	8307	1	3
296	11	5983194	29.16	372	71	1	8307	1	3
297	12	6386109	37.86	372	109	3	8307	1	3
298	13	6698000	44.59	372	40	2	8307	1	3
1049	1	2830623	0.00	374	118	2	8307	2	5
1050	2	3025481	6.88	374	7	3	8307	2	5
1051	3	3283738	16.01	374	122	2	8307	2	5
1052	4	3751860	32.55	374	52	2	8307	2	5
1053	5	3832142	35.38	374	119	3	8307	2	5
1054	6	3889725	37.42	374	96	2	8307	2	5
1055	7	4103646	44.97	374	79	2	8307	2	5
1056	8	4240377	49.80	374	49	2	8307	2	5
1057	9	4573479	61.57	374	69	3	8307	2	5
1058	10	6029800	113.02	374	45	2	8307	2	5
1059	11	7336500	159.18	374	43	2	8307	2	5
2256	1	1973130	0.00	848	118	2	8307	2	15
2257	2	2035956	3.18	848	2	2	8307	2	15
2258	3	2067676	4.79	848	45	2	8307	2	15
2259	4	2099598	6.41	848	39	1	8307	2	15
2260	5	2127159	7.81	848	141	2	8307	2	15
2261	6	2136506	8.28	848	122	2	8307	2	15
2262	7	2566566	30.08	848	48	1	8307	2	15
2263	8	2600754	31.81	848	25	1	8307	2	15
2264	9	3227910	63.59	848	92	2	8307	2	15
1681	1	13819706	0.00	713	119	3	8308	1	8
1682	2	13941042	0.88	713	109	3	8308	1	8
1683	3	14245068	3.08	713	73	3	8308	1	8
1684	4	14761566	6.82	713	24	3	8308	1	8
1685	5	14764027	6.83	713	69	3	8308	1	8
1686	6	14868668	7.59	713	54	3	8308	1	8
1687	7	14903768	7.84	713	150	3	8308	1	8
1688	8	15781731	14.20	713	42	3	8308	1	8
1689	9	15880000	14.91	713	46	3	8308	1	8
1690	10	16135271	16.76	713	143	3	8308	1	8
1691	11	16369281	18.45	713	33	3	8308	1	8
1692	12	16518334	19.53	713	65	3	8308	1	8
1693	13	16779504	21.42	713	140	3	8308	1	8
1694	14	16957032	22.70	713	60	3	8308	1	8
1695	15	16998585	23.00	713	4	3	8308	1	8
1696	16	17118440	23.87	713	121	3	8308	1	8
1697	17	17243674	24.78	713	126	3	8308	1	8
1698	18	17993299	30.20	713	37	2	8308	1	8
1699	19	18940730	37.06	713	124	3	8308	1	8
2250	1	6970313	0.00	848	7	3	8308	1	13
2251	2	7427930	6.57	848	118	2	8308	1	13
2252	3	7886695	13.15	848	65	3	8308	1	13
2253	4	8920323	27.98	848	109	3	8308	1	13
2254	5	10336864	48.30	848	148	3	8308	1	13
2255	6	11435561	64.06	848	24	3	8308	1	13
2265	1	4362116	0.00	848	109	3	8309	1	15
2266	2	4800583	10.05	848	9	2	8309	1	15
2267	3	4902451	12.39	848	134	3	8309	1	15
2268	4	5048238	15.73	848	69	3	8309	1	15
2269	5	5213300	19.51	848	52	2	8309	1	15
2270	6	5225818	19.80	848	150	3	8309	1	15
2271	7	5386829	23.49	848	118	2	8309	1	15
2272	8	5420179	24.26	848	79	2	8309	1	15
2273	9	5455469	25.06	848	36	3	8309	1	15
2274	10	5456622	25.09	848	92	2	8309	1	15
2275	11	5520590	26.56	848	140	3	8309	1	15
2276	12	5598863	28.35	848	119	3	8309	1	15
2277	13	5776183	32.42	848	142	3	8309	1	15
2278	14	5838188	33.84	848	176	2	8309	1	15
2279	15	5915480	35.61	848	99	2	8309	1	15
2280	16	6105064	39.96	848	122	2	8309	1	15
2281	17	6132357	40.58	848	154	2	8309	1	15
2282	18	6177467	41.62	848	133	3	8309	1	15
2283	19	6188411	41.87	848	45	2	8309	1	15
2284	20	6299809	44.42	848	50	2	8309	1	15
2285	21	6431079	47.43	848	27	3	8309	1	15
2286	22	6528000	49.65	848	68	2	8309	1	15
2287	23	6529767	49.69	848	20	2	8309	1	15
2288	24	6662728	52.74	848	43	2	8309	1	15
2289	25	6882884	57.79	848	123	3	8309	1	15

2290	26	6962670	59.62	848	149	2	8309	1	15
2291	27	7124600	63.33	848	175	2	8309	1	15
1150	1	5600586	0.00	712	71	1	8310	1	7
1151	2	5719715	2.13	712	99	2	8310	1	7
1152	3	5850000	4.45	712	40	2	8310	1	7
1153	4	5990434	6.96	712	127	2	8310	1	7
1154	5	6077998	8.52	712	74	2	8310	1	7
1155	6	6383013	13.97	712	24	3	8310	1	7
1156	7	6450763	15.18	712	69	3	8310	1	7
1157	8	6573273	17.37	712	9	2	8310	1	7
1158	9	6615491	18.12	712	122	2	8310	1	7
1159	10	6762379	20.74	712	92	2	8310	1	7
1160	11	6977800	24.59	712	136	2	8310	1	7
1161	12	7996197	42.77	712	45	2	8310	1	7
1187	1	6612834	0.00	712	99	2	8310	1	7
1188	2	6680354	1.02	712	79	2	8310	1	7
1189	3	7087486	7.18	712	150	3	8310	1	7
1190	4	7120000	7.67	712	40	2	8310	1	7
1191	5	7419570	12.20	712	74	2	8310	1	7
1192	6	7473558	13.02	712	9	2	8310	1	7
1193	7	7440665	12.52	712	69	3	8310	1	7
1194	8	7615653	15.16	712	92	2	8310	1	7
1195	9	7620350	15.24	712	127	2	8310	1	7
1196	10	8310474	25.67	712	149	2	8310	1	7
1197	11	8865639	34.07	712	140	3	8310	1	7
1198	12	8989392	35.94	712	50	2	8310	1	7
1199	13	9556844	44.52	712	45	2	8310	1	7
2197	1	16626082	0.00	848	150	3	8310	1	15
2198	2	19361204	16.45	848	140	3	8310	1	15
2199	3	19639166	18.12	848	8	3	8310	1	15
2200	4	20235234	21.71	848	109	3	8310	1	15
2201	5	20361378	22.47	848	134	3	8310	1	15
2202	6	20445396	22.97	848	27	3	8310	1	15
2203	7	21523264	29.45	848	37	2	8310	1	15
2204	8	21599097	29.91	848	126	3	8310	1	15
2205	9	21653818	30.24	848	117	3	8310	1	15
2206	10	22174598	33.37	848	60	3	8310	1	15
2207	11	22177688	33.39	848	69	3	8310	1	15
2208	12	22869715	37.55	848	135	3	8310	1	15
2209	13	23121489	39.07	848	4	3	8310	1	15
2210	14	23148254	39.23	848	124	3	8310	1	15
2211	15	23385059	40.65	848	24	3	8310	1	15
2212	16	24124095	45.10	848	142	3	8310	1	15
2213	17	25138289	51.20	848	89	3	8310	1	15
2214	18	25183884	51.47	848	148	3	8310	1	15
2215	19	25336043	52.39	848	123	3	8310	1	15
2216	1	2522600	0.00	848	52	2	8311	1	14
2217	2	2528830	0.25	848	71	1	8311	1	14
2218	3	2886627	14.43	848	172	1	8311	1	14
2219	4	2900000	14.96	848	6	1	8311	1	14
2220	5	3256423	29.09	848	16	2	8311	1	14
2221	6	3498773	38.70	848	100	1	8311	1	14
2222	7	4130797	63.75	848	149	2	8311	1	14
2223	1	17817951	0.00	848	119	3	8312	1	14
2224	2	18030541	1.19	848	126	3	8312	1	14
2225	3	18665099	4.75	848	133	3	8312	1	14
2226	4	18759726	5.29	848	150	3	8312	1	14
2227	5	19378266	8.76	848	69	3	8312	1	14
2228	6	19389619	8.82	848	65	3	8312	1	14
2229	7	20391247	14.44	848	124	3	8312	1	14
2230	8	20478068	14.93	848	140	3	8312	1	14
2231	9	21993664	23.44	848	4	3	8312	1	14
2232	10	22305958	25.19	848	146	3	8312	1	14
2233	11	22671666	27.24	848	33	3	8312	1	14
2234	12	22872768	28.37	848	109	3	8312	1	14
2235	13	24623181	38.19	848	90	3	8312	1	14
2236	1	766366	0.00	848	119	3	8312	2	14
2237	2	951952	24.22	848	92	2	8312	2	14
2238	3	964175	25.81	848	187	1	8312	2	14
2239	4	991669	29.40	848	52	2	8312	2	14
2240	5	1026500	33.94	848	45	2	8312	2	14
2241	6	1053192	37.43	848	96	2	8312	2	14
2242	7	1056288	37.83	848	48	1	8312	2	14
2243	8	1082632	41.27	848	118	2	8312	2	14
2244	9	1086477	41.77	848	20	2	8312	2	14
2245	10	1113718	45.32	848	135	3	8312	2	14
2246	11	1185383	54.68	848	133	3	8312	2	14

2247	12	1249041	62.98	848	79	2	8312	2	14
2248	13	1316442	71.78	848	132	1	8312	2	14
2249	14	1546906	101.85	848	24	3	8312	2	14
212	1	4541128	0.00	372	79	2	8401	2	3
213	2	4614370	1.61	372	127	2	8401	2	3
214	3	4688784	3.25	372	9	2	8401	2	3
215	4	4821448	6.17	372	150	3	8401	2	3
216	5	4896905	7.83	372	115	2	8401	2	3
217	6	4912514	8.18	372	52	2	8401	2	3
218	7	4929981	8.56	372	58	2	8401	2	3
219	8	4975916	9.57	372	74	2	8401	2	3
220	9	5200892	14.53	372	154	2	8401	2	3
221	10	5214074	14.82	372	43	2	8401	2	3
222	11	5214453	14.83	372	20	2	8401	2	3
223	12	5283646	16.35	372	122	2	8401	2	3
224	13	5384392	18.57	372	134	3	8401	2	3
225	14	5608248	23.50	372	136	2	8401	2	3
226	15	5688362	25.26	372	102	2	8401	2	3
227	16	5758520	26.81	372	142	3	8401	2	3
228	17	5872868	29.33	372	99	2	8401	2	3
229	18	6024928	32.67	372	92	2	8401	2	3
230	19	6245493	37.53	372	71	1	8401	2	3
231	20	6425436	41.49	372	60	3	8401	2	3
232	21	6437711	41.76	372	143	3	8401	2	3
233	22	6453272	42.11	372	45	2	8401	2	3
2187	1	1705169	0.00	848	96	2	8402	2	14
2188	2	1957738	14.81	848	194	1	8402	2	14
2189	3	1971206	15.60	848	145	1	8402	2	14
2190	4	2045204	19.94	848	120	1	8402	2	14
2191	5	2101297	23.23	848	71	1	8402	2	14
2192	6	2153735	26.31	848	64	1	8402	2	14
2193	7	2321240	36.13	848	187	1	8402	2	14
2194	8	2379076	39.52	848	20	2	8402	2	14
2195	9	2471238	44.93	848	27	3	8402	2	14
2196	10	2866670	68.12	848	25	1	8402	2	14
2498	1	603009	0.00	848	18	3	8402	2	14
2499	2	616714	2.27	848	25	1	8402	2	14
2500	3	680390	12.83	848	45	2	8402	2	14
2501	4	715767	18.70	848	71	1	8402	2	14
2502	5	775213	28.56	848	92	2	8402	2	14
2503	6	775383	28.59	848	100	1	8402	2	14
2504	7	783630	29.95	848	103	1	8402	2	14
2505	8	806467	33.74	848	43	2	8402	2	14
2506	9	1449699	140.41	848	191	1	8402	2	14
170	1	5939516	0.00	372	152	3	8403	1	3
171	2	6293727	5.96	372	52	2	8403	1	3
172	3	6312477	6.28	372	20	2	8403	1	3
173	4	6325416	6.50	372	9	2	8403	1	3
174	5	6458932	8.75	372	49	2	8403	1	3
175	6	6474634	9.01	372	58	2	8403	1	3
176	7	6546318	10.22	372	154	2	8403	1	3
177	8	6654689	12.04	372	71	1	8403	1	3
178	9	6690566	12.64	372	115	2	8403	1	3
179	10	6744152	13.55	372	127	2	8403	1	3
180	11	6766144	13.92	372	18	3	8403	1	3
181	12	6919095	16.49	372	96	2	8403	1	3
182	13	7172991	20.77	372	27	3	8403	1	3
183	14	7187788	21.02	372	99	2	8403	1	3
184	15	7291004	22.75	372	79	2	8403	1	3
185	16	7318137	23.21	372	136	2	8403	1	3
186	17	7436767	25.21	372	92	2	8403	1	3
187	18	7518819	26.59	372	60	3	8403	1	3
188	19	7610222	28.13	372	142	3	8403	1	3
189	20	8073111	35.92	372	149	2	8403	1	3
190	21	8089644	36.20	372	45	2	8403	1	3
191	22	8132255	36.92	372	98	3	8403	1	3
192	23	8550305	43.96	372	84	2	8403	1	3
193	24	8827320	48.62	372	151	2	8403	1	3
701	1	1417052	0.00	374	92	2	8403	2	5
702	2	1459037	2.96	374	64	1	8403	2	5
703	3	1586042	11.93	374	39	1	8403	2	5
704	4	1652120	16.59	374	120	1	8403	2	5
705	5	1681997	18.70	374	48	1	8403	2	5
706	6	1756000	23.92	374	125	1	8403	2	5
707	7	1815204	28.10	374	115	2	8403	2	5
708	8	1835141	29.50	374	122	2	8403	2	5
709	9	1916550	35.25	374	45	2	8403	2	5

710	10	1927415	36.02	374	17	1	8403	2	5
711	11	1988819	40.35	374	20	2	8403	2	5
712	12	1992958	40.64	374	118	2	8403	2	5
713	13	1998235	41.01	374	71	1	8403	2	5
714	14	2085690	47.19	374	30	2	8403	2	5
715	15	2107826	48.75	374	100	1	8403	2	5
716	16	3904700	175.55	374	52	2	8403	2	5
717	1	853837	0.00	374	71	1	8404	2	5
718	2	1095561	28.31	374	115	2	8404	2	5
719	3	1115593	30.66	374	78	1	8404	2	5
720	4	1138520	33.34	374	119	3	8404	2	5
721	5	1139000	33.40	374	52	2	8404	2	5
722	6	1188118	39.15	374	48	1	8404	2	5
723	7	1188482	39.19	374	92	2	8404	2	5
724	8	1252000	46.63	374	64	1	8404	2	5
725	9	1422565	66.61	374	45	2	8404	2	5
726	10	1649131	93.14	374	63	1	8404	2	5
727	11	1947799	128.12	374	18	3	8404	2	5
728	12	3500000	309.91	374	130	1	8404	2	5
1162	1	6432606	0.00	712	115	2	8405	1	7
1163	2	6497708	1.01	712	99	2	8405	1	7
1164	3	6523140	1.41	712	74	2	8405	1	7
1165	4	6550413	1.83	712	153	2	8405	1	7
1166	5	6570302	2.14	712	49	2	8405	1	7
1167	6	6597346	2.56	712	122	2	8405	1	7
1168	7	6638497	3.20	712	127	2	8405	1	7
1169	8	6675723	3.78	712	118	2	8405	1	7
1170	9	6813213	5.92	712	148	3	8405	1	7
1171	10	6906554	7.37	712	69	3	8405	1	7
1172	11	6997815	8.79	712	18	3	8405	1	7
1173	12	7051427	9.62	712	79	2	8405	1	7
1174	13	7118628	10.66	712	133	3	8405	1	7
1175	14	7180763	11.63	712	27	3	8405	1	7
1176	15	7195818	11.86	712	142	3	8405	1	7
1177	16	7215828	12.18	712	9	2	8405	1	7
1178	17	7227034	12.35	712	84	2	8405	1	7
1179	18	7580157	17.84	712	151	2	8405	1	7
1180	19	7592071	18.02	712	40	2	8405	1	7
1181	20	7846621	21.98	712	109	3	8405	1	7
1182	21	7869177	22.33	712	92	2	8405	1	7
1183	22	7990530	24.22	712	71	1	8405	1	7
1184	23	8112017	26.11	712	149	2	8405	1	7
1185	24	8807053	36.91	712	45	2	8405	1	7
1186	25	10925518	69.85	712	43	2	8405	1	7
1200	1	5929773	0.00	712	52	2	8405	1	7
1201	2	6280649	5.92	712	152	3	8405	1	7
1202	3	6281573	5.93	712	115	2	8405	1	7
1203	4	6388902	7.74	712	99	2	8405	1	7
1204	5	6431486	8.46	712	58	2	8405	1	7
1205	6	6455225	8.86	712	153	2	8405	1	7
1206	7	6487390	9.40	712	127	2	8405	1	7
1207	8	6498390	9.59	712	49	2	8405	1	7
1208	9	6580230	10.97	712	122	2	8405	1	7
1209	10	6687081	12.77	712	84	2	8405	1	7
1210	11	6726280	13.43	712	18	3	8405	1	7
1211	12	6740609	13.67	712	74	2	8405	1	7
1212	13	6838734	15.33	712	79	2	8405	1	7
1213	14	6850278	15.52	712	69	3	8405	1	7
1214	15	7158888	20.73	712	142	3	8405	1	7
1215	16	7217395	21.71	712	43	2	8405	1	7
1216	17	7358758	24.10	712	149	2	8405	1	7
1217	18	7567979	27.63	712	40	2	8405	1	7
1218	19	7860090	32.55	712	133	3	8405	1	7
1219	20	8084834	36.34	712	45	2	8405	1	7
1220	21	8125337	37.03	712	71	1	8405	1	7
1221	22	9318049	57.14	712	138	2	8405	1	7
401	1	8619752	0.00	372	49	2	8407	1	3
402	2	8928274	3.58	372	96	2	8407	1	3
403	3	8947326	3.80	372	127	2	8407	1	3
404	4	8990500	4.30	372	58	2	8407	1	3
405	5	9111454	5.70	372	122	2	8407	1	3
406	6	9302501	7.92	372	88	3	8407	1	3
407	7	9426337	9.36	372	20	2	8407	1	3
408	8	9461647	9.77	372	74	2	8407	1	3
409	9	9707685	12.62	372	27	3	8407	1	3
410	10	9716340	12.72	372	115	2	8407	1	3
411	11	9839693	14.15	372	117	3	8407	1	3

412	12	9859135	14.38	372	149	2	8407	1	3
413	13	10291808	19.40	372	99	2	8407	1	3
414	14	10390755	20.55	372	69	3	8407	1	3
415	15	10591843	22.88	372	52	2	8407	1	3
416	16	10600000	22.97	372	98	3	8407	1	3
417	17	10622644	23.24	372	102	2	8407	1	3
418	18	11079189	28.53	372	148	3	8407	1	3
419	19	11100103	28.78	372	142	3	8407	1	3
420	20	11303792	31.14	372	60	3	8407	1	3
421	21	11418421	32.47	372	45	2	8407	1	3
2137	1	12147504	0.00	848	119	3	8407	1	15
2138	2	12469494	2.65	848	69	3	8407	1	15
2139	3	12998620	7.01	848	24	3	8407	1	15
2140	4	13180870	8.51	848	95	2	8407	1	15
2141	5	13282177	9.34	848	43	2	8407	1	15
2142	6	13304419	9.52	848	89	3	8407	1	15
2143	7	13482222	10.99	848	178	3	8407	1	15
2144	8	13535875	11.43	848	152	3	8407	1	15
2145	9	13749927	13.19	848	2	2	8407	1	15
2146	10	13828679	13.84	848	127	2	8407	1	15
2147	11	13942622	14.78	848	122	2	8407	1	15
2148	12	13991593	15.18	848	99	2	8407	1	15
2149	13	14060660	15.75	848	9	2	8407	1	15
2150	14	14087828	15.97	848	58	2	8407	1	15
2151	15	14398124	18.53	848	151	2	8407	1	15
2152	16	14398947	18.53	848	149	2	8407	1	15
2153	17	14572050	19.96	848	36	3	8407	1	15
2154	18	14587492	20.09	848	49	2	8407	1	15
2155	19	14730625	21.26	848	104	2	8407	1	15
2156	20	14752742	21.45	848	26	3	8407	1	15
2157	21	14839245	22.16	848	96	2	8407	1	15
2158	22	14919851	22.82	848	27	3	8407	1	15
2159	23	14999134	23.48	848	118	2	8407	1	15
2160	24	15039976	23.81	848	15	2	8407	1	15
2161	25	15076320	24.11	848	150	3	8407	1	15
2162	26	15316815	26.09	848	133	3	8407	1	15
2163	27	15585631	28.30	848	142	3	8407	1	15
2164	28	15875090	30.69	848	20	2	8407	1	15
2165	29	15885191	30.77	848	109	3	8407	1	15
2166	30	15988062	31.62	848	60	3	8407	1	15
2167	31	16065406	32.25	848	45	2	8407	1	15
2168	32	16133698	32.81	848	52	2	8407	1	15
2169	33	16414528	35.13	848	30	2	8407	1	15
2170	34	17313741	42.53	848	92	2	8407	1	15
2171	35	20971941	72.64	848	182	2	8407	1	15
637	1	3710343	0.00	374	18	3	8411	2	5
638	2	3712413	0.06	374	71	1	8411	2	5
639	3	3732321	0.59	374	99	2	8411	2	5
640	4	3781241	1.91	374	122	2	8411	2	5
641	5	3893673	4.94	374	58	2	8411	2	5
642	6	4002722	7.88	374	9	2	8411	2	5
643	7	4060384	9.43	374	95	2	8411	2	5
644	8	4109856	10.77	374	133	3	8411	2	5
645	9	4288012	15.57	374	27	3	8411	2	5
646	10	4333152	16.79	374	45	2	8411	2	5
647	11	4467702	20.41	374	142	3	8411	2	5
648	12	4470906	20.50	374	127	2	8411	2	5
649	13	4549070	22.61	374	119	3	8411	2	5
650	14	4607729	24.19	374	73	3	8411	2	5
651	15	4767233	28.48	374	151	2	8411	2	5
882	1	6879111	0.00	374	40	2	8411	1	5
883	2	6926902	0.69	374	118	2	8411	1	5
884	3	6957687	1.14	374	104	2	8411	1	5
885	4	7080982	2.93	374	45	2	8411	1	5
886	5	7211817	4.84	374	20	2	8411	1	5
887	6	7262240	5.57	374	21	2	8411	1	5
888	7	7338546	6.68	374	9	2	8411	1	5
889	8	7553565	9.80	374	18	3	8411	1	5
890	9	7636752	11.01	374	7	3	8411	1	5
891	10	7808114	13.50	374	6	2	8411	1	5
892	11	7989419	16.14	374	99	2	8411	1	5
893	12	8479643	23.27	374	122	2	8411	1	5
894	13	8506224	23.65	374	16	2	8411	1	5
895	14	8544000	24.20	374	88	3	8411	1	5
896	15	8795659	27.86	374	115	2	8411	1	5
897	16	8907723	29.49	374	140	3	8411	1	5
898	17	9862867	43.37	374	152	3	8411	1	5

899	18	12139000	76.46	374	4	3	8411	1	5
900	19	12139258	76.47	374	58	2	8411	1	5
1313	1	5867709	0.00	712	58	2	8411	1	7
1314	2	6206461	5.77	712	74	2	8411	1	7
1315	3	6220000	6.00	712	52	2	8411	1	7
1316	4	6260784	6.70	712	99	2	8411	1	7
1317	5	6339680	8.04	712	115	2	8411	1	7
1318	6	6430018	9.58	712	136	2	8411	1	7
1319	7	6455495	10.02	712	140	3	8411	1	7
1320	8	6550686	11.64	712	127	2	8411	1	7
1321	9	6583508	12.20	712	20	2	8411	1	7
1322	10	6690098	14.02	712	9	2	8411	1	7
1323	11	6698941	14.17	712	18	3	8411	1	7
1324	12	6972380	18.83	712	149	2	8411	1	7
1325	13	7042436	20.02	712	95	2	8411	1	7
1326	14	7063000	20.37	712	30	2	8411	1	7
1327	15	7255075	23.64	712	36	3	8411	1	7
1328	16	7329171	24.91	712	24	3	8411	1	7
1329	17	8121908	38.42	712	92	2	8411	1	7
2113	1	18643813	0.00	848	7	3	8411	1	15
2114	2	19566965	4.95	848	33	3	8411	1	15
2115	3	19970207	7.11	848	126	3	8411	1	15
2116	4	20105881	7.84	848	150	3	8411	1	15
2117	5	20189160	8.29	848	24	3	8411	1	15
2118	6	20397090	9.40	848	65	3	8411	1	15
2119	7	20518881	10.06	848	69	3	8411	1	15
2120	8	20602316	10.50	848	134	3	8411	1	15
2121	9	20650943	10.77	848	10	3	8411	1	15
2122	10	20889036	12.04	848	109	3	8411	1	15
2123	11	20895023	12.07	848	140	3	8411	1	15
2124	12	20988000	12.57	848	54	3	8411	1	15
2125	13	21016685	12.73	848	148	3	8411	1	15
2126	14	21184856	13.63	848	89	3	8411	1	15
2127	15	21226692	13.85	848	119	3	8411	1	15
2128	16	22284770	19.53	848	88	3	8411	1	15
2129	17	22558746	21.00	848	154	2	8411	1	15
2130	18	22700000	21.76	848	188	3	8411	1	15
2131	19	23332886	25.15	848	149	2	8411	1	15
2132	20	23358463	25.29	848	26	3	8411	1	15
2133	21	24483181	31.32	848	124	3	8411	1	15
2134	22	24671768	32.33	848	134	3	8411	1	15
2135	23	25103457	34.65	848	142	3	8411	1	15
2136	24	25975444	39.32	848	53	3	8411	1	15
983	1	8619620	0.00	374	178	3	8502	2	5
984	2	8766058	1.70	374	104	2	8502	2	5
985	3	9283077	7.70	374	18	3	8502	2	5
986	4	9487750	10.07	374	45	2	8502	2	5
987	5	9935649	15.27	374	58	2	8502	2	5
988	6	10016301	16.20	374	122	2	8502	2	5
989	7	10267515	19.12	374	142	3	8502	2	5
990	8	10274345	19.20	374	20	2	8502	2	5
991	9	10760000	24.83	374	152	3	8502	2	5
992	10	11022600	27.88	374	54	3	8502	2	5
993	11	12187673	41.39	374	27	3	8502	2	5
994	12	12244025	42.05	374	71	2	8502	2	5
1041	1	1546025	0.00	374	71	2	8503	2	5
1042	2	1556950	0.71	374	86	1	8503	2	5
1043	3	1724145	11.52	374	45	2	8503	2	5
1044	4	1842041	19.15	374	119	3	8503	2	5
1045	5	1883000	21.80	374	103	1	8503	2	5
1046	6	1899516	22.86	374	27	3	8503	2	5
1047	7	2192369	41.81	374	147	1	8503	2	5
1048	8	2245700	45.26	374	44	1	8503	2	5
1060	1	7399365	0.00	374	153	2	8503	1	5
1061	2	7403136	0.05	374	115	2	8503	1	5
1062	3	7832567	5.85	374	99	2	8503	1	5
1063	4	7850000	6.09	374	52	2	8503	1	5
1064	5	7914351	6.96	374	129	2	8503	1	5
1065	6	7959635	7.57	374	9	2	8503	1	5
1066	7	8239053	11.35	374	152	3	8503	1	5
1067	8	8310363	12.31	374	20	2	8503	1	5
1068	9	8413295	13.70	374	7	3	8503	1	5
1069	10	8428800	13.91	374	30	2	8503	1	5
1070	11	8526925	15.24	374	18	3	8503	1	5
1071	12	8948420	20.93	374	121	3	8503	1	5
1072	13	9489617	28.25	374	150	3	8503	1	5
1073	14	9489972	28.25	374	176	2	8503	1	5

1074	15	9622906	30.05	374	43	2	8503	1	5
1075	16	10169068	37.43	374	71	2	8503	1	5
1076	17	11078088	49.72	374	45	2	8503	1	5
1635	1	18093930	0.00	713	152	3	8503	1	9
1636	2	18932586	4.64	713	69	3	8503	1	9
1637	3	18956814	4.77	713	109	3	8503	1	9
1638	4	19383258	7.13	713	143	3	8503	1	9
1639	5	19455520	7.53	713	133	3	8503	1	9
1640	6	19688989	8.82	713	54	3	8503	1	9
1641	7	19717646	8.97	713	119	3	8503	1	9
1642	8	19970000	10.37	713	10	3	8503	1	9
1643	9	20074934	10.95	713	150	3	8503	1	9
1644	10	20141898	11.32	713	51	3	8503	1	9
1645	11	20542000	13.53	713	46	3	8503	1	9
1646	12	21674376	19.79	713	126	3	8503	1	9
1647	13	21965277	21.40	713	33	3	8503	1	9
1648	14	22704841	25.48	713	124	3	8503	1	9
1649	15	22794828	25.98	713	89	3	8503	1	9
1650	16	22868261	26.39	713	4	3	8503	1	9
1651	17	29815055	64.78	713	9	2	8503	1	9
683	1	2656409	0.00	374	103	1	8504	2	5
684	2	2795800	5.25	374	75	2	8504	2	5
685	3	3038000	14.36	374	45	2	8504	2	5
686	4	3260642	22.75	374	71	2	8504	2	5
687	5	3368654	26.81	374	27	3	8504	2	5
688	6	3855170	45.13	374	23	1	8504	2	5
964	1	7832155	0.00	374	129	2	8504	1	5
965	2	8150000	4.06	374	52	2	8504	1	5
966	3	8314293	6.16	374	136	2	8504	1	5
967	4	8374542	6.93	374	9	2	8504	1	5
968	5	8392440	7.15	374	2	2	8504	1	5
969	6	8475250	8.21	374	149	2	8504	1	5
970	7	8838288	12.85	374	150	3	8504	1	5
971	8	8990307	14.79	374	27	3	8504	1	5
972	9	9006056	14.99	374	152	3	8504	1	5
973	10	9067116	15.77	374	20	2	8504	1	5
974	11	9170502	17.09	374	119	3	8504	1	5
975	12	9246313	18.06	374	99	2	8504	1	5
976	13	9320742	19.01	374	37	3	8504	1	5
977	14	9448385	20.64	374	142	3	8504	1	5
978	15	9482529	21.07	374	127	2	8504	1	5
979	16	9825946	25.46	374	109	3	8504	1	5
980	17	9998174	27.66	374	124	3	8504	1	5
981	18	10769549	37.50	374	45	2	8504	1	5
982	19	10770000	37.51	374	98	3	8504	1	5
1272	1	6470000	0.00	712	52	2	8506	1	7
1273	2	6490983	0.32	712	58	2	8506	1	7
1274	3	6643518	2.68	712	119	3	8506	1	7
1275	4	6677612	3.21	712	127	2	8506	1	7
1276	5	6747398	4.29	712	18	3	8506	1	7
1277	6	6760479	4.49	712	60	3	8506	1	7
1278	7	6760680	4.49	712	149	2	8506	1	7
1279	8	6845835	5.81	712	6	2	8506	1	7
1280	9	6875889	6.27	712	74	2	8506	1	7
1281	10	6958183	7.55	712	36	3	8506	1	7
1282	11	7138259	10.33	712	20	2	8506	1	7
1283	12	7500000	15.92	712	54	3	8506	1	7
1284	13	8315810	28.53	712	99	2	8506	1	7
1285	14	8550297	32.15	712	45	2	8506	1	7
829	1	17825901	0.00	374	69	3	8507	1	6
830	2	17969483	0.81	374	135	3	8507	1	6
831	3	18088355	1.47	374	18	3	8507	1	6
832	4	18242102	2.33	374	140	3	8507	1	6
833	5	18274420	2.52	374	7	3	8507	1	6
834	6	18670108	4.74	374	27	3	8507	1	6
835	7	18779681	5.35	374	109	3	8507	1	6
836	8	19313000	8.34	374	66	3	8507	1	6
837	9	19400156	8.83	374	124	3	8507	1	6
838	10	19758028	10.84	374	150	3	8507	1	6
839	11	20298800	13.87	374	88	3	8507	1	6
840	12	20611922	15.63	374	148	3	8507	1	6
841	13	20706978	16.16	374	33	3	8507	1	6
842	14	22536556	26.43	374	10	3	8507	1	6
843	15	23235712	30.35	374	134	3	8507	1	6
158	1	33833556	0.00	848	7	3	8508	1	15
159	2	34343328	1.51	848	10	3	8508	1	15
160	3	34427167	1.75	848	51	3	8508	1	15

161	4	34670047	2.47	848	121	3	8508	1	15
162	5	34750231	2.71	848	135	3	8508	1	15
163	6	35780830	5.76	848	69	3	8508	1	15
164	7	36090667	6.67	848	140	3	8508	1	15
165	8	36525000	7.95	848	108	3	8508	1	15
166	9	36940801	9.18	848	124	3	8508	1	15
167	10	37740353	11.55	848	24	3	8508	1	15
168	11	38874454	14.90	848	146	3	8508	1	15
169	12	39829293	17.72	848	89	3	8508	1	15
384	1	6281800	0.00	372	108	3	8508	1	3
385	2	6430893	2.37	372	18	3	8508	1	3
386	3	6443581	2.58	372	74	2	8508	1	3
387	4	6486056	3.25	372	20	2	8508	1	3
388	5	6644171	5.77	372	116	2	8508	1	3
389	6	6867184	9.32	372	50	2	8508	1	3
390	7	6900950	9.86	372	16	2	8508	1	3
391	8	7036741	12.02	372	142	3	8508	1	3
392	9	7040838	12.08	372	75	2	8508	1	3
393	10	7045514	12.16	372	127	2	8508	1	3
394	11	7070169	12.55	372	96	2	8508	1	3
395	12	7277213	15.85	372	134	3	8508	1	3
396	13	7346688	16.95	372	122	2	8508	1	3
397	14	7405849	17.89	372	149	2	8508	1	3
398	15	7993888	27.25	372	71	2	8508	1	3
399	16	8683325	38.23	372	45	2	8508	1	3
400	17	8749456	39.28	372	99	2	8508	1	3
362	1	4632091	0.00	372	75	2	8509	1	3
363	2	5267689	13.72	372	50	2	8509	1	3
364	3	6024215	30.05	372	142	3	8509	1	3
365	4	6344655	36.97	372	45	2	8509	1	3
366	5	6933709	49.69	372	71	2	8509	1	3
1254	1	6339823	0.00	712	58	2	8509	1	7
1255	2	6469666	2.05	712	74	2	8509	1	7
1256	3	6606760	4.21	712	71	2	8509	1	7
1257	4	6703949	5.74	712	127	2	8509	1	7
1258	5	6741560	6.34	712	6	2	8509	1	7
1259	6	6884827	8.60	712	99	2	8509	1	7
1260	7	6898476	8.81	712	20	2	8509	1	7
1261	8	6933195	9.36	712	27	3	8509	1	7
1262	9	6980712	10.11	712	69	3	8509	1	7
1263	10	7000191	10.42	712	122	2	8509	1	7
1264	11	7039636	11.04	712	18	3	8509	1	7
1265	12	7134434	12.53	712	149	2	8509	1	7
1266	13	7214207	13.79	712	49	2	8509	1	7
1267	14	7221250	13.90	712	142	3	8509	1	7
1268	15	7512918	18.50	712	50	2	8509	1	7
1269	16	7635406	20.44	712	40	3	8509	1	7
1270	17	7659108	20.81	712	126	3	8509	1	7
1271	18	8424649	32.88	712	45	2	8509	1	7
1722	1	12615990	0.00	713	20	2	8509	1	8
1723	2	12724294	0.86	713	16	2	8509	1	8
1724	3	12739640	0.98	713	152	3	8509	1	8
1725	4	13326634	5.63	713	151	2	8509	1	8
1726	5	13570075	7.56	713	75	2	8509	1	8
1727	6	13959898	10.65	713	140	3	8509	1	8
1728	7	13977458	10.79	713	122	2	8509	1	8
1729	8	14230559	12.80	713	50	2	8509	1	8
1730	9	14398898	14.13	713	26	3	8509	1	8
1731	10	14849496	17.70	713	71	2	8509	1	8
1732	11	15459935	22.54	713	127	2	8509	1	8
1733	12	15684115	24.32	713	124	3	8509	1	8
1734	13	15849331	25.63	713	80	3	8509	1	8
1735	14	18008174	42.74	713	45	2	8509	1	8
1736	15	18554947	47.07	713	99	2	8509	1	8
1737	16	19128135	51.62	713	142	3	8509	1	8
1738	17	19954924	58.17	713	40	3	8509	1	8
2507	1	3991006	0.00	848	96	2	8509	1	14
2508	2	4041822	1.27	848	43	2	8509	1	14
2509	3	4212843	5.56	848	115	2	8509	1	14
2510	4	4382886	9.82	848	119	3	8509	1	14
2511	5	4562370	14.32	848	122	2	8509	1	14
2512	6	4563741	14.35	848	16	2	8509	1	14
2513	7	4668355	16.97	848	20	2	8509	1	14
2514	8	4678752	17.23	848	18	3	8509	1	14
2515	9	4808644	20.49	848	36	3	8509	1	14
2516	10	4925295	23.41	848	149	2	8509	1	14
2517	11	4970778	24.55	848	127	2	8509	1	14

2518	12	5012870	25.60	848	49	2	8509	1	14
2519	13	5059673	26.78	848	58	2	8509	1	14
2520	14	5060000	26.79	848	30	2	8509	1	14
2521	15	5286008	32.45	848	71	2	8509	1	14
2522	16	5303466	32.89	848	142	3	8509	1	14
2523	17	5581028	39.84	848	50	2	8509	1	14
2524	18	5915396	48.22	848	99	2	8509	1	14
2525	19	5988681	50.05	848	45	2	8509	1	14
353	1	4056233	0.00	372	74	2	8510	1	3
354	2	4396197	8.38	372	127	2	8510	1	3
355	3	4407156	8.65	372	18	3	8510	1	3
356	4	4526610	11.60	372	58	2	8510	1	3
357	5	4758694	17.32	372	49	2	8510	1	3
358	6	4813000	18.66	372	30	2	8510	1	3
359	7	4861509	19.85	372	50	2	8510	1	3
360	8	5094198	25.59	372	102	2	8510	1	3
361	9	5697619	40.47	372	45	2	8510	1	3
689	1	2791950	0.00	372	71	2	8510	2	3
690	2	2794269	0.08	372	41	2	8510	2	3
691	3	2798100	0.22	372	48	1	8510	2	3
692	4	2811900	0.71	372	130	1	8510	2	3
693	5	2891343	3.56	372	131	2	8510	2	3
694	6	2895300	3.70	372	64	1	8510	2	3
695	7	2955500	5.86	372	45	2	8510	2	3
696	8	3012928	7.91	372	101	1	8510	2	3
697	9	3030775	8.55	372	86	1	8510	2	3
698	10	3158420	13.13	372	57	1	8510	2	3
699	11	3176193	13.76	372	144	1	8510	2	3
700	12	3428216	22.79	372	103	1	8510	2	3
2456	1	11794043	0.00	848	119	3	8510	1	15
2457	2	12196848	3.42	848	43	2	8510	1	15
2458	3	12463247	5.67	848	60	3	8510	1	15
2459	4	12575550	6.63	848	75	2	8510	1	15
2460	5	13041171	10.57	848	36	3	8510	1	15
2461	6	13085501	10.95	848	6	2	8510	1	15
2462	7	13488821	14.37	848	71	2	8510	1	15
2463	8	13693324	16.10	848	18	3	8510	1	15
2464	9	13732168	16.43	848	58	2	8510	1	15
2465	10	13828437	17.25	848	127	2	8510	1	15
2466	11	14030726	18.96	848	9	2	8510	1	15
2467	12	14243926	20.77	848	140	3	8510	1	15
2468	13	14996294	27.15	848	50	2	8510	1	15
2469	14	14998055	27.17	848	99	2	8510	1	15
2470	15	15265094	29.43	848	122	2	8510	1	15
2471	16	16097620	36.49	848	142	3	8510	1	15
2472	17	19002490	61.12	848	45	2	8510	1	15
2473	18	19335457	63.94	848	69	3	8510	1	15
2474	1	31950538	0.00	848	140	3	8510	1	15
2475	2	35370585	10.70	848	33	3	8510	1	15
2476	3	35800723	12.05	848	124	3	8510	1	15
2477	4	38445000	20.33	848	66	3	8510	1	15
2478	5	40064713	25.40	848	7	3	8510	1	15
2479	6	40280451	26.07	848	119	3	8510	1	15
2480	7	40488040	26.72	848	10	3	8510	1	15
2481	8	54317895	70.01	848	146	3	8510	1	15
194	1	2642930	0.00	372	58	2	8511	1	3
195	2	2677345	1.30	372	134	3	8511	1	3
196	3	2688379	1.72	372	115	2	8511	1	3
197	4	2711165	2.58	372	127	2	8511	1	3
198	5	2810260	6.33	372	60	3	8511	1	3
199	6	2939969	11.24	372	96	2	8511	1	3
200	7	2946008	11.47	372	71	2	8511	1	3
201	8	3004733	13.69	372	75	2	8511	1	3
202	9	3036003	14.87	372	16	2	8511	1	3
203	10	3154250	19.35	372	122	2	8511	1	3
204	11	3320099	25.62	372	49	2	8511	1	3
205	12	3413608	29.16	372	30	2	8511	1	3
206	13	3420091	29.41	372	74	2	8511	1	3
207	14	3692896	39.73	372	18	3	8511	1	3
208	15	3760031	42.27	372	118	2	8511	1	3
209	16	3880483	46.83	372	45	2	8511	1	3
210	17	4690587	77.48	372	140	3	8511	1	3
211	18	5946159	124.98	372	85	2	8511	1	3
541	1	5901867	0.00	372	75	2	8511	1	3
542	2	6892302	16.78	372	140	3	8511	1	3
543	3	7212620	22.21	372	45	2	8511	1	3
544	4	8075441	36.83	372	71	2	8511	1	3

844	1	18897242	0.00	374	119	3	8511	1	6
845	2	19110118	1.13	374	69	3	8511	1	6
846	3	19138800	1.28	374	121	3	8511	1	6
847	4	19228875	1.75	374	33	3	8511	1	6
848	5	19602937	3.73	374	140	3	8511	1	6
849	6	19727937	4.40	374	18	3	8511	1	6
850	7	20071330	6.21	374	150	3	8511	1	6
851	8	20184000	6.81	374	108	3	8511	1	6
852	9	20248567	7.15	374	10	3	8511	1	6
853	10	22093380	16.91	374	124	3	8511	1	6
854	11	22332828	18.18	374	142	3	8511	1	6
855	12	22717913	20.22	374	24	3	8511	1	6
856	13	22922190	21.30	374	133	3	8511	1	6
1222	1	6379834	0.00	712	20	2	8511	1	7
1223	2	6392210	0.19	712	109	3	8511	1	7
1224	3	6403743	0.37	712	127	2	8511	1	7
1225	4	6432205	0.82	712	74	2	8511	1	7
1226	5	6497361	1.84	712	58	2	8511	1	7
1227	6	6510443	2.05	712	122	2	8511	1	7
1228	7	6550000	2.67	712	52	2	8511	1	7
1229	8	6588464	3.27	712	102	2	8511	1	7
1230	9	6629100	3.91	712	18	3	8511	1	7
1231	10	6672712	4.59	712	99	2	8511	1	7
1232	11	6736888	5.60	712	140	3	8511	1	7
1233	12	6881105	7.86	712	115	2	8511	1	7
1234	13	6900170	8.16	712	133	3	8511	1	7
1235	14	7220680	13.18	712	9	2	8511	1	7
1236	15	7274412	14.02	712	142	3	8511	1	7
1237	16	7284320	14.18	712	84	2	8511	1	7
1238	17	7330644	14.90	712	36	3	8511	1	7
1239	18	7420198	16.31	712	45	2	8511	1	7
1240	19	7525911	17.96	712	149	2	8511	1	7
1241	20	7747666	21.44	712	26	3	8511	1	7
1242	21	8075621	26.58	712	37	3	8511	1	7
323	1	4226784	0.00	372	115	2	8601	1	3
324	2	4683886	10.81	372	96	2	8601	1	3
325	3	4800000	13.56	372	52	2	8601	1	3
326	4	4901327	15.96	372	152	3	8601	1	3
327	5	4914049	16.26	372	74	2	8601	1	3
328	6	4952424	17.17	372	18	3	8601	1	3
329	7	4965868	17.49	372	71	2	8601	1	3
330	8	5060590	19.73	372	142	3	8601	1	3
331	9	5242190	24.02	372	102	2	8601	1	3
332	10	5792200	37.04	372	43	2	8601	1	3
603	1	11015409	0.00	374	118	2	8601	1	5
604	2	11171771	1.42	374	2	2	8601	1	5
605	3	11274935	2.36	374	18	3	8601	1	5
606	4	11318724	2.75	374	96	2	8601	1	5
607	5	12315651	11.80	374	122	2	8601	1	5
608	6	12317056	11.82	374	61	2	8601	1	5
609	7	12450804	13.03	374	43	2	8601	1	5
610	8	12615047	14.52	374	133	3	8601	1	5
611	9	13085846	18.80	374	71	2	8601	1	5
612	10	13398888	21.64	374	108	3	8601	1	5
613	11	13455680	22.15	374	21	2	8601	1	5
2482	1	4798494	0.00	848	96	2	8601	1	14
2483	2	5007141	4.35	848	30	2	8601	1	14
2484	3	5059713	5.44	848	19	2	8601	1	14
2485	4	5210000	8.58	848	52	2	8601	1	14
2486	5	5461984	13.83	848	95	2	8601	1	14
2487	6	5889705	22.74	848	119	3	8601	1	14
2488	7	6758520	40.85	848	71	2	8601	1	14
336	1	4976206	0.00	372	115	2	8603	1	3
337	2	5278616	6.08	372	95	2	8603	1	3
338	3	5343000	7.37	372	52	2	8603	1	3
339	4	5390818	8.33	372	16	2	8603	1	3
340	5	5395307	8.42	372	61	2	8603	1	3
341	6	5491678	10.36	372	127	2	8603	1	3
342	7	5491800	10.36	372	72	2	8603	1	3
343	8	5543392	11.40	372	49	2	8603	1	3
344	9	5632916	13.20	372	96	2	8603	1	3
345	10	5771255	15.98	372	21	2	8603	1	3
346	11	5824840	17.05	372	30	2	8603	1	3
347	12	5879835	18.16	372	122	2	8603	1	3
348	13	6088272	22.35	372	142	3	8603	1	3
349	14	6288539	26.37	372	2	2	8603	1	3
350	15	6293714	26.48	372	26	3	8603	1	3

351	16	6680000	34.24	372	54	3	8603	1	3
352	17	6825235	37.16	372	50	2	8603	1	3
729	1	2528168	0.00	374	48	1	8605	2	5
730	2	2677421	5.90	374	71	2	8605	2	5
731	3	2803564	10.89	374	95	2	8605	2	5
732	4	2887957	14.23	374	32	1	8605	2	5
733	5	2931858	15.97	374	144	1	8605	2	5
734	6	2996300	18.52	374	143	1	8605	2	5
735	7	3282828	29.85	374	64	1	8605	2	5
736	8	3301135	30.57	374	93	1	8605	2	5
737	9	3328304	31.65	374	86	1	8605	2	5
738	10	4037178	59.69	374	139	1	8605	2	5
1286	1	6903000	0.00	712	52	2	8605	1	7
1287	2	7100804	2.87	712	1	2	8605	1	7
1288	3	7168181	3.84	712	74	2	8605	1	7
1289	4	7187275	4.12	712	72	2	8605	1	7
1290	5	7188923	4.14	712	18	3	8605	1	7
1291	6	7339759	6.33	712	43	2	8605	1	7
1292	7	7365802	6.70	712	115	2	8605	1	7
1293	8	7339515	6.32	712	96	2	8605	1	7
1294	9	7412336	7.38	712	148	3	8605	1	7
1295	10	7455564	8.00	712	21	2	8605	1	7
1296	11	7555210	9.45	712	54	3	8605	1	7
1297	12	7666230	11.06	712	36	3	8605	1	7
1298	13	7688035	11.37	712	9	2	8605	1	7
1299	14	7792000	12.88	712	30	2	8605	1	7
1300	15	7803922	13.05	712	49	2	8605	1	7
1301	16	7894192	14.36	712	131	2	8605	1	7
1302	17	7904763	14.51	712	75	2	8605	1	7
1303	18	7905937	14.53	712	133	3	8605	1	7
1304	19	7988804	15.73	712	102	2	8605	1	7
1305	20	8039076	16.46	712	58	2	8605	1	7
1306	21	8064486	16.83	712	142	3	8605	1	7
1307	22	8069038	16.89	712	61	2	8605	1	7
1308	23	8081934	17.08	712	151	2	8605	1	7
1309	24	8268000	19.77	712	108	3	8605	1	7
1310	25	8272789	19.84	712	40	3	8605	1	7
1311	26	8444292	22.33	712	127	2	8605	1	7
1312	27	10804697	56.52	712	110	2	8605	1	7
267	1	8160101	0.00	372	6	2	8606	1	2
268	2	8490926	4.05	372	96	2	8606	1	2
269	3	8645156	5.94	372	129	2	8606	1	2
270	4	8721509	6.88	372	20	2	8606	1	2
271	5	8832495	8.24	372	27	3	8606	1	2
272	6	8955165	9.74	372	133	3	8606	1	2
273	7	9050000	10.91	372	30	2	8606	1	2
274	8	9054737	10.96	372	127	2	8606	1	2
275	9	9069058	11.14	372	50	2	8606	1	2
276	10	9161546	12.27	372	43	2	8606	1	2
277	11	9196038	12.70	372	18	3	8606	1	2
278	12	9277305	13.69	372	71	2	8606	1	2
279	13	9298176	13.95	372	69	3	8606	1	2
280	14	9373853	14.87	372	149	2	8606	1	2
281	15	9901508	21.34	372	152	3	8606	1	2
282	16	10232283	25.39	372	136	2	8606	1	2
283	17	10549951	29.29	372	99	2	8606	1	2
284	18	10625490	30.21	372	142	3	8606	1	2
285	19	11587222	42.00	372	45	2	8606	1	2
864	1	8253724	0.00	374	9	2	8606	1	5
865	2	8493000	2.90	374	108	3	8606	1	5
866	3	8677936	5.14	374	96	2	8606	1	5
867	4	8947479	8.41	374	115	2	8606	1	5
868	5	9108210	10.35	374	1	2	8606	1	5
869	6	9130956	10.63	374	72	2	8606	1	5
870	7	9274086	12.36	374	133	3	8606	1	5
871	8	9306778	12.76	374	58	2	8606	1	5
872	9	9331159	13.05	374	148	3	8606	1	5
873	10	9383957	13.69	374	61	2	8606	1	5
874	11	9385193	13.71	374	16	2	8606	1	5
875	12	9480000	14.86	374	54	3	8606	1	5
876	13	9510000	15.22	374	52	2	8606	1	5
877	14	9649634	16.91	374	49	2	8606	1	5
878	15	9727151	17.85	374	21	2	8606	1	5
879	16	9810956	18.87	374	142	3	8606	1	5
880	17	10357831	25.49	374	151	2	8606	1	5
881	18	10951369	32.68	374	104	2	8606	1	5
1077	1	21477171	0.00	374	51	3	8607	1	5

1078	2	22649529	5.46	374	152	3	8607	1	5
1079	3	22944365	6.83	374	121	3	8607	1	5
1080	4	23282529	8.41	374	148	3	8607	1	5
1081	5	23380000	8.86	374	108	3	8607	1	5
1082	6	23386172	8.89	374	26	3	8607	1	5
1083	7	24217153	12.76	374	119	3	8607	1	5
1084	8	24310849	13.19	374	4	3	8607	1	5
1085	9	24729719	15.14	374	24	3	8607	1	5
1086	10	26719621	24.41	374	109	3	8607	1	5
1087	11	27022887	25.82	374	124	3	8607	1	5
1088	12	28652465	33.41	374	146	3	8607	1	5
367	1	11553623	0.00	372	1	2	8608	1	2
368	2	11663176	0.95	372	21	2	8608	1	2
369	3	12088191	4.63	372	106	2	8608	1	2
370	4	12898572	11.64	372	9	2	8608	1	2
371	5	12899736	11.65	372	96	2	8608	1	2
372	6	12910098	11.74	372	16	2	8608	1	2
373	7	13180449	14.08	372	58	2	8608	1	2
374	8	13200000	14.25	372	52	2	8608	1	2
375	9	13227292	14.49	372	61	2	8608	1	2
376	10	13230058	14.51	372	74	2	8608	1	2
377	11	13671395	18.33	372	2	2	8608	1	2
378	12	13870000	20.05	372	108	3	8608	1	2
379	13	14431161	24.91	372	20	2	8608	1	2
380	14	14717026	27.38	372	119	3	8608	1	2
381	15	14830243	28.36	372	26	3	8608	1	2
382	16	15291058	32.35	372	142	3	8608	1	2
383	17	15298536	32.41	372	18	3	8608	1	2
739	1	1033373	0.00	374	101	1	8608	2	5
740	2	1119440	8.33	374	93	1	8608	2	5
741	3	1157631	12.02	374	34	1	8608	2	5
742	4	1373488	32.91	374	127	2	8608	2	5
743	5	1484748	43.68	374	119	3	8608	2	5
744	6	1502060	45.36	374	32	1	8608	2	5
745	7	1566933	51.63	374	48	1	8608	2	5
746	8	1571077	52.03	374	71	2	8608	2	5
747	9	1617426	56.52	374	64	1	8608	2	5
748	10	1654811	60.14	374	18	3	8608	2	5
749	11	3298910	219.24	374	70	1	8608	2	5
750	1	1888888	0.00	374	64	1	8609	2	5
751	2	2293926	21.44	374	119	3	8609	2	5
752	3	2378000	25.89	374	130	1	8609	2	5
753	4	2447478	29.57	374	48	1	8609	2	5
754	5	2450818	29.75	374	55	1	8609	2	5
755	6	2613804	38.38	374	93	1	8609	2	5
756	7	2946772	56.01	374	32	1	8609	2	5
757	8	2988842	58.23	374	137	1	8609	2	5
758	9	3433494	81.77	374	20	2	8609	2	5
448	1	9030485	0.00	372	119	3	8610	1	2
449	2	9309231	3.09	372	43	2	8610	1	2
450	3	9403687	4.13	372	96	2	8610	1	2
451	4	9840673	8.97	372	48	2	8610	1	2
452	5	9861721	9.20	372	74	2	8610	1	2
453	6	9868610	9.28	372	21	2	8610	1	2
454	7	10186837	12.80	372	115	2	8610	1	2
455	8	10385000	15.00	372	108	3	8610	1	2
456	9	10404419	15.21	372	118	2	8610	1	2
457	10	10654982	17.99	372	2	2	8610	1	2
458	11	10688544	18.36	372	16	2	8610	1	2
459	12	11338135	25.55	372	72	2	8610	1	2
460	13	11355660	25.75	372	151	2	8610	1	2
461	14	11561506	28.03	372	61	2	8610	1	2
462	15	12299832	36.20	372	148	3	8610	1	2
463	16	12812812	41.88	372	127	2	8610	1	2
759	1	1300000	0.00	374	130	1	8610	2	5
760	2	1338023	2.92	374	17	1	8610	2	5
761	3	1488560	14.50	374	83	1	8610	2	5
762	4	1633631	25.66	374	119	3	8610	2	5
763	5	2700000	107.69	374	64	1	8610	2	5
918	1	28603634	0.00	374	124	3	8610	2	5
919	2	29661595	3.70	374	67	3	8610	2	5
920	3	31141000	8.87	374	88	3	8610	2	5
921	4	32261692	12.79	374	76	3	8610	2	5
922	5	32996853	15.36	374	10	3	8610	2	5
923	6	33788000	18.12	374	66	3	8610	2	5
924	7	35195628	23.05	374	51	3	8610	2	5
925	8	37653522	31.64	374	31	3	8610	2	5

926	9	38323000	33.98	374	108	3	8610	2	5
927	10	38500000	34.60	374	111	3	8610	2	5
928	11	39801842	39.15	374	18	3	8610	2	5
929	12	41131113	43.80	374	109	3	8610	2	5
930	13	42057416	47.04	374	148	3	8610	2	5
1422	1	629414	0.00	712	97	1	8611	2	7
1423	2	722182	14.74	712	127	2	8611	2	7
1424	3	844123	34.11	712	64	1	8611	2	7
1425	4	865337	37.48	712	18	3	8611	2	7
901	1	9257333	0.00	374	96	2	8612	2	5
902	2	9389505	1.43	374	94	2	8612	2	5
903	3	9898133	6.92	374	71	2	8612	2	5
904	4	9990000	7.91	374	52	2	8612	2	5
905	5	10016002	8.20	374	21	2	8612	2	5
906	6	10713512	15.73	374	118	2	8612	2	5
907	7	11551103	24.78	374	50	2	8612	2	5
1411	1	1475575	0.00	712	155	1	8612	1	7
1412	2	1711416	15.98	712	118	2	8612	1	7
1413	3	1770873	20.01	712	48	2	8612	1	7
1414	4	1784381	20.93	712	16	2	8612	1	7
1415	5	1894612	28.40	712	180	1	8612	1	7
1416	6	1899601	28.74	712	38	1	8612	1	7
1417	7	1930000	30.80	712	52	2	8612	1	7
1418	8	1969765	33.49	712	86	1	8612	1	7
1419	9	2013226	36.44	712	119	3	8612	1	7
1420	10	2092330	41.80	712	32	1	8612	1	7
1421	11	2727889	84.87	712	64	1	8612	1	7
1779	1	11525142	0.00	713	61	2	8703	1	8
1780	2	11772000	2.14	713	43	2	8703	1	8
1781	3	12044151	4.50	713	18	3	8703	1	8
1782	4	12070000	4.73	713	52	2	8703	1	8
1783	5	12170540	5.60	713	96	2	8703	1	8
1784	6	12318883	6.89	713	48	2	8703	1	8
1785	7	12418440	7.75	713	49	2	8703	1	8
1786	8	12439554	7.93	713	6	2	8703	1	8
1787	9	12623804	9.53	713	115	2	8703	1	8
1788	10	12740225	10.54	713	16	2	8703	1	8
1789	11	12782480	10.91	713	21	2	8703	1	8
1790	12	13090405	13.58	713	127	2	8703	1	8
1791	13	13572132	17.76	713	9	2	8703	1	8
1792	14	13619445	18.17	713	122	2	8703	1	8
1793	15	13703711	18.90	713	152	3	8703	1	8
1794	16	14292235	24.01	713	60	3	8703	1	8
1795	17	14413336	25.06	713	94	2	8703	1	8
1796	18	14973961	29.92	713	71	2	8703	1	8
1797	19	15991038	38.75	713	50	2	8703	1	8
431	1	4750155	0.00	372	21	2	8704	1	3
432	2	4971933	4.67	372	96	2	8704	1	3
433	3	5077800	6.90	372	52	2	8704	1	3
434	4	5185224	9.16	372	49	2	8704	1	3
435	5	5204283	9.56	372	142	3	8704	1	3
436	6	5374313	13.14	372	127	2	8704	1	3
437	7	5528638	16.39	372	122	2	8704	1	3
438	8	5651593	18.98	372	64	1	8704	1	3
439	9	5853394	23.23	372	16	2	8704	1	3
440	10	5882338	23.83	372	136	2	8704	1	3
441	11	6454896	35.89	372	18	3	8704	1	3
442	12	6621286	39.39	372	94	2	8704	1	3
1764	1	11882332	0.00	713	43	2	8704	1	8
1765	2	11891023	0.07	713	18	3	8704	1	8
1766	3	12323000	3.71	713	52	2	8704	1	8
1767	4	12528522	5.44	713	6	2	8704	1	8
1768	5	12745126	7.26	713	49	2	8704	1	8
1769	6	12843713	8.09	713	122	2	8704	1	8
1770	7	12860000	8.23	713	94	2	8704	1	8
1771	8	12985719	9.29	713	127	2	8704	1	8
1772	9	13417005	12.92	713	16	2	8704	1	8
1773	10	13497359	13.59	713	9	2	8704	1	8
1774	11	13557837	14.10	713	26	3	8704	1	8
1775	12	13681131	15.14	713	136	2	8704	1	8
1776	13	14760237	24.22	713	61	2	8704	1	8
764	1	2278880	0.00	374	101	1	8706	2	5
765	2	2811620	23.38	374	148	3	8706	2	5
766	3	2928434	28.50	374	18	3	8706	2	5
767	4	2944480	29.21	374	137	1	8706	2	5
768	5	2963451	30.04	374	62	1	8706	2	5
769	6	3615000	58.63	374	64	1	8706	2	5

857	1	54535944	0.00	374	148	3	8706	1	6
858	2	54815585	0.51	374	135	3	8706	1	6
859	3	55069270	0.98	374	69	3	8706	1	6
860	4	58053379	6.45	374	119	3	8706	1	6
861	5	59700000	9.47	374	3	3	8706	1	6
862	6	59800000	9.65	374	111	3	8706	1	6
863	7	67882699	24.47	374	113	3	8706	1	6
1330	1	7665000	0.00	712	52	2	8706	1	7
1331	2	7729000	0.83	712	107	2	8706	1	7
1332	3	7794000	1.68	712	29	2	8706	1	7
1333	4	7908189	3.17	712	49	2	8706	1	7
1334	5	7938523	3.57	712	36	3	8706	1	7
1335	6	7950804	3.73	712	18	3	8706	1	7
1336	7	7986231	4.19	712	20	2	8706	1	7
1337	8	7989934	4.24	712	127	2	8706	1	7
1338	9	8084941	5.48	712	115	2	8706	1	7
1339	10	8116806	5.89	712	122	2	8706	1	7
1340	11	8155640	6.40	712	43	2	8706	1	7
1341	12	8495375	10.83	712	21	2	8706	1	7
1342	13	8976526	17.11	712	37	3	8706	1	7
1343	14	8981269	17.17	712	94	2	8706	1	7
1344	15	9104054	18.77	712	146	3	8706	1	7
1345	16	9288248	21.18	712	64	1	8706	1	7
1346	17	9385411	22.45	712	9	2	8706	1	7
1375	1	7919000	0.00	712	107	2	8706	1	7
1376	2	7923523	0.06	712	142	3	8706	1	7
1377	3	8021357	1.29	712	49	2	8706	1	7
1378	4	8039647	1.52	712	96	2	8706	1	7
1379	5	8064730	1.84	712	20	2	8706	1	7
1380	6	8150000	2.92	712	52	2	8706	1	7
1381	7	8290723	4.69	712	127	2	8706	1	7
1382	8	8492297	7.24	712	18	3	8706	1	7
1383	9	8623658	8.90	712	26	3	8706	1	7
1384	10	8674521	9.54	712	64	1	8706	1	7
1385	11	8678461	9.59	712	21	2	8706	1	7
1386	12	8951599	13.04	712	131	2	8706	1	7
1387	13	9202451	16.21	712	9	2	8706	1	7
1388	14	9260000	16.93	712	94	2	8706	1	7
1389	15	9261174	16.95	712	36	3	8706	1	7
443	1	4600000	0.00	372	18	3	8708	1	3
444	2	4817144	4.72	372	21	2	8708	1	3
445	3	6093090	32.46	372	48	2	8708	1	3
446	4	6400966	39.15	372	26	3	8708	1	3
447	5	6900000	50.00	372	40	3	8708	1	3
1402	1	1019238	0.00	712	185	1	8708	2	7
1403	2	1030670	1.12	712	179	1	8708	2	7
1404	3	1032300	1.28	712	125	1	8708	2	7
1405	4	1093259	7.26	712	195	1	8708	2	7
1406	5	1145941	12.43	712	86	1	8708	2	7
1407	6	1238701	21.53	712	64	1	8708	2	7
1408	7	1767830	73.45	712	25	1	8708	2	7
1409	8	1794370	76.05	712	103	1	8708	2	7
1410	9	1988000	95.05	712	8	3	8708	2	7
908	1	111168000	0.00	374	124	3	8709	1	6
909	2	117382053	5.59	374	135	3	8709	1	6
910	3	118807679	6.87	374	109	3	8709	1	6
911	4	119980000	7.93	374	14	3	8709	1	6
912	5	121231728	9.05	374	140	3	8709	1	6
913	6	122000000	9.74	374	108	3	8709	1	6
914	7	122970000	10.62	374	3	3	8709	1	6
915	8	126100000	13.43	374	88	3	8709	1	6
916	9	126685982	13.96	374	148	3	8709	1	6
917	10	138000000	24.14	374	111	3	8709	1	6
2489	1	18286365	0.00	848	18	3	8710	1	15
2490	2	21436285	17.23	848	119	3	8710	1	15
2491	3	21643021	18.36	848	37	3	8710	1	15
2492	4	21738027	18.88	848	135	3	8710	1	15
2493	5	22843513	24.92	848	12	3	8710	1	15
2494	6	25221584	37.93	848	69	3	8710	1	15
2495	7	25581925	39.90	848	9	2	8710	1	15
2496	8	25833102	41.27	848	133	3	8710	1	15
2497	9	27786655	51.95	848	142	3	8710	1	15
152	1	9334750	0.00	372	49	2	8711	1	3
153	2	9892174	5.97	372	48	2	8711	1	3
154	3	10599411	13.55	372	136	2	8711	1	3
155	4	11431397	22.46	372	127	2	8711	1	3
156	5	12986229	39.12	372	40	3	8711	1	3

157	6	22219690	138.03	372	85	2	8711	1	3
333	1	3888550	0.00	372	49	2	8711	1	3
334	2	4586058	17.94	372	18	3	8711	1	3
335	3	7244241	86.30	372	129	2	8711	1	3
464	1	16857446	0.00	848	74	2	8711	1	15
465	2	16890166	0.19	848	8	3	8711	1	15
466	3	17221604	2.16	848	11	3	8711	1	15
467	4	17419208	3.33	848	14	3	8711	1	15
468	5	17819409	5.71	848	148	3	8711	1	15
469	6	17873043	6.02	848	119	3	8711	1	15
470	7	17977374	6.64	848	134	3	8711	1	15
471	8	18680000	10.81	848	81	3	8711	1	15
472	9	19252677	14.21	848	24	3	8711	1	15
473	10	19452000	15.39	848	88	3	8711	1	15
474	11	19621523	16.40	848	69	3	8711	1	15
475	12	20452269	21.32	848	109	3	8711	1	15
476	13	21370000	26.77	848	3	3	8711	1	15
477	14	23414551	38.90	848	142	3	8711	1	15
478	15	30942009	83.55	848	33	3	8711	1	15
1956	1	29418936	0.00	713	109	3	8711	1	9
1957	2	30733884	4.47	713	142	3	8711	1	9
1958	3	32508717	10.50	713	11	3	8711	1	9
1959	4	32600000	10.81	713	3	3	8711	1	9
1960	5	32798241	11.49	713	18	3	8711	1	9
1961	6	34102653	15.92	713	12	3	8711	1	9
1962	7	34600000	17.61	713	108	3	8711	1	9
1963	8	36423648	23.81	713	133	3	8711	1	9
479	1	34299000	0.00	848	42	3	8712	1	15
480	2	34969867	1.96	848	37	3	8712	1	15
481	3	35856023	4.54	848	12	3	8712	1	15
482	4	35992074	4.94	848	142	3	8712	1	15
483	5	36200000	5.54	848	18	3	8712	1	15
484	6	36214044	5.58	848	113	3	8712	1	15
485	7	37823388	10.28	848	133	3	8712	1	15
486	8	38179105	11.31	848	24	3	8712	1	15
487	9	41699211	21.58	848	14	3	8712	1	15
488	10	44480000	29.68	848	124	3	8712	1	15
936	1	54516745	0.00	374	148	3	8712	1	5
937	2	55433968	1.68	374	11	3	8712	1	5
938	3	55670000	2.12	374	108	3	8712	1	5
939	4	60404341	10.80	374	35	3	8712	1	5
940	5	62546000	14.73	374	117	3	8712	1	5
941	6	74788648	37.18	374	14	3	8712	1	5
1964	1	20299047	0.00	713	133	3	8712	1	8
1965	2	20391470	0.46	713	188	3	8712	1	8
1966	3	22000611	8.38	713	142	3	8712	1	8
1967	4	22805463	12.35	713	42	3	8712	1	8
1968	5	23231397	14.45	713	109	3	8712	1	8
1969	6	23400000	15.28	713	3	3	8712	1	8
1970	7	23787827	17.19	713	12	3	8712	1	8
422	1	25000010	0.00	372	18	3	8801	1	3
423	2	26456357	5.83	372	37	3	8801	1	3
424	3	26682212	6.73	372	12	3	8801	1	3
425	4	27370778	9.48	372	142	3	8801	1	3
426	5	27790471	11.16	372	24	3	8801	1	3
427	6	29659090	18.64	372	148	3	8801	1	3
428	7	29941072	19.76	372	135	3	8801	1	3
429	8	33015650	32.06	372	133	3	8801	1	3
430	9	35751893	43.01	372	109	3	8801	1	3
788	1	29913191	0.00	374	37	3	8803	1	5
789	2	30200000	0.96	374	12	3	8803	1	5
790	3	31658743	5.84	374	9	2	8803	1	5
791	4	36000000	20.35	374	40	3	8803	1	5
792	5	36410187	21.72	374	148	3	8803	1	5
1243	1	62639711	0.00	713	148	3	8803	1	11
1244	2	69373394	10.75	713	109	3	8803	1	11
1777	1	41550816	0.00	713	148	3	8803	1	9
1778	2	49726871	19.68	713	109	3	8803	1	9
1245	1	13513399	0.00	712	43	2	8804	1	7
1246	2	14362387	6.28	712	1	2	8804	1	7
1247	3	14385499	6.45	712	48	2	8804	1	7
1248	4	14641961	8.35	712	39	2	8804	1	7
1249	5	15438000	14.24	712	52	2	8804	1	7
1250	6	15608070	15.50	712	142	3	8804	1	7
1251	7	15613839	15.54	712	128	2	8804	1	7
1252	8	16468192	21.87	712	27	3	8804	1	7
1253	9	18356997	35.84	712	18	3	8804	1	7

1758	1	80683227	0.00	713	27	3	8804	1	10
1759	2	82984716	2.85	713	69	3	8804	1	10
1760	3	92937599	15.19	713	148	3	8804	1	10
1761	4	99682802	23.55	713	109	3	8804	1	10
1971	1	9923551	0.00	713	122	2	8804	2	8
1972	2	13580250	36.85	713	52	2	8804	2	8
1973	3	13654916	37.60	713	48	2	8804	2	8
1974	4	22793236	129.69	713	94	2	8804	2	8
1347	1	10096092	0.00	712	118	2	8805	1	7
1348	2	10135602	0.39	712	1	2	8805	1	7
1349	3	10430184	3.31	712	127	2	8805	1	7
1350	4	10475901	3.76	712	52	2	8805	1	7
1351	5	10768016	6.66	712	39	2	8805	1	7
1352	6	10855213	7.52	712	136	2	8805	1	7
1353	7	11638726	15.28	712	48	2	8805	1	7
1354	8	11680279	15.69	712	61	2	8805	1	7
1355	9	12000000	18.86	712	107	2	8805	1	7
1356	10	12380289	22.62	712	21	2	8805	1	7
1357	11	12889648	27.67	712	18	3	8805	1	7
1358	12	12968895	28.45	712	129	2	8805	1	7
1359	13	13222629	30.97	712	152	3	8805	1	7
1360	14	13629688	35.00	712	26	3	8805	1	7
1361	15	14998379	48.56	712	94	2	8805	1	7
1505	1	5898990	0.00	712	48	2	8805	1	7
1506	2	6173869	4.66	712	127	2	8805	1	7
1507	3	6177415	4.72	712	126	3	8805	1	7
1508	4	6251036	5.97	712	52	2	8805	1	7
1509	5	6319307	7.13	712	9	2	8805	1	7
1510	6	6330000	7.31	712	40	3	8805	1	7
1511	7	6442759	9.22	712	136	2	8805	1	7
1512	8	6453173	9.39	712	74	2	8805	1	7
1513	9	6701806	13.61	712	79	2	8805	1	7
1514	10	6812568	15.49	712	150	3	8805	1	7
1515	11	7042903	19.39	712	104	2	8805	1	7
1516	12	7063475	19.74	712	61	2	8805	1	7
1517	13	7098039	20.33	712	102	2	8805	1	7
1362	1	9665075	0.00	712	52	2	8806	1	7
1363	2	9685226	0.21	712	1	2	8806	1	7
1364	3	9881497	2.24	712	136	2	8806	1	7
1365	4	10637737	10.06	712	152	3	8806	1	7
1366	5	10670351	10.40	712	61	2	8806	1	7
1367	6	10839158	12.15	712	127	2	8806	1	7
1368	7	11292277	16.84	712	41	2	8806	1	7
1369	8	11559696	19.60	712	48	2	8806	1	7
1370	9	12098037	25.17	712	21	2	8806	1	7
1371	10	12335411	27.63	712	18	3	8806	1	7
1372	11	12348648	27.77	712	71	2	8806	1	7
1373	12	12493935	29.27	712	142	3	8806	1	7
1374	13	12932331	33.80	712	94	2	8806	1	7
1390	1	10006665	0.00	712	52	2	8806	1	7
1391	2	10094092	0.87	712	1	2	8806	1	7
1392	3	11100000	10.93	712	107	2	8806	1	7
1393	4	11133088	11.26	712	127	2	8806	1	7
1394	5	11246654	12.39	712	152	3	8806	1	7
1395	6	11709137	17.01	712	136	2	8806	1	7
1396	7	11840505	18.33	712	48	2	8806	1	7
1397	8	12209361	22.01	712	142	3	8806	1	7
1398	9	12304241	22.96	712	61	2	8806	1	7
1399	10	13258519	32.50	712	18	3	8806	1	7
1400	11	13767284	37.58	712	50	2	8806	1	7
1401	12	13890035	38.81	712	129	2	8806	1	7
561	1	7315666	0.00	372	1	2	8809	1	3
562	2	7571670	3.50	372	136	2	8809	1	3
563	3	7636397	4.38	372	96	2	8809	1	3
564	4	7951058	8.69	372	127	2	8809	1	3
565	5	8596529	17.51	372	75	2	8809	1	3
566	6	8713245	19.10	372	48	2	8809	1	3
567	7	8751424	19.63	372	21	2	8809	1	3
568	8	8831898	20.73	372	18	3	8809	1	3
569	9	8855209	21.04	372	50	2	8809	1	3
570	10	9293973	27.04	372	128	2	8809	1	3
571	11	10339844	41.34	372	58	2	8809	1	3
572	12	10775618	47.30	372	158	2	8809	1	3
573	13	15888794	117.19	372	2	2	8809	1	3
1089	1	49333192	0.00	374	148	3	8811	1	5
1090	2	51255305	3.90	374	109	3	8811	1	5
1091	3	53230000	7.90	374	117	3	8811	1	5

1977	1	41868321	0.00	713	11	3	8811	1	9
1978	2	41999995	0.31	713	61	2	8811	1	9
1979	3	42430222	1.34	713	48	2	8811	1	9
1980	4	43351437	3.54	713	136	2	8811	1	9
1981	5	43702287	4.38	713	160	3	8811	1	9
1982	6	43949336	4.97	713	9	2	8811	1	9
1983	7	44015053	5.13	713	115	2	8811	1	9
1984	8	44993347	7.46	713	122	2	8811	1	9
1985	9	46127000	10.17	713	43	2	8811	1	9
1986	10	47468551	13.38	713	148	3	8811	1	9
1987	11	48022030	14.70	713	164	3	8811	1	9
1988	12	48600000	16.08	713	40	3	8811	1	9
1989	13	48742133	16.42	713	74	3	8811	1	9
1990	14	50808338	21.35	713	76	3	8811	1	9
1991	15	51340449	22.62	713	104	2	8811	1	9
1992	1	20358464	0.00	713	160	3	8811	1	8
1993	2	20880174	2.56	713	136	2	8811	1	8
1994	3	21995700	8.04	713	127	2	8811	1	8
1995	4	22519758	10.62	713	21	2	8811	1	8
1996	5	22876714	12.37	713	96	2	8811	1	8
1997	6	23500000	15.43	713	159	3	8811	1	8
1998	7	23936172	17.57	713	43	2	8811	1	8
1999	8	23983817	17.81	713	11	3	8811	1	8
2000	9	24184736	18.79	713	164	3	8811	1	8
2001	10	24748052	21.56	713	122	2	8811	1	8
2002	11	25362938	24.58	713	61	2	8811	1	8
2003	12	25415039	24.84	713	115	2	8811	1	8
2004	13	25464967	25.08	713	148	3	8811	1	8
2005	14	35947527	76.57	713	152	3	8811	1	8
2006	15	26000000	27.71	713	40	3	8811	1	8
2007	16	26152282	28.46	713	48	2	8811	1	8
2008	17	26289053	29.13	713	24	3	8811	1	8
2009	18	26712923	31.21	713	74	3	8811	1	8
2010	19	27133174	33.28	713	119	3	8811	1	8
2011	20	28375702	39.38	713	121	3	8811	1	8
2012	21	28962405	42.26	713	126	3	8811	1	8
2013	22	31376013	54.12	713	27	3	8811	1	8
2014	1	38880525	0.00	713	136	2	8811	1	9
2015	2	39595064	1.84	713	11	3	8811	1	9
2016	3	39670505	2.03	713	61	2	8811	1	9
2017	4	39993000	2.86	713	159	3	8811	1	9
2018	5	40772922	4.87	713	115	2	8811	1	9
2019	6	42000000	8.02	713	40	3	8811	1	9
2020	7	42088570	8.25	713	122	2	8811	1	9
2021	8	42971490	10.52	713	52	2	8811	1	9
2022	9	42998900	10.59	713	9	2	8811	1	9
2023	10	43211322	11.14	713	48	2	8811	1	9
2024	11	43547413	12.00	713	75	2	8811	1	9
2025	12	44187036	13.65	713	74	3	8811	1	9
2026	13	45891843	18.03	713	1	2	8811	1	9
2027	14	47310743	21.68	713	148	3	8811	1	9
2028	15	47699684	22.68	713	104	2	8811	1	9
2029	16	48545376	24.86	713	27	3	8811	1	9
2030	17	49631538	27.65	713	121	3	8811	1	9
574	1	8390311	0.00	372	96	2	8812	1	3
575	2	8824379	5.17	372	127	2	8812	1	3
576	3	8979025	7.02	372	75	2	8812	1	3
577	4	9360188	11.56	372	136	2	8812	1	3
578	5	9380667	11.80	372	1	2	8812	1	3
579	6	9398900	12.02	372	50	2	8812	1	3
580	7	9634629	14.83	372	128	2	8812	1	3
581	8	9666100	15.21	372	193	2	8812	1	3
582	9	10136944	20.82	372	18	3	8812	1	3
583	10	10198676	21.55	372	72	2	8812	1	3
584	11	10397721	23.93	372	61	2	8812	1	3
585	12	10579937	26.10	372	16	2	8812	1	3
586	13	10812000	28.86	372	107	2	8812	1	3
587	14	12685849	51.20	372	121	3	8812	1	3
1461	1	21676592	0.00	712	128	2	8901	1	7
1462	2	23098745	6.56	712	1	2	8901	1	7
1463	3	23980000	10.63	712	158	2	8901	1	7
1464	4	24882160	14.79	712	121	3	8901	1	7
1465	5	25980678	19.86	712	96	2	8901	1	7
1466	6	26282800	21.25	712	107	2	8901	1	7
1467	7	26343820	21.53	712	11	3	8901	1	7
1468	8	26606940	22.75	712	74	3	8901	1	7
1469	9	26815569	23.71	712	104	2	8901	1	7

1470	10	27316571	26.02	712	33	3	8901	1	7
1471	11	27755321	28.04	712	122	3	8901	1	7
1472	12	28224697	30.21	712	50	2	8901	1	7
1473	13	30365905	40.09	712	18	3	8901	1	7
1474	14	31509948	45.36	712	129	2	8901	1	7
2031	1	45416275	0.00	713	152	3	8901	1	9
2032	2	47502608	4.59	713	1	2	8901	1	9
2033	3	47900381	5.47	713	21	2	8901	1	9
2034	4	49907992	9.89	713	118	2	8901	1	9
2035	5	52800000	16.26	713	9	2	8901	1	9
2036	6	53252307	17.25	713	69	3	8901	1	9
2037	7	53506813	17.81	713	26	3	8901	1	9
2038	8	54008080	18.92	713	61	2	8901	1	9
2039	9	54047953	19.01	713	74	3	8901	1	9
2040	10	54073195	19.06	713	122	3	8901	1	9
2041	11	54160337	19.25	713	104	2	8901	1	9
2042	12	56137235	23.61	713	96	2	8901	1	9
2043	13	56700000	24.85	713	126	3	8901	1	9
2044	14	61502697	35.42	713	121	3	8901	1	9
2045	15	65855222	45.00	713	18	3	8901	1	9
2046	16	70048649	54.24	713	142	3	8901	1	9
1105	1	49360690	0.00	374	119	3	8902	1	6
1106	2	50713504	2.74	374	73	3	8902	1	6
1107	3	54883841	11.19	374	108	3	8902	1	6
1108	4	55373908	12.18	374	35	3	8902	1	6
1109	5	56055860	13.56	374	148	3	8902	1	6
1110	6	56162258	13.78	374	24	3	8902	1	6
1111	7	57220973	15.92	374	109	3	8902	1	6
1112	8	57900000	17.30	374	3	3	8902	1	6
1113	9	61534072	24.66	374	135	3	8902	1	6
1475	1	23033382	0.00	712	127	2	8902	1	7
1476	2	23297565	1.15	712	1	2	8902	1	7
1477	3	23829330	3.46	712	121	3	8902	1	7
1478	4	24695267	7.22	712	61	2	8902	1	7
1479	5	24990015	8.49	712	73	3	8902	1	7
1480	6	28572376	24.05	712	18	3	8902	1	7
1092	1	680338	0.00	374	64	1	8903	2	5
1093	2	743586	9.30	374	132	1	8903	2	5
1094	3	827094	21.57	374	171	1	8903	2	5
1095	4	884000	29.94	374	101	1	8903	2	5
1096	5	898581	32.08	374	86	1	8903	2	5
1097	6	899428	32.20	374	72	2	8903	2	5
1098	7	906790	33.29	374	44	1	8903	2	5
1099	8	938349	37.92	374	191	1	8903	2	5
1100	9	971264	42.76	374	143	1	8903	2	5
1101	10	993188	45.98	374	131	2	8903	2	5
1102	11	1096258	61.13	374	165	1	8903	2	5
1103	12	1099215	61.57	374	139	1	8903	2	5
1104	13	1411174	107.42	374	5	1	8903	2	5
1114	1	32740988	0.00	374	24	3	8903	1	5
1115	2	32754120	0.04	374	106	2	8903	1	5
1116	3	33500000	2.32	374	3	3	8903	1	5
1117	4	34121275	4.22	374	9	2	8903	1	5
1118	5	34604731	5.69	374	148	3	8903	1	5
1119	6	35742011	9.17	374	35	3	8903	1	5
1120	7	37879003	15.69	374	166	3	8903	1	5
1034	1	6286516	0.00	374	75	2	8904	2	5
1035	2	6301522	0.24	374	118	2	8904	2	5
1036	3	6543139	4.08	374	72	2	8904	2	5
1037	4	6900321	9.76	374	127	2	8904	2	5
1038	5	6976500	10.98	374	26	3	8904	2	5
1039	6	7649049	21.67	374	43	2	8904	2	5
1040	7	7933049	26.19	374	18	3	8904	2	5
2108	1	1422699	0.00	374	93	1	8904	2	5
2109	2	1598381	12.35	374	101	1	8904	2	5
2110	3	1768800	24.33	374	183	1	8904	2	5
2111	4	1797454	26.34	374	165	1	8904	2	5
2112	5	1888198	32.72	374	86	1	8904	2	5
2047	1	4751506	0.00	713	129	2	8905	2	8
2048	2	4781000	0.62	713	96	2	8905	2	8
2049	3	5289184	11.32	713	122	3	8905	2	8
2050	4	6146142	29.35	713	21	2	8905	2	8
2051	5	6182542	30.12	713	20	2	8905	2	8
1121	1	55490957	0.00	374	69	3	8907	2	6
1122	2	59000000	6.32	374	124	3	8907	2	6
1123	3	59108470	6.52	374	35	3	8907	2	6
1124	4	59475096	7.18	374	24	3	8907	2	6

1125	5	60519618	9.06	374	135	3	8907	2	6
1126	6	61187795	10.27	374	148	3	8907	2	6
1127	7	61447280	10.73	374	178	3	8907	2	6
1128	8	62898852	13.35	374	146	3	8907	2	6
1129	9	64025840	15.38	374	109	3	8907	2	6
1130	10	64500000	16.24	374	3	3	8907	2	6
1131	11	65769724	18.52	374	108	3	8907	2	6
1132	12	66378000	19.62	374	117	3	8907	2	6
2097	1	35447695	0.00	848	69	3	8907	1	15
2098	2	38304584	8.06	848	14	3	8907	1	15
2099	3	38435378	8.43	848	109	3	8907	1	15
2100	4	38798863	9.45	848	9	2	8907	1	15
2101	5	38950501	9.88	848	146	3	8907	1	15
2102	6	38964887	9.92	848	148	3	8907	1	15
2103	7	41087560	15.91	848	108	3	8907	1	15
2104	8	42450000	19.75	848	3	3	8907	1	15
2105	9	44846000	26.51	848	117	3	8907	1	15
2106	10	45321189	27.85	848	152	3	8907	1	15
2107	11	46168824	30.24	848	71	3	8907	1	15
2526	1	17271800	0.00	848	39	2	8907	1	13
2527	2	17403008	0.76	848	72	2	8907	1	13
2528	3	17708730	2.53	848	6	2	8907	1	13
2529	4	18160025	5.14	848	96	2	8907	1	13
2530	5	18215000	5.46	848	158	2	8907	1	13
2531	6	18387088	6.46	848	48	2	8907	1	13
2532	7	18722908	8.40	848	129	2	8907	1	13
2533	8	18737348	8.49	848	1	2	8907	1	13
2534	9	18810908	8.91	848	21	2	8907	1	13
2535	10	19046718	10.28	848	61	2	8907	1	13
2536	11	19545591	13.16	848	118	2	8907	1	13
2537	12	19976975	15.66	848	9	2	8907	1	13
2538	13	20285732	17.45	848	26	3	8907	1	13
2539	14	21278833	23.20	848	151	2	8907	1	13
2540	15	21866903	26.60	848	104	2	8907	1	13
2541	16	21992033	27.33	848	18	3	8907	1	13
2542	17	22504947	30.30	848	121	3	8907	1	13
2543	18	22992584	33.12	848	177	2	8907	1	13
2544	19	23686760	37.14	848	142	3	8907	1	13
527	1	10599165	0.00	372	129	2	8908	1	3
528	2	10778268	1.69	372	50	2	8908	1	3
529	3	10837058	2.24	372	26	3	8908	1	3
530	4	11369560	7.27	372	72	2	8908	1	3
531	5	11558646	9.05	372	1	2	8908	1	3
532	6	11750236	10.86	372	127	2	8908	1	3
533	7	11884134	12.12	372	48	2	8908	1	3
534	8	12212059	15.22	372	96	2	8908	1	3
535	9	13080000	23.41	372	158	2	8908	1	3
536	10	13332685	25.79	372	18	3	8908	1	3
537	11	13870063	30.86	372	136	2	8908	1	3
538	12	14871806	40.31	372	142	3	8908	1	3
539	13	15056978	42.06	372	177	2	8908	1	3
540	14	17650823	66.53	372	2	2	8908	1	3
2088	1	28499808	0.00	848	148	3	8908	1	13
2089	2	29200000	2.46	848	3	3	8908	1	13
2090	3	30071662	5.52	848	133	3	8908	1	13
2091	4	31712934	11.27	848	69	3	8908	1	13
2092	5	31915310	11.98	848	71	3	8908	1	13
2093	6	33500000	17.54	848	40	3	8908	1	13
2094	7	33692373	18.22	848	36	3	8908	1	13
2095	8	36466673	27.95	848	122	3	8908	1	13
2096	9	37483946	31.52	848	146	3	8908	1	13
1884	1	58065212	0.00	713	146	3	8909	1	9
1885	2	60000088	3.33	713	152	3	8909	1	9
1886	3	60329000	3.90	713	74	3	8909	1	9
1887	4	60978329	5.02	713	26	3	8909	1	9
1888	5	61268668	5.52	713	24	3	8909	1	9
1889	6	63304583	9.02	713	27	3	8909	1	9
1890	7	63687127	9.68	713	160	3	8909	1	9
1891	8	64537131	11.15	713	11	3	8909	1	9
1892	9	64730698	11.48	713	148	3	8909	1	9
1893	10	64761223	11.53	713	71	3	8909	1	9
1894	11	64953708	11.86	713	8	3	8909	1	9
1895	12	66492882	14.51	713	109	3	8909	1	9
1896	13	68600000	18.14	713	40	3	8909	1	9
1897	14	69516783	19.72	713	12	3	8909	1	9
1898	15	70133274	20.78	713	122	3	8909	1	9
1899	16	71669260	23.43	713	88	3	8909	1	9

1900	1	29769999	0.00	713	72	2	8909	1	8
1901	2	31399326	5.47	713	61	2	8909	1	8
1902	3	32530010	9.27	713	26	3	8909	1	8
1903	4	33356739	12.05	713	127	2	8909	1	8
1904	5	33365075	12.08	713	1	2	8909	1	8
1905	6	33511451	12.57	713	74	3	8909	1	8
1906	7	34035811	14.33	713	24	3	8909	1	8
1907	8	34500000	15.89	713	94	2	8909	1	8
1908	9	34501897	15.89	713	48	2	8909	1	8
1909	10	35536611	19.37	713	129	2	8909	1	8
1910	11	35729346	20.02	713	21	2	8909	1	8
1911	12	36504915	22.62	713	142	3	8909	1	8
1912	13	36953402	24.13	713	122	3	8909	1	8
1913	14	37158348	24.82	713	121	3	8909	1	8
1914	15	37843941	27.12	713	138	2	8909	1	8
1915	16	38625361	29.75	713	18	3	8909	1	8
1916	17	40544014	36.19	713	177	2	8909	1	8
1917	1	31490739	0.00	713	61	2	8909	1	8
1918	2	31945992	1.45	713	18	3	8909	1	8
1919	3	32614144	3.57	713	127	2	8909	1	8
1920	4	32825032	4.24	713	1	2	8909	1	8
1921	5	32950000	4.63	713	158	2	8909	1	8
1922	6	33165119	5.32	713	26	3	8909	1	8
1923	7	33478440	6.31	713	48	2	8909	1	8
1924	8	35560868	12.92	713	43	2	8909	1	8
1925	9	38476764	22.18	713	15	2	8909	1	8
1926	10	39907241	26.73	713	24	3	8909	1	8
1927	11	42214560	34.05	713	136	2	8909	1	8
1928	1	28828689	0.00	713	61	2	8909	1	8
1929	2	29806236	3.39	713	1	2	8909	1	8
1930	3	29814850	3.42	713	96	2	8909	1	8
1931	4	29886234	3.67	713	118	2	8909	1	8
1932	5	30060000	4.27	713	158	2	8909	1	8
1933	6	30762207	6.71	713	26	3	8909	1	8
1934	7	30996903	7.52	713	48	2	8909	1	8
1935	8	31293170	8.55	713	129	2	8909	1	8
1936	9	31747273	10.12	713	127	2	8909	1	8
1937	10	31885256	10.60	713	18	3	8909	1	8
1938	11	38330192	32.96	713	136	2	8909	1	8
1022	1	54291819	0.00	374	148	3	8910	1	6
1023	2	58500000	7.75	374	40	3	8910	1	6
1024	3	58606500	7.95	374	115	3	8910	1	6
1025	4	59244634	9.12	374	12	3	8910	1	6
1026	5	59414838	9.44	374	109	3	8910	1	6
1027	6	59868803	10.27	374	122	3	8910	1	6
1028	7	60900000	12.17	374	126	3	8910	1	6
1029	8	62566886	15.24	374	37	3	8910	1	6
1030	9	65180682	20.06	374	142	3	8910	1	6
1031	10	67978353	25.21	374	18	3	8910	1	6
1032	11	68100972	25.44	374	166	3	8910	1	6
1033	12	73339545	35.08	374	71	3	8910	1	6
1426	1	28670767	0.00	712	1	2	8910	1	7
1427	2	29193487	1.82	712	127	2	8910	1	7
1428	3	29479449	2.82	712	167	2	8910	1	7
1429	4	29981103	4.57	712	129	2	8910	1	7
1430	5	29985534	4.59	712	20	2	8910	1	7
1431	6	30099584	4.98	712	6	2	8910	1	7
1432	7	30417620	6.09	712	152	3	8910	1	7
1433	8	30780940	7.36	712	128	2	8910	1	7
1434	9	32390574	12.97	712	61	2	8910	1	7
1435	10	33433000	16.61	712	159	3	8910	1	7
1436	11	36741626	28.15	712	18	3	8910	1	7
1437	12	44772640	56.16	712	2	2	8910	1	7
1855	1	29500000	0.00	713	158	2	8910	1	8
1856	2	30432746	3.16	713	74	3	8910	1	8
1857	3	30531109	3.50	713	18	3	8910	1	8
1858	4	30548025	3.55	713	148	3	8910	1	8
1859	5	30577239	3.65	713	26	3	8910	1	8
1860	6	31012474	5.13	713	1	2	8910	1	8
1861	7	31228695	5.86	713	11	3	8910	1	8
1862	8	31437315	6.57	713	129	2	8910	1	8
1863	9	31792299	7.77	713	127	2	8910	1	8
1864	10	31841151	7.94	713	20	2	8910	1	8
1865	11	32773376	11.10	713	61	2	8910	1	8
1866	12	32800000	11.19	713	94	2	8910	1	8
1867	13	33191385	12.51	713	24	3	8910	1	8
1868	14	34970930	18.55	713	48	2	8910	1	8

1869	15	35406436	20.02	713	15	2	8910	1	8
1870	16	35500000	20.34	713	3	3	8910	1	8
1871	17	35907251	21.72	713	142	3	8910	1	8
1872	1	57521942	0.00	713	74	3	8910	1	9
1873	2	58448470	1.61	713	11	3	8910	1	9
1874	3	59555446	3.54	713	146	3	8910	1	9
1875	4	59590763	3.60	713	18	3	8910	1	9
1876	5	59766729	3.90	713	148	3	8910	1	9
1877	6	60279852	4.79	713	24	3	8910	1	9
1878	7	62801658	9.18	713	160	3	8910	1	9
1879	8	63000000	9.52	713	40	3	8910	1	9
1880	9	63333333	10.10	713	71	3	8910	1	9
1881	10	63576943	10.53	713	109	3	8910	1	9
1882	11	64545997	12.21	713	115	3	8910	1	9
1883	12	64562378	12.24	713	122	3	8910	1	9
1835	1	66699396	0.00	713	152	3	8911	1	9
1836	2	67880000	1.77	713	142	3	8911	1	9
1837	3	68379149	2.52	713	24	3	8911	1	9
1838	4	69154406	3.68	713	148	3	8911	1	9
1839	5	69300000	3.90	713	71	3	8911	1	9
1840	6	69808732	4.66	713	160	3	8911	1	9
1841	7	70359922	5.49	713	106	2	8911	1	9
1842	8	71043000	6.51	713	159	3	8911	1	9
1843	9	71637833	7.40	713	69	3	8911	1	9
1844	10	71843097	7.71	713	146	3	8911	1	9
1845	11	72786624	9.13	713	36	3	8911	1	9
1846	12	72821164	9.18	713	188	3	8911	1	9
1847	13	73041251	9.51	713	27	3	8911	1	9
1848	14	73043046	9.51	713	18	3	8911	1	9
1849	15	74946335	12.36	713	109	3	8911	1	9
1850	16	75494816	13.19	713	133	3	8911	1	9
1851	17	75986862	13.92	713	181	3	8911	1	9
1852	18	77871191	16.75	713	166	3	8911	1	9
1853	19	78603682	17.85	713	173	3	8911	1	9
1854	20	79067947	18.54	713	161	3	8911	1	9
1815	1	30571000	0.00	713	158	2	8912	1	8
1816	2	30898000	1.07	713	26	3	8912	1	8
1817	3	30961173	1.28	713	96	2	8912	1	8
1818	4	31074486	1.65	713	152	3	8912	1	8
1819	5	31275859	2.31	713	127	2	8912	1	8
1820	6	31297788	2.38	713	167	2	8912	1	8
1821	7	31301881	2.39	713	118	2	8912	1	8
1822	8	31409238	2.74	713	129	2	8912	1	8
1823	9	31543039	3.18	713	21	2	8912	1	8
1824	10	31644798	3.51	713	6	2	8912	1	8
1825	11	31899501	4.35	713	18	3	8912	1	8
1826	12	33235817	8.72	713	1	2	8912	1	8
1827	13	34446762	12.68	713	15	2	8912	1	8
1828	14	34712783	13.55	713	104	2	8912	1	8
1829	15	35273626	15.38	713	43	2	8912	1	8
1830	16	35349660	15.63	713	94	2	8912	1	8
1831	17	35582146	16.39	713	61	2	8912	1	8
1832	18	36104348	18.10	713	153	2	8912	1	8
1833	19	36932439	20.81	713	136	2	8912	1	8
1834	20	43326549	41.72	713	2	2	8912	1	8
1010	1	37838321	0.00	374	12	3	9001	1	5
1011	2	38034325	0.52	374	9	3	9001	1	5
1012	3	38233000	1.04	374	142	3	9001	1	5
1013	4	38330586	1.30	374	148	3	9001	1	5
1014	5	39114502	3.37	374	122	3	9001	1	5
1015	6	39500000	4.39	374	40	3	9001	1	5
1016	7	39824135	5.25	374	65	3	9001	1	5
1017	8	39878073	5.39	374	133	3	9001	1	5
1018	9	39916246	5.49	374	37	3	9001	1	5
1019	10	39999900	5.71	374	161	3	9001	1	5
1020	11	41513895	9.71	374	18	3	9001	1	5
1021	12	43376534	14.64	374	109	3	9001	1	5
1438	1	25341807	0.00	712	21	2	9001	1	7
1439	2	26054350	2.81	712	129	2	9001	1	7
1440	3	26616551	5.03	712	1	2	9001	1	7
1441	4	27006262	6.57	712	6	2	9001	1	7
1442	5	28518000	12.53	712	167	2	9001	1	7
1443	6	28607724	12.89	712	18	3	9001	1	7
1444	7	28734650	13.39	712	168	2	9001	1	7
1445	8	28830000	13.76	712	64	1	9001	1	7
1446	9	29287611	15.57	712	176	2	9001	1	7
1447	10	29381016	15.94	712	136	2	9001	1	7

1448	11	29648893	17.00	712	75	2	9001	1	7
1449	12	31935575	26.02	712	94	2	9001	1	7
1450	13	32919294	29.90	712	54	3	9001	1	7
1451	14	35342894	39.46	712	71	3	9001	1	7
505	1	16830192	0.00	372	1	2	9004	1	2
506	2	16888618	0.35	372	96	2	9004	1	2
507	3	17802918	5.78	372	129	2	9004	1	2
508	4	17862537	6.13	372	168	2	9004	1	2
509	5	17965655	6.75	372	104	2	9004	1	2
510	6	18353724	9.05	372	64	1	9004	1	2
511	7	18902881	12.32	372	55	1	9004	1	2
512	8	18937236	12.52	372	15	2	9004	1	2
513	9	19250000	14.38	372	43	2	9004	1	2
514	10	19253264	14.40	372	127	2	9004	1	2
515	11	19777057	17.51	372	24	3	9004	1	2
516	12	20389413	21.15	372	16	2	9004	1	2
517	13	20430134	21.39	372	74	3	9004	1	2
518	14	21101866	25.38	372	142	3	9004	1	2
519	15	21738475	29.16	372	21	2	9004	1	2
520	16	21994951	30.69	372	192	2	9004	1	2
521	17	21995465	30.69	372	184	1	9004	1	2
522	18	22308786	32.55	372	20	2	9004	1	2
523	19	22823391	35.61	372	71	3	9004	1	2
524	20	22894252	36.03	372	177	2	9004	1	2
525	21	23760584	41.18	372	2	2	9004	1	2
526	22	25978395	54.36	372	94	2	9004	1	2
489	1	9966287	0.00	372	96	2	9005	1	3
490	2	10131229	1.65	372	129	2	9005	1	3
491	3	10238674	2.73	372	133	3	9005	1	3
492	4	10322673	3.58	372	1	2	9005	1	3
493	5	10658983	6.95	372	55	1	9005	1	3
494	6	10790839	8.27	372	168	2	9005	1	3
495	7	10888280	9.25	372	110	2	9005	1	3
496	8	11453875	14.93	372	48	2	9005	1	3
497	9	11969396	20.10	372	178	3	9005	1	3
498	10	12288787	23.30	372	50	2	9005	1	3
499	11	12302054	23.44	372	184	1	9005	1	3
500	12	12436132	24.78	372	142	3	9005	1	3
501	13	13151845	31.96	372	177	2	9005	1	3
502	14	13248510	32.93	372	128	2	9005	1	3
503	15	13509488	35.55	372	2	2	9005	1	3
504	16	13860990	39.08	372	18	3	9005	1	3
995	1	46087409	0.00	374	11	3	9005	1	5
996	2	47000000	1.98	374	161	3	9005	1	5
997	3	47339555	2.72	374	133	3	9005	1	5
998	4	49207422	6.77	374	24	3	9005	1	5
999	5	49575000	7.57	374	159	3	9005	1	5
1000	6	50110556	8.73	374	119	3	9005	1	5
1001	7	50365843	9.28	374	178	3	9005	1	5
1002	8	50589967	9.77	374	196	2	9005	1	5
1003	9	51305888	11.32	374	160	3	9005	1	5
1004	10	52543617	14.01	374	142	3	9005	1	5
1005	11	55045760	19.44	374	189	3	9005	1	5
1006	12	55133499	19.63	374	135	3	9005	1	5
1007	13	57100000	23.90	374	3	3	9005	1	5
1008	14	62188305	34.94	374	65	3	9005	1	5
1009	15	65748475	42.66	374	163	3	9005	1	5
109	1	38816299	0.00	372	178	3	9006	1	2
110	2	41888000	7.91	372	161	3	9006	1	2
111	3	43000000	10.78	372	133	3	9006	1	2
112	4	43447804	11.93	372	11	3	9006	1	2
113	5	44333825	14.21	372	142	3	9006	1	2
114	6	44669560	15.08	372	24	3	9006	1	2
115	7	45069261	16.11	372	148	3	9006	1	2
116	8	45389265	16.93	372	69	3	9006	1	2
117	9	45613921	17.51	372	40	3	9006	1	2
118	10	46000000	18.51	372	126	3	9006	1	2
119	11	46768305	20.49	372	186	3	9006	1	2
120	12	46777545	20.51	372	37	3	9006	1	2
121	13	48288399	24.40	372	135	3	9006	1	2
122	14	50005763	28.83	372	71	3	9006	1	2
123	15	51602524	32.94	372	122	3	9006	1	2
1798	1	62800000	0.00	713	15	2	9007	1	12
1799	2	63183000	0.61	713	158	2	9007	1	12
1800	3	63688866	1.42	713	1	2	9007	1	12
1801	4	64280355	2.36	713	133	3	9007	1	12
1802	5	65000000	3.50	713	40	3	9007	1	12

1803	6	65681000	4.59	713	159	3	9007	1	12
1804	7	66174097	5.37	713	18	3	9007	1	12
1805	8	66833671	6.42	713	161	3	9007	1	12
1806	9	69028340	9.92	713	21	2	9007	1	12
1807	10	69801459	11.15	713	43	2	9007	1	12
1808	11	69846838	11.22	713	167	2	9007	1	12
1809	12	69875732	11.27	713	142	3	9007	1	12
1810	13	75484129	20.20	713	127	2	9007	1	12
1811	14	76118560	21.21	713	163	3	9007	1	12
1812	15	78605248	25.17	713	36	3	9007	1	12
1813	16	89772586	42.95	713	146	3	9007	1	12
1814	17	113835007	81.27	713	74	3	9007	1	12

APPENDIX B

SPSS-X command file for selecting best model (using MANOVA)

```
file handle drew/name='bs_d01:[bsdsdrew]phd99dat.txt.'
data list file=drew fixed
 /record 1-7 rank 8-14 bid 15-26 pct 27-35 type 36-40 bidder 41-47
  size 48-52 date 53-58 nat 59-62 alt 63-66.
compute lowbid=(bid/1000000)/(1+(pct*0.01)).
compute bid=bid/1000000.
compute bd1=bid.
compute bd2=lowbid.
compute pct=pct/100.
compute rata=bid/lowbid.
compute ratb=lowbid/bid.
compute bid=bd2.
compute dep=pct.
if (bidder eq 18)b=1.
if (bidder eq 142)b=2.
if (bidder eq 119)b=3.
if (bidder eq 127)b=4.
if (bidder eq 148)b=5.
if (bidder eq 122)b=6.
if (bidder eq 45)b=7.
if (bidder eq 52)b=8.
if (bidder eq 96)b=9.
if (bidder eq 71)b=10.
if (bidder eq 109)b=11.
if (bidder eq 69)b=12.
if (bidder eq 24)b=13.
if (bidder eq 20)b=14.
if (bidder eq 9)b=15.
if (type eq 372)j=1.
if (type eq 374)j=2.
if (type eq 712)j=3.
if (type eq 713)j=4.
if (type eq 848)j=5.
if ((date eq 8001) or (date eq 8002) or (date eq 8003))index=347.
if ((date eq 8004) or (date eq 8005) or (date eq 8006))index=353.
if ((date eq 8007) or (date eq 8008) or (date eq 8009))index=369.
if ((date eq 8010) or (date eq 8011) or (date eq 8012))index=381.
if ((date eq 8101) or (date eq 8102) or (date eq 8103))index=389.
if ((date eq 8104) or (date eq 8105) or (date eq 8106))index=393.
if ((date eq 8107) or (date eq 8108) or (date eq 8109))index=375.
if ((date eq 8110) or (date eq 8111) or (date eq 8112))index=376.
if ((date eq 8201) or (date eq 8202) or (date eq 8203))index=364.
if ((date eq 8204) or (date eq 8205) or (date eq 8206))index=370.
if ((date eq 8207) or (date eq 8208) or (date eq 8209))index=342.
if ((date eq 8210) or (date eq 8211) or (date eq 8212))index=327.
if ((date eq 8301) or (date eq 8302) or (date eq 8303))index=298.
if ((date eq 8304) or (date eq 8305) or (date eq 8306))index=298.
if ((date eq 8307) or (date eq 8308) or (date eq 8309))index=317.
if ((date eq 8310) or (date eq 8311) or (date eq 8312))index=326.
if ((date eq 8401) or (date eq 8402) or (date eq 8403))index=328.
if ((date eq 8404) or (date eq 8405) or (date eq 8406))index=332.
if ((date eq 8407) or (date eq 8408) or (date eq 8409))index=323.
if ((date eq 8410) or (date eq 8411) or (date eq 8412))index=337.
if ((date eq 8501) or (date eq 8502) or (date eq 8503))index=326.
if ((date eq 8504) or (date eq 8505) or (date eq 8506))index=335.
if ((date eq 8507) or (date eq 8508) or (date eq 8509))index=344.
if ((date eq 8510) or (date eq 8511) or (date eq 8512))index=351.
if ((date eq 8601) or (date eq 8602) or (date eq 8603))index=376.
if ((date eq 8604) or (date eq 8605) or (date eq 8606))index=392.
if ((date eq 8607) or (date eq 8608) or (date eq 8609))index=373.
if ((date eq 8610) or (date eq 8611) or (date eq 8612))index=380.
if ((date eq 8701) or (date eq 8702) or (date eq 8703))index=385.
if ((date eq 8704) or (date eq 8705) or (date eq 8706))index=403.
if ((date eq 8707) or (date eq 8708) or (date eq 8709))index=411.
if ((date eq 8710) or (date eq 8711) or (date eq 8712))index=438.
if ((date eq 8801) or (date eq 8802) or (date eq 8803))index=479.
if ((date eq 8804) or (date eq 8805) or (date eq 8806))index=510.
if ((date eq 8807) or (date eq 8808) or (date eq 8809))index=521.
if ((date eq 8810) or (date eq 8811) or (date eq 8812))index=541.
if ((date eq 8901) or (date eq 8902) or (date eq 8903))index=542.
if ((date eq 8904) or (date eq 8905) or (date eq 8906))index=548.
if ((date eq 8907) or (date eq 8908) or (date eq 8909))index=552.
if ((date eq 8910) or (date eq 8911) or (date eq 8912))index=559.
if ((date eq 9001) or (date eq 9002) or (date eq 9003))index=574.
if ((date eq 9004) or (date eq 9005) or (date eq 9006))index=561.
```

```
if ((date eq 9007) or (date eq 9008) or (date eq 9009))index=582.
compute bid=bid*582/index.
compute bid2=bid*bid.
select if (bidder eq 18) or (bidder eq 142) or (bidder eq 119)
 or (bidder eq 127) or (bidder eq 148) or (bidder eq 122) or (bidder eq 45)
 or (bidder eq 52) or (bidder eq 96) or (bidder eq 71) or (bidder eq 109)
 or (bidder eq 69) or (bidder eq 24) or (bidder eq 20) or (bidder eq 9)
descriptives variables=all
select if (type eq 372) or (type eq 374) or (type eq 712) or (type eq 713)
 or (type eq 848)
descriptives variables=all
comment 1. MODEL 3 (S+T)
manova dep by j(1,5) with bid bid2
 /design=constant,j
comment 2. MODEL 4 (S+B)
manova dep by b(1,15) with bid bid2
 /design=constant,b
comment 3. MODEL 5 (S+T+ST)
manova dep by j(1,5) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,j by bid,j by bid2
comment 4. MODEL 6 (S+B+SB)
manova dep by b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,b,b by bid,b by bid2
comment 5. MODEL 7 (S+T+B)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b
comment 6. MODEL 8 (S+T+B+ST)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2
comment 7. MODEL 9 (S+T+B+SB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,b by bid,b by bid2
comment 8.  MODEL 10 (S+T+B+TB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by b
comment 9.  MODEL 11 (S+T+B+STB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by b by bid,j by b by bid2
comment 10.  MODEL 12 (S+T+B+ST+SB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2,b by bid,b by bid2
comment 11.  MODEL 13 (S+T+B+ST+TB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2,j by b
comment 12.  MODEL 14 (S+T+B+TB+SB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,b by bid,b by bid2,j by b
comment 13.  MODEL 15 (S+T+B+STB+ST)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2,j by b by bid,
  j by b by bid2
comment 14.  MODEL 16 (S+T+B+STB+SB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,b by bid,b by bid2,j by b by bid,
  j by b by bid2
comment 15.  MODEL 17 (S+T+B+STB+TB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by b,j by b by bid,j by b by bid2
comment 16.  MODEL 18 (S+T+B+SB+ST+STB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2,b by bid,b by bid2,
  j by b by bid,j by b by bid2
comment 17.  MODEL 19 (S+T+B+SB+BT+STB)
```

```
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by b,b by bid,b by bid2,
  j by b by bid,j by b by bid2
comment 18.  MODEL 20 (S+T+B+BT+ST+STB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2,j by b,
  j by b by bid,j by b by bid2
comment 19.  MODEL 21 (S+T+B+BT+SB+ST)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2,b by bid,b by bid2,
  j by b
comment 20.  MODEL 22 (S+T+B+BT+SB+ST+STB)
manova dep by j(1,5) b(1,15) with bid bid2
 /analysis=dep
 /design=constant,bid,bid2,j,b,j by bid,j by bid2,b by bid,b by bid2,
```

APPENDIX C

SPSS-X command file for testing regression assumptions

```
file handle drew/name='bre_d01:[bsdsdrew]phd99uuu.zzz.'
data list file=drew fixed
 /record 1-7 rank 8-14 bid 15-26 pct 27-35 type 36-40 bidder 41-47
 size 48-52 date 53-58 nat 59-62 alt 63-66.
compute lowbid=(bid/1000000)/(1+(pct*0.01)).
compute bid=bid/1000000.
compute rata=bid/lowbid
compute ratb=lowbid/bid
compute bd1=bid.
compute bd2=lowbid**(2/3)
compute pct=pct/100.
compute bid=bd2.
compute dep=rata
compute lambda= -4.2
if (lambda ne 0)dep = (dep**lambda-1)/lambda
if (lambda eq 0)dep = ln(dep)
if (bidder ne 18)b1=0.
if (bidder eq 18)b1=1.
if (bidder ne 142)b2=0.
if (bidder eq 142)b2=1.
if (bidder ne 119)b3=0.
if (bidder eq 119)b3=1.
if (bidder ne 127)b4=0.
if (bidder eq 127)b4=1.
if (bidder ne 122)b5=0.
if (bidder eq 122)b5=1.
if (bidder ne 148)b6=0.
if (bidder eq 148)b6=1.
if (bidder ne 45)b7=0.
if (bidder eq 45)b7=1.
if (bidder ne 52)b8=0.
if (bidder eq 52)b8=1.
if (bidder ne 96)b9=0.
if (bidder eq 96)b9=1.
if (bidder ne 71)b10=0.
if (bidder eq 71)b10=1.
if (bidder ne 109)b11=0.
if (bidder eq 109)b11=1.
if (bidder ne 69)b12=0.
if (bidder eq 69)b12=1.
if (bidder ne 20)b13=0.
if (bidder eq 20)b13=1.
if (bidder ne 24)b14=0.
if (bidder eq 24)b14=1.
if (bidder ne 9)b15=0.
if (bidder eq 9)b15=1.
if (type ne 372)j1=0.
if (type eq 372)j1=1.
if (type ne 374)j2=0.
if (type eq 374)j2=1.
if (type ne 712)j3=0.
if (type eq 712)j3=1.
if (type ne 713)j4=0.
if (type eq 713)j4=1.
if (type ne 848)j5=0.
if (type eq 848)j5=1.
if ((date eq 8001) or (date eq 8002) or (date eq 8003))index=347.
if ((date eq 8004) or (date eq 8005) or (date eq 8006))index=353.
if ((date eq 8007) or (date eq 8008) or (date eq 8009))index=369.
if ((date eq 8010) or (date eq 8011) or (date eq 8012))index=381.
if ((date eq 8101) or (date eq 8102) or (date eq 8103))index=389.
if ((date eq 8104) or (date eq 8105) or (date eq 8106))index=398.
if ((date eq 8107) or (date eq 8108) or (date eq 8109))index=375.
if ((date eq 8110) or (date eq 8111) or (date eq 8112))index=376.
if ((date eq 8201) or (date eq 8202) or (date eq 8203))index=364.
if ((date eq 8204) or (date eq 8205) or (date eq 8206))index=370.
if ((date eq 8207) or (date eq 8208) or (date eq 8209))index=342.
if ((date eq 8210) or (date eq 8211) or (date eq 8212))index=327.
if ((date eq 8301) or (date eq 8302) or (date eq 8303))index=298.
if ((date eq 8304) or (date eq 8305) or (date eq 8306))index=298.
if ((date eq 8307) or (date eq 8308) or (date eq 8309))index=317.
if ((date eq 8310) or (date eq 8311) or (date eq 8312))index=326.
if ((date eq 8401) or (date eq 8402) or (date eq 8403))index=328.
if ((date eq 8404) or (date eq 8405) or (date eq 8406))index=332.
if ((date eq 8407) or (date eq 8408) or (date eq 8409))index=323.
if ((date eq 8410) or (date eq 8411) or (date eq 8412))index=337.
```

```
if ((date eq 8501) or (date eq 8502) or (date eq 8503))index=326.
if ((date eq 8504) or (date eq 8505) or (date eq 8506))index=335.
if ((date eq 8507) or (date eq 8508) or (date eq 8509))index=344.
if ((date eq 8510) or (date eq 8511) or (date eq 8512))index=351.
if ((date eq 8601) or (date eq 8602) or (date eq 8603))index=376.
if ((date eq 8604) or (date eq 8605) or (date eq 8606))index=392.
if ((date eq 8607) or (date eq 8608) or (date eq 8609))index=373.
if ((date eq 8610) or (date eq 8611) or (date eq 8612))index=380.
if ((date eq 8701) or (date eq 8702) or (date eq 8703))index=385.
if ((date eq 8704) or (date eq 8705) or (date eq 8706))index=403.
if ((date eq 8707) or (date eq 8708) or (date eq 8709))index=411.
if ((date eq 8710) or (date eq 8711) or (date eq 8712))index=438.
if ((date eq 8801) or (date eq 8802) or (date eq 8803))index=479.
if ((date eq 8804) or (date eq 8805) or (date eq 8806))index=510.
if ((date eq 8807) or (date eq 8808) or (date eq 8809))index=521.
if ((date eq 8810) or (date eq 8811) or (date eq 8812))index=541.
if ((date eq 8901) or (date eq 8902) or (date eq 8903))index=542.
if ((date eq 8904) or (date eq 8905) or (date eq 8906))index=548.
if ((date eq 8907) or (date eq 8908) or (date eq 8909))index=552.
if ((date eq 8910) or (date eq 8911) or (date eq 8912))index=559.
if ((date eq 9001) or (date eq 9002) or (date eq 9003))index=574.
if ((date eq 9004) or (date eq 9005) or (date eq 9006))index=561.
if ((date eq 9007) or (date eq 9008) or (date eq 9009))index=582.
compute bid=(bid*582/index) -7.68
compute bid2=bid*bid.
descriptives variables=all
compute j1bid=j1*bid
compute j2bid=j2*bid
compute j3bid=j3*bid
compute j4bid=j4*bid
compute j1bid2=j1*bid2
compute j2bid2=j2*bid2
compute j3bid2=j3*bid2
compute j4bid2=j4*bid2
compute b1bid=b1*bid
compute b2bid=b2*bid
compute b3bid=b3*bid
compute b4bid=b4*bid
compute b5bid=b5*bid
compute b6bid=b6*bid
compute b7bid=b7*bid
compute b8bid=b8*bid
compute b9bid=b9*bid
compute b10bid=b10*bid
compute b11bid=b11*bid
compute b12bid=b12*bid
compute b13bid=b13*bid
compute b14bid=b14*bid
compute b1bid2=b1*bid2
compute b2bid2=b2*bid2
compute b3bid2=b3*bid2
compute b4bid2=b4*bid2
compute b5bid2=b5*bid2
compute b6bid2=b6*bid2
compute b6bid2=b6*bid2
compute b7bid2=b7*bid2
compute b8bid2=b8*bid2
compute b9bid2=b9*bid2
compute b10bid2=b10*bid2
compute b11bid2=b11*bid2
compute b12bid2=b12*bid2
compute b13bid2=b13*bid2
compute b14bid2=b14*bid2
compute j1b1=j1*b1
compute j2b1=j2*b1
compute j3b1=j3*b1
compute j4b1=j4*b1
compute j1b2=j1*b2
compute j2b2=j2*b2
compute j3b2=j3*b2
compute j4b2=j4*b2
compute j1b3=j1*b3
compute j2b3=j2*b3
compute j3b3=j3*b3
compute j4b3=j4*b3
compute j1b4=j1*b4
compute j2b4=j2*b4
```

```
compute j3b4=j3*b4
compute j4b4=j4*b4
compute j1b5=j1*b5
compute j2b5=j2*b5
compute j3b5=j3*b5
compute j4b5=j4*b5
compute j1b6=j1*b6
compute j2b6=j2*b6
compute j3b6=j3*b6
compute j4b6=j4*b6
compute j1b7=j1*b7
compute j2b7=j2*b7
compute j3b7=j3*b7
compute j4b7=j4*b7
compute j1b8=j1*b8
compute j2b8=j2*b8
compute j3b8=j3*b8
compute j4b8=j4*b8
compute j1b9=j1*b9
compute j2b9=j2*b9
compute j3b9=j3*b9
compute j4b9=j4*b9
compute j1b10=j1*b10
compute j2b10=j2*b10
compute j3b10=j3*b10
compute j4b10=j4*b10
compute j1b11=j1*b11
compute j2b11=j2*b11
compute j3b11=j3*b11
compute j4b11=j4*b11
compute j1b12=j1*b12
compute j2b12=j2*b12
compute j3b12=j3*b12
compute j4b12=j4*b12
compute j1b13=j1*b13
compute j2b13=j2*b13
compute j3b13=j3*b13
compute j4b13=j4*b13
compute j1b14=j1*b14
compute j2b14=j2*b14
compute j3b14=j3*b14
compute j4b14=j4*b14
compute j1b1id=j1*b1*bid
compute j2b1id=j2*b1*bid
compute j3b1id=j3*b1*bid
compute j4b1id=j4*b1*bid
compute j1b2id=j1*b2*bid
compute j2b2id=j2*b2*bid
compute j3b2id=j3*b2*bid
compute j4b2id=j4*b2*bid
compute j1b3id=j1*b3*bid
compute j2b3id=j2*b3*bid
compute j3b3id=j3*b3*bid
compute j4b3id=j4*b3*bid
compute j1b4id=j1*b4*bid
compute j2b4id=j2*b4*bid
compute j3b4id=j3*b4*bid
compute j4b4id=j4*b4*bid
compute j1b5id=j1*b5*bid
compute j2b5id=j2*b5*bid
compute j3b5id=j3*b5*bid
compute j4b5id=j4*b5*bid
compute j1b6id=j1*b6*bid
compute j2b6id=j2*b6*bid
compute j3b6id=j3*b6*bid
compute j4b6id=j4*b6*bid
compute j1b7id=j1*b7*bid
compute j2b7id=j2*b7*bid
compute j3b7id=j3*b7*bid
compute j4b7id=j4*b7*bid
compute j1b8id=j1*b8*bid
compute j2b8id=j2*b8*bid
compute j3b8id=j3*b8*bid
compute j4b8id=j4*b8*bid
compute j1b9id=j1*b9*bid
compute j2b9id=j2*b9*bid
compute j3b9id=j3*b9*bid
```

```
compute j4b9id=j4*b9*bid
compute j1b10id=j1*b10*bid
compute j2b10id=j2*b10*bid
compute j3b10id=j3*b10*bid
compute j4b10id=j4*b10*bid
compute j1b11id=j1*b11*bid
compute j2b11id=j2*b11*bid
compute j3b11id=j3*b11*bid
compute j4b11id=j4*b11*bid
compute j1b12id=j1*b12*bid
compute j2b12id=j2*b12*bid
compute j3b12id=j3*b12*bid
compute j4b12id=j4*b12*bid
compute j1b13id=j1*b13*bid
compute j2b13id=j2*b13*bid
compute j3b13id=j3*b13*bid
compute j4b13id=j4*b13*bid
compute j1b14id=j1*b14*bid
compute j2b14id=j2*b14*bid
compute j3b14id=j3*b14*bid
compute j4b14id=j4*b14*bid
compute j1b1id2=j1*b1*bid2
compute j2b1id2=j2*b1*bid2
compute j3b1id2=j3*b1*bid2
compute j4b1id2=j4*b1*bid2
compute j1b2id2=j1*b2*bid2
compute j2b2id2=j2*b2*bid2
compute j3b2id2=j3*b2*bid2
compute j4b2id2=j4*b2*bid2
compute j1b3id2=j1*b3*bid2
compute j2b3id2=j2*b3*bid2
compute j3b3id2=j3*b3*bid2
compute j4b3id2=j4*b3*bid2
compute j1b4id2=j1*b4*bid2
compute j2b4id2=j2*b4*bid2
compute j3b4id2=j3*b4*bid2
compute j4b4id2=j4*b4*bid2
compute j1b5id2=j1*b5*bid2
compute j2b5id2=j2*b5*bid2
compute j3b5id2=j3*b5*bid2
compute j4b5id2=j4*b5*bid2
compute j1b6id2=j1*b6*bid2
compute j2b6id2=j2*b6*bid2
compute j3b6id2=j3*b6*bid2
compute j4b6id2=j4*b6*bid2
compute j1b7id2=j1*b7*bid2
compute j2b7id2=j2*b7*bid2
compute j3b7id2=j3*b7*bid2
compute j4b7id2=j4*b7*bid2
compute j1b8id2=j1*b8*bid2
compute j2b8id2=j2*b8*bid2
compute j3b8id2=j3*b8*bid2
compute j4b8id2=j4*b8*bid2
compute j1b9id2=j1*b9*bid2
compute j2b9id2=j2*b9*bid2
compute j3b9id2=j3*b9*bid2
compute j4b9id2=j4*b9*bid2
compute j1b10id2=j1*b10*bid2
compute j2b10id2=j2*b10*bid2
compute j3b10id2=j3*b10*bid2
compute j4b10id2=j4*b10*bid2
compute j1b11id2=j1*b11*bid2
compute j2b11id2=j2*b11*bid2
compute j3b11id2=j3*b11*bid2
compute j4b11id2=j4*b11*bid2
compute j1b12id2=j1*b12*bid2
compute j2b12id2=j2*b12*bid2
compute j3b12id2=j3*b12*bid2
compute j4b12id2=j4*b12*bid2
compute j1b13id2=j1*b13*bid2
compute j2b13id2=j2*b13*bid2
compute j3b13id2=j3*b13*bid2
compute j4b13id2=j4*b13*bid2
compute j1b14id2=j1*b14*bid2
compute j2b14id2=j2*b14*bid2
compute j3b14id2=j3*b14*bid2
compute j4b14id2=j4*b14*bid2
```

```
missing value bid to j4b14id2 (999)
comment MODEL 12 (S+T+B+SB+ST)
regression
 /width=76
 /descriptives corr
 /vari=dep bid bid2 b1 to b14 j1 to j4 b1bid to b14bid2
 j1bid to j4bid2
 /statistics=defaults tol
 /depe=dep
 /enter /backwards /stepwise
 /residual=defaults
 /casewise=defaults all
 /scatterplot =(*sresid,*pre) (*sresid, b2bid2) (*sresid, b3bid)
  (*sresid, b7bid) (*sresid, b8bid2) (*sresid, b9bid)
  (*sresid, b9bid2) (*sresid, b10bid) (*sresid, b10bid2) (*sresid, b12bid)
  (*sresid, b13bid2) (*sresid, b14bid) (*sresid, j2bid)
  (*sresid, j2bid2) (*sresid, j3bid) (*sresid, j3bid2) (*resid, b2)
  (*resid, b7) (*resid, b8) (*resid, b9) (*resid, b10) (*resid, b14)
  (*resid, j2) (*resid, j3) (*resid, j4)
 /save = resid (res)
comment test for normality
npar tests k-s (normal)=res
comment homoscedacity test
sort cases by bid
compute caseno=$casenum
compute top=caseno*res*res
compute bottom=res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by bid2
compute caseno=$casenum
compute top=caseno*res*res
compute bottom=res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b1bid
compute caseno=$casenum
compute top=caseno*res*res
compute bottom=res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b1bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b2bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b2bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b3bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b3bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b4bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b4bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b5bid
```

```
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b5bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b6bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b6bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b7bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b7bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b8bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b8bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b9bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b9bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b10bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b10bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b11bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b11bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b12bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b12bid2
compute caseno=$casenum
compute top=caseno*res*res
```

```
descriptives variables=top bottom
 /statistics=sum
sort cases by b13bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b13bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b14bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by b14bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j1bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j1bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j2bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j2bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j3bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j3bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j4bid
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
sort cases by j4bid2
compute caseno=$casenum
compute top=caseno*res*res
descriptives variables=top bottom
 /statistics=sum
oneway res by b1(0,1)
 /statistics=homogeneity
oneway res by b2(0,1)
 /statistics=homogeneity
oneway res by b3(0,1)
 /statistics=homogeneity
oneway res by b4(0,1)
 /statistics=homogeneity
oneway res by b5(0,1)
 /statistics=homogeneity
oneway res by b6(0,1)
 /statistics=homogeneity
oneway res by b7(0,1)
 /statistics=homogeneity
oneway res by b8(0,1)
```

```
 /statistics=homogeneity
oneway res by b9(0,1)
 /statistics=homogeneity
oneway res by b10(0,1)
 /statistics=homogeneity
oneway res by b11(0,1)
 /statistics=homogeneity
oneway res by b12(0,1)
 /statistics=homogeneity
oneway res by b13(0,1)
 /statistics=homogeneity
oneway res by b14(0,1)
 /statistics=homogeneity
oneway res by j1(0,1)
 /statistics=homogeneity
oneway res by j2(0,1)
 /statistics=homogeneity
oneway res by j3(0,1)
 /statistics=homogeneity
oneway res by j4(0,1)
 /statistics=homogeneity
```

APPENDIX D

Confidence intervals t for Szroeter's test statistic based on 5% level of significance according to different values of b for 776 cases

b	t		b	t	
	Non-significant values			Non-significant values	
	Minimum	Maximum		Minimum	Maximum
1.00	369.79	407.21	10.50	3882.82	4275.68
1.20	443.75	488.65	11.00	4067.72	4479.28
1.40	517.71	570.09	11.50	4252.61	4682.89
1.60	591.67	651.53	12.00	4437.51	4886.49
1.80	665.63	732.97	12.50	4622.40	5090.10
2.00	739.58	814.42	13.00	4807.30	5293.70
2.20	813.54	895.86	13.50	4992.20	5497.30
2.40	887.50	977.30	14.00	5177.09	5700.91
2.60	961.46	1058.74	14.50	5361.99	5904.51
2.80	1035.42	1140.18	15.00	5546.88	6108.12
3.00	1109.38	1221.62	15.50	5731.78	6311.72
3.20	1183.34	1303.06	16.00	5916.68	6515.32
3.40	1257.29	1384.51	16.50	6101.57	6718.93
3.60	1331.25	1465.95	17.00	6286.47	6922.53
3.80	1405.21	1547.39	17.50	6471.36	7126.14
4.00	1479.17	1628.83	18.00	6656.26	7329.74
4.20	1553.13	1710.27	18.50	6841.16	7533.34
4.40	1627.09	1791.71	19.00	7026.05	7736.95
4.60	1701.04	1873.16	19.50	7210.95	7940.55
4.80	1775.00	1954.60	20.00	7395.85	8144.15
5.00	1848.96	2036.04	20.50	7580.74	8347.76
5.20	1922.92	2117.48	21.00	7765.64	8551.36
5.40	1996.88	2198.92	21.50	7950.53	8754.97
5.60	2070.84	2280.36	22.00	8135.43	8958.57
5.80	2144.80	2361.80	22.50	8320.33	9162.17
6.00	2218.75	2443.25	23.00	8505.22	9365.78
6.20	2292.71	2524.69	23.50	8690.12	9569.38
6.40	2366.67	2606.13	24.00	8875.01	9772.99
6.60	2440.63	2687.57	24.50	9059.91	9976.59
6.80	2514.59	2769.01	25.00	9244.81	10180.19
7.00	2588.55	2850.45	26.00	9614.60	10587.40
7.20	2662.50	2931.90	27.00	9984.39	10994.61
7.40	2736.46	3013.34	28.00	10354.18	11401.82
7.60	2810.42	3094.78	29.00	10723.98	11809.02
7.80	2884.38	3176.22	30.00	11093.77	12216.23
8.00	2958.34	3257.66	31.00	11463.56	12623.44
8.20	3032.30	3339.10	32.00	11833.35	13030.65
8.40	3106.26	3420.54	33.00	12203.15	13437.85
8.60	3180.21	3501.99	34.00	12572.94	13845.06
8.80	3254.17	3583.43	35.00	12942.73	14252.27
9.00	3328.13	3664.87	36.00	13312.52	14659.48
9.20	3402.09	3746.31	37.00	13682.31	15066.69
9.40	3476.05	3827.75	38.00	14052.11	15473.89
9.60	3550.01	3909.19	39.00	14421.90	15881.10
9.80	3623.96	3990.64	40.00	14791.69	16288.31
10.00	3697.92	4072.08	41.00	15161.48	16695.52

APPENDIX E

SAS command file for determining 95% prediction intervals

```
OPTIONS   LINESIZE = 80;
DATA DREW;
     INFILE     'bre_d01:[bsdsdrew]phd99uuu.zzz.';
     INPUT      @1   rec   7.
          @8    rank 7.
          @15   bid  12.
          @27   pct  9.2
          @36   type 5.
          @41   bidder     7.
          @48   size 5.
          @53   date 6.
          @59   nat  4.
          @63   alt  4.;
     lowbid=(bid/1000000)/(1+(pct*0.01));
     bid=bid/1000000;
     rata=bid/lowbid;
     ratb=lowbid/bid;
     bd1=bid;
     bd2=lowbid**(2/3);
     pct=pct/100;
     bid=bd2;
     dep=rata;
     lambda= -4.2;
     if (lambda ne 0) then dep = (dep**lambda-1)/lambda;
     if (lambda eq 0) then dep = log(dep);
     if (bidder ne 18) then b1=0.;
     if (bidder eq 18) then b1=1.;
     if (bidder ne 142) then b2=0.;
     if (bidder eq 142) then b2=1.;
     if (bidder ne 119) then b3=0.;
     if (bidder eq 119) then b3=1.;
     if (bidder ne 127) then b4=0.;
     if (bidder eq 127) then b4=1.;
     if (bidder ne 122) then b5=0.;
     if (bidder eq 122) then b5=1.;
     if (bidder ne 148) then b6=0.;
     if (bidder eq 148) then b6=1.;
     if (bidder ne 45) then b7=0.;
     if (bidder eq 45) then b7=1.;
     if (bidder ne 52) then b8=0.;
     if (bidder eq 52) then b8=1.;
     if (bidder ne 96) then b9=0.;
     if (bidder eq 96) then b9=1.;
     if (bidder ne 71) then b10=0.;
     if (bidder eq 71) then b10=1.;
     if (bidder ne 109) then b11=0.;
     if (bidder eq 109) then b11=1.;
     if (bidder ne 69) then b12=0.;
     if (bidder eq 69) then b12=1.;
     if (bidder ne 20) then b13=0.;
     if (bidder eq 20) then b13=1.;
     if (bidder ne 24) then b14=0.;
     if (bidder eq 24) then b14=1.;
     if (bidder ne 9) then b15=0.;
     if (bidder eq 9) then b15=1.;
     if (type ne 372) then j1=0.;
     if (type eq 372) then j1=1.;
     if (type ne 374) then j2=0.;
     if (type eq 374) then j2=1.;
     if (type ne 712) then j3=0.;
     if (type eq 712) then j3=1.;
     if (type ne 713) then j4=0.;
     if (type eq 713) then j4=1.;
     if (type ne 848) then j5=0.;
     if (type eq 848) then j5=1.;
     if ((date eq 8001) or (date eq 8002) or (date eq 8003)) then index=347.;
     if ((date eq 8004) or (date eq 8005) or (date eq 8006)) then index=353.;
     if ((date eq 8007) or (date eq 8008) or (date eq 8009)) then index=369.;
     if ((date eq 8010) or (date eq 8011) or (date eq 8012)) then index=381.;
     if ((date eq 8101) or (date eq 8102) or (date eq 8103)) then index=389.;
     if ((date eq 8104) or (date eq 8105) or (date eq 8106)) then index=398.;
     if ((date eq 8107) or (date eq 8108) or (date eq 8109)) then index=375.;
     if ((date eq 8110) or (date eq 8111) or (date eq 8112)) then index=376.;
     if ((date eq 8201) or (date eq 8202) or (date eq 8203)) then index=364.;
     if ((date eq 8204) or (date eq 8205) or (date eq 8206)) then index=370.;
     if ((date eq 8207) or (date eq 8208) or (date eq 8209)) then index=342.;
```

```
if ((date eq 8210) or (date eq 8211) or (date eq 8212)) then index=327.;
if ((date eq 8301) or (date eq 8302) or (date eq 8303)) then index=298.;
if ((date eq 8304) or (date eq 8305) or (date eq 8306)) then index=298.;
if ((date eq 8307) or (date eq 8308) or (date eq 8309)) then index=317.;
if ((date eq 8310) or (date eq 8311) or (date eq 8312)) then index=326.;
if ((date eq 8401) or (date eq 8402) or (date eq 8403)) then index=328.;
if ((date eq 8404) or (date eq 8405) or (date eq 8406)) then index=332.;
if ((date eq 8407) or (date eq 8408) or (date eq 8409)) then index=323.;
if ((date eq 8410) or (date eq 8411) or (date eq 8412)) then index=337.;
if ((date eq 8501) or (date eq 8502) or (date eq 8503)) then index=326.;
if ((date eq 8504) or (date eq 8505) or (date eq 8506)) then index=335.;
if ((date eq 8507) or (date eq 8508) or (date eq 8509)) then index=344.;
if ((date eq 8510) or (date eq 8511) or (date eq 8512)) then index=351.;
if ((date eq 8601) or (date eq 8602) or (date eq 8603)) then index=376.;
if ((date eq 8604) or (date eq 8605) or (date eq 8606)) then index=392.;
if ((date eq 8607) or (date eq 8608) or (date eq 8609)) then index=373.;
if ((date eq 8610) or (date eq 8611) or (date eq 8612)) then index=380.;
if ((date eq 8701) or (date eq 8702) or (date eq 8703)) then index=385.;
if ((date eq 8704) or (date eq 8705) or (date eq 8706)) then index=403.;
if ((date eq 8707) or (date eq 8708) or (date eq 8709)) then index=411.;
if ((date eq 8710) or (date eq 8711) or (date eq 8712)) then index=438.;
if ((date eq 8801) or (date eq 8802) or (date eq 8803)) then index=479.;
if ((date eq 8804) or (date eq 8805) or (date eq 8806)) then index=510.;
if ((date eq 8807) or (date eq 8808) or (date eq 8809)) then index=521.;
if ((date eq 8810) or (date eq 8811) or (date eq 8812)) then index=541.;
if ((date eq 8901) or (date eq 8902) or (date eq 8903)) then index=542.;
if ((date eq 8904) or (date eq 8905) or (date eq 8906)) then index=548.;
if ((date eq 8907) or (date eq 8908) or (date eq 8909)) then index=552.;
if ((date eq 8910) or (date eq 8911) or (date eq 8912)) then index=559.;
if ((date eq 9001) or (date eq 9002) or (date eq 9003)) then index=574.;
if ((date eq 9004) or (date eq 9005) or (date eq 9006)) then index=561.;
if ((date eq 9007) or (date eq 9008) or (date eq 9009)) then index=582.;
bid=(bid*582/index) -7.68;
bid2=bid*bid;
j1bid=j1*bid;
j2bid=j2*bid;
j3bid=j3*bid;
j4bid=j4*bid;
j1bid2=j1*bid2;
j2bid2=j2*bid2;
j3bid2=j3*bid2;
j4bid2=j4*bid2;
b1bid=b1*bid;
b2bid=b2*bid;
b3bid=b3*bid;
b4bid=b4*bid;
b5bid=b5*bid;
b6bid=b6*bid;
b7bid=b7*bid;
b8bid=b8*bid;
b9bid=b9*bid;
b10bid=b10*bid;
b11bid=b11*bid;
b12bid=b12*bid;
b13bid=b13*bid;
b14bid=b14*bid;
b1bid2=b1*bid2;
b2bid2=b2*bid2;
b3bid2=b3*bid2;
b4bid2=b4*bid2;
b5bid2=b5*bid2;
b6bid2=b6*bid2;
b6bid2=b6*bid2;
b7bid2=b7*bid2;
b8bid2=b8*bid2;
b9bid2=b9*bid2;
b10bid2=b10*bid2;
b11bid2=b11*bid2;
b12bid2=b12*bid2;
b13bid2=b13*bid2;
b14bid2=b14*bid2;
j1b1=j1*b1;
j2b1=j2*b1;
j3b1=j3*b1;
j4b1=j4*b1;
j1b2=j1*b2;
j2b2=j2*b2;
```

```
j3b2=j3*b2;
j4b2=j4*b2;
j1b3=j1*b3;
j2b3=j2*b3;
j3b3=j3*b3;
j4b3=j4*b3;
j1b4=j1*b4;
j2b4=j2*b4;
j3b4=j3*b4;
j4b4=j4*b4;
j1b5=j1*b5;
j2b5=j2*b5;
j3b5=j3*b5;
j4b5=j4*b5;
j1b6=j1*b6;
j2b6=j2*b6;
j3b6=j3*b6;
j4b6=j4*b6;
j1b7=j1*b7;
j2b7=j2*b7;
j3b7=j3*b7;
j4b7=j4*b7;
j1b8=j1*b8;
j2b8=j2*b8;
j3b8=j3*b8;
j4b8=j4*b8;
j1b9=j1*b9;
j2b9=j2*b9;
j3b9=j3*b9;
j4b9=j4*b9;
j1b10=j1*b10;
j2b10=j2*b10;
j3b10=j3*b10;
j4b10=j4*b10;
j1b11=j1*b11;
j2b11=j2*b11;
j3b11=j3*b11;
j4b11=j4*b11;
j1b12=j1*b12;
j2b12=j2*b12;
j3b12=j3*b12;
j4b12=j4*b12;
j1b13=j1*b13;
j2b13=j2*b13;
j3b13=j3*b13;
j4b13=j4*b13;
j1b14=j1*b14;
j2b14=j2*b14;
j3b14=j3*b14;
j4b14=j4*b14;
j1b1id=j1*b1*bid;
j2b1id=j2*b1*bid;
j3b1id=j3*b1*bid;
j4b1id=j4*b1*bid;
j1b2id=j1*b2*bid;
j2b2id=j2*b2*bid;
j3b2id=j3*b2*bid;
j4b2id=j4*b2*bid;
j1b3id=j1*b3*bid;
j2b3id=j2*b3*bid;
j3b3id=j3*b3*bid;
j4b3id=j4*b3*bid;
j1b4id=j1*b4*bid;
j2b4id=j2*b4*bid;
j3b4id=j3*b4*bid;
j4b4id=j4*b4*bid;
j1b5id=j1*b5*bid;
j2b5id=j2*b5*bid;
j3b5id=j3*b5*bid;
j4b5id=j4*b5*bid;
j1b6id=j1*b6*bid;
j2b6id=j2*b6*bid;
j3b6id=j3*b6*bid;
j4b6id=j4*b6*bid;
j1b7id=j1*b7*bid;
j2b7id=j2*b7*bid;
j3b7id=j3*b7*bid;
```

```
j4b7id=j4*b7*bid;
j1b8id=j1*b8*bid;
j2b8id=j2*b8*bid;
j3b8id=j3*b8*bid;
j4b8id=j4*b8*bid;
j1b9id=j1*b9*bid;
j2b9id=j2*b9*bid;
j3b9id=j3*b9*bid;
j4b9id=j4*b9*bid;
j1b10id=j1*b10*bid;
j2b10id=j2*b10*bid;
j3b10id=j3*b10*bid;
j4b10id=j4*b10*bid;
j1b11id=j1*b11*bid;
j2b11id=j2*b11*bid;
j3b11id=j3*b11*bid;
j4b11id=j4*b11*bid;
j1b12id=j1*b12*bid;
j2b12id=j2*b12*bid;
j3b12id=j3*b12*bid;
j4b12id=j4*b12*bid;
j1b13id=j1*b13*bid;
j2b13id=j2*b13*bid;
j3b13id=j3*b13*bid;
j4b13id=j4*b13*bid;
j1b14id=j1*b14*bid;
j2b14id=j2*b14*bid;
j3b14id=j3*b14*bid;
j4b14id=j4*b14*bid;
j1b1id2=j1*b1*bid2;
j2b1id2=j2*b1*bid2;
j3b1id2=j3*b1*bid2;
j4b1id2=j4*b1*bid2;
j1b2id2=j1*b2*bid2;
j2b2id2=j2*b2*bid2;
j3b2id2=j3*b2*bid2;
j4b2id2=j4*b2*bid2;
j1b3id2=j1*b3*bid2;
j2b3id2=j2*b3*bid2;
j3b3id2=j3*b3*bid2;
j4b3id2=j4*b3*bid2;
j1b4id2=j1*b4*bid2;
j2b4id2=j2*b4*bid2;
j3b4id2=j3*b4*bid2;
j4b4id2=j4*b4*bid2;
j1b5id2=j1*b5*bid2;
j2b5id2=j2*b5*bid2;
j3b5id2=j3*b5*bid2;
j4b5id2=j4*b5*bid2;
j1b6id2=j1*b6*bid2;
j2b6id2=j2*b6*bid2;
j3b6id2=j3*b6*bid2;
j4b6id2=j4*b6*bid2;
j1b7id2=j1*b7*bid2;
j2b7id2=j2*b7*bid2;
j3b7id2=j3*b7*bid2;
j4b7id2=j4*b7*bid2;
j1b8id2=j1*b8*bid2;
j2b8id2=j2*b8*bid2;
j3b8id2=j3*b8*bid2;
j4b8id2=j4*b8*bid2;
j1b9id2=j1*b9*bid2;
j2b9id2=j2*b9*bid2;
j3b9id2=j3*b9*bid2;
j4b9id2=j4*b9*bid2;
j1b10id2=j1*b10*bid2;
j2b10id2=j2*b10*bid2;
j3b10id2=j3*b10*bid2;
j4b10id2=j4*b10*bid2;
j1b11id2=j1*b11*bid2;
j2b11id2=j2*b11*bid2;
j3b11id2=j3*b11*bid2;
j4b11id2=j4*b11*bid2;
j1b12id2=j1*b12*bid2;
j2b12id2=j2*b12*bid2;
j3b12id2=j3*b12*bid2;
j4b12id2=j4*b12*bid2;
```

```
     j1b13id2=j1*b13*bid2;
     j2b13id2=j2*b13*bid2;
     j3b13id2=j3*b13*bid2;
     j4b13id2=j4*b13*bid2;
     j1b14id2=j1*b14*bid2;
     j2b14id2=j2*b14*bid2;
     j3b14id2=j3*b14*bid2;
     j4b14id2=j4*b14*bid2;
RUN;

PROC reg;
  MODEL dep = b2 b7 b8 b9 b10 b14 j2 j3 j4
              b3bid b7bid b9bid b10bid b12bid b14bid
              b2bid2 b8bid2 b9bid2 b10bid2 b13bid2
              j2bid j3bid j2bid2 j3bid2
  / cli clm;
RUN;
```