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Engineering Statistics and Data Analysis in Construction Contract Bids

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ABSTRACT

The manuscript will introduce a new engineering statistical and data analysis which are used to evaluate successful construction contract bids. The methods used in the evaluation analysis includes coefficient of correlation (COC), hypothesis testing (Z-test for Estimated Cost, Z-test for % Mark-up and T-test). The evaluation was conducted on various construction company in accordance to sectors A to D. It has been concluded that the % mark-up percentage had a minor effect on the win or loss of the contract bid between different sectors. This research has found that (1) the null hypothesis cannot be rejected at the 5% significance level the samples showed no significant proof to which of the sectors is more successful in winning bids than other, (2) the regression analysis indicated that as the estimated cost increases the % mark-up decrease for all sectors, (3) the t-test illustrated no significant difference existing between the mean estimated cost and mean % mark-up between contracts won and contracts lost for all sectors, since the value of t Stat was less than t-critical two tailed the null hypothesis cannot be rejected and (4) there is a stronger correlation existing for the successful bids than unsuccessful.

1. Introduction

A contractor called Discovery Contracts desired to perform an analysis of their construction contract bids (Mackie et al., 2010). The contractor's data file consisted of a 160 Discovery Contract's bids. The contract bids were divided in to four sectors A, B, C and D and in each sector the contracts was alienated in to either successful or unsuccessful. The set of data was separated into four tables according to the sector, win and loss. Tables 8, 14, 20 and 26 in Appendix 1 to 4 section of this manuscript represents the data for sectors A, B, C and D respectively. The data mainly consisted of the following key information:

- The estimated cost of the project.
- The % mark-up applied to the estimated cost in order to arrive at the bid price.
- The sector (type of project) from which the contract arose.
- Whether or not the bid was successful.

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The purpose of this venture was to highlight and describe the main characteristics and anomalies in the data, performing general statistical and graphical descriptions and carrying out suitable statistical tests (Vardeman et al., 1994).
The International Federation of Consulting Engineers FIDIC (1999) is the main source of reference for employers to establish the contract conditions for the construction and engineering works. Abu Hammad et al. (2010) carried out a research on the duration and cost of public building construction projects using statistical analysis and simulations. Moreover, Bakhshi et al. (2012) proposed and validated cost correlation calculation method between construction projects. In addition, Bilal et al. (2016) presented a state of art review on the current status, prospects and forthcoming trends of huge data in the construction sector. Furthermore, Thomas et al. (2003) stated ten simple aspects for the selection of subcontractors in the construction projects. On the other hand, Ugochukwu (2013) evaluated the suitability of contractors by focusing on the duration of the tending process in public building projects in Nigeria.

2. Information Breakdown

The first stage of the analysis was to identify useful summations which could be extracted from the data provided (Miller and Freund et al., 1965). The summations would include answers to questions, such as, what percentage of the contracts were won or lost, which sector the bids were most successful in, is there any substantial dissimilarity flanked by the mean percentage mark-up among contracts won and contracts lost, is there any considerable variation between the estimated cost flanked by contracts won and contracts lost, is there a relationship between the estimated cost and the % mark-up and do these questions differ whatsoever from one sector to another (Metcalfr et al., 1997).

3. Analysis and Results

The first and most basic piece of information to be determined as part of highlighting the key features of data was the percentage of contracts won and lost by Discovery Contracts. Initially, the data was sorted according to successful and unsuccessful contracts and from that it was found that the Discovery Contracts had 45 winning contracts and 115 lost contracts. Thus, the percentage of contracts won was 28% of total bids, more than one quarter of contracts was successful and the percentage of contracts lost was 72% as revealed in Figure 1 and Figure 2 (a).

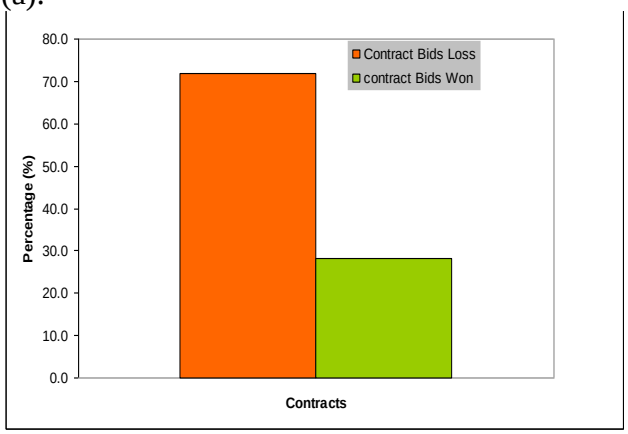

Figure 1. Overall percentage of bids won and loss

Table 1 demonstrates the total number of bids for each sector and number of win and loss contracts. For instance, sector A had 39 bids by which, only 13 bids were successful and 26 unsuccessful bids.

Table 1.
The number of win, loss and total for each sector

Sector	Win	Loss	Total
A	13	26	39
B	13	24	37
C	8	33	41
D	11	32	43
Overall	45	115	160

The next step to be determined was if Discovery Contracts was more successful at winning contracts in some sectors than in others and the percentage of contracts bids the company has done for all sectors. As presented in Figure 2 (b), there was only a minor discrimination between the division of sectors with only a 4% difference between the least and greatest sector percentages. This indicates that Discovery Contracts does not focus or prefer a certain sector on the other. Moreover, the company was more successful at winning bids in sectors A and B with a 29% of contracts won for each compared with sectors C and D which they had only 18% and 24% of contracts won respectively as described in Figure 2 (c). On the other hand, sector B had the least percentage of contracts lost with 21% and sector C and sector D had the highest with 28% for each of them as presented in figure 2 (d).
After determining the success rate for each sector (Figure 3) it was observed that sector B had the greatest success with an amount of 36. Therefore, there is one winning bid for every 2.85 tenders. Conversely, sector C had the lowest amount with a value of 19, which indicates that there is one winning bid for every 5.13 tenders.

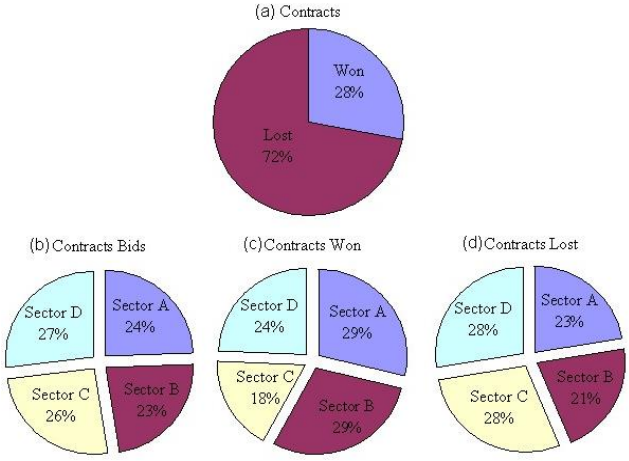

Figure 2. Highlight of the main features of the data being (a) percentage of contracts win and loss; (b) percentage of contract bids for each sector; (c) percentage of contracts won for each sector and (d) percentage of contracts loss for each sector

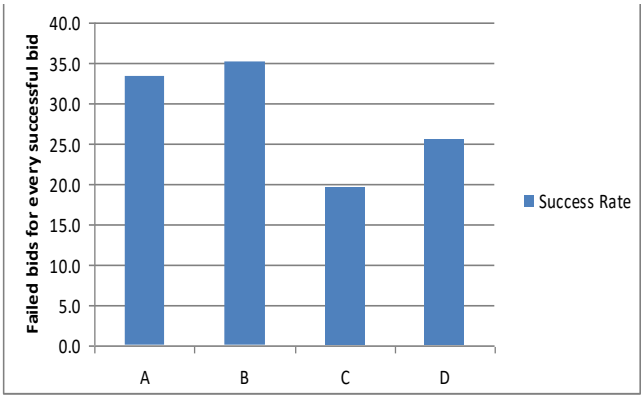

Figure 3. Success rate for each sector

Table 2.

Comparing sectors to obtain p, 1-p and z values

Sectors compared	p	1-p	Z	Z critical
A vs. B	0.3171	0.6829	-0.1749	1.9600
A vs. C	0.2625	0.7375	1.4022	1.9600
A vs. D	0.3158	0.6842	0.7218	1.9600
B vs.C	0.2500	0.7500	1.6505	1.9600
B Vs.D	0.3000	0.7000	0.9245	1.9600
C Vs.D	0.2436	0.7564	-0.6267	1.9600

A comparison has been made as presented in table 2 to find the z value. For all cases of comparison the value of z is less than the z critical (1.96). Therefore, the null hypothesis cannot be rejected at the 5% significance level the samples showed no significant proof to which of the sectors is more successful in winning bids than other. With respect to the success rate in figure 3 a judgment can be made that sectors A and B is more successful in winning contracts than sectors C and D.

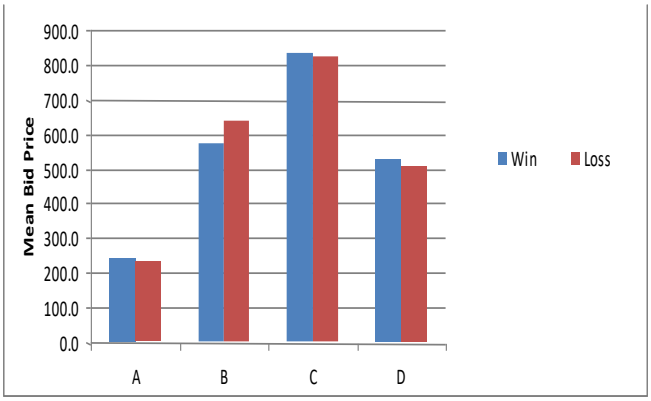

Figure 4. Mean bid price win and loss for all sectors

A histogram of mean bid price win and loss has been carried as shown is figure 4. Though there is a minor difference in the mean bid price values for win and loss contracts, the data somehow shows symmetry for both win and loss contracts. The symmetry is clearly view at the middle (sector C). The mean bid price starts at sector A with the minimum mean and going up to maximum value at sector C and starts to go down again at sector D.

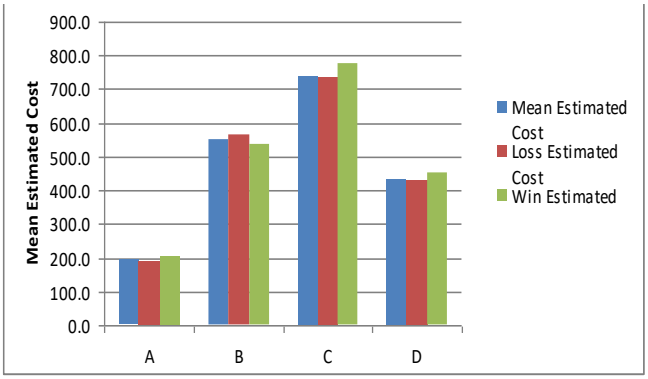

Figure 5. Mean estimated cost for all sectors

Again, symmetry occurs for the mean, loss and won estimated cost as illustrated in figure 5. The highest mean estimated cost was for sector C, while lower was for sector A. Additionally, the same situation was for loss estimated cost and win estimated cost with the highest mean being in sector C and lowest in sector A.

For the mean % mark-up the case was different from that for mean estimated cost, for instance, sector A had the highest mean % mark-up, mean loss and mean win compared with other sectors. On the other hand, sector C had the lowest means for % mark-up, loss and win. In addition, the mean loss seem to be slightly higher than mean win for sectors A, C, D and similar in sector B (Figure 6).

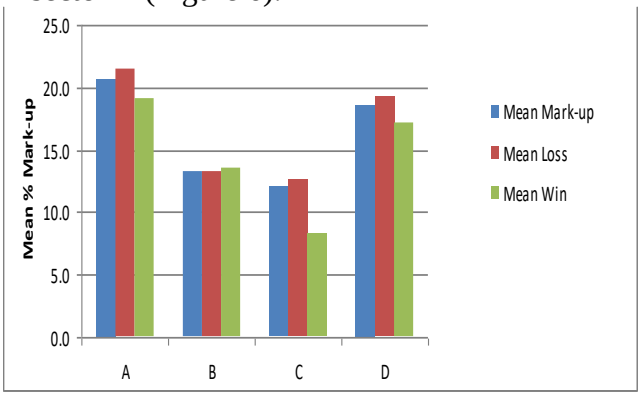

Figure 6. Mean % mark-up for all sectors

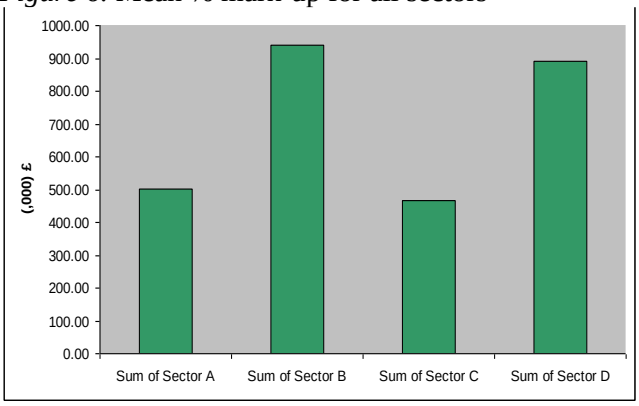

Figure 7. Sum of win for each sector

Although there is a slightly small difference in the sum of win between sector B and sector D (about £47.1) sector B had the highest sum of win with an amount of £939. Alternatively,

sector C had the lowest sum of win with an amount of £465.5. By comparing the sum of win for sector A with that for sector C, the difference is again minor (approximately £36.8). Generally, sectors B and D has higher sum of win than sectors A and C as demonstrated in figure 7.

4. Inferential Statistics

4.1. Coefficient of Correlation

Estimated Cost vs. % Mark-up using overall correlation to find the linear relationship between estimated cost and % mark-up using equation 1, 2, 3 and 4 respectively.

$$S_{xy} = \sum x_i y_i - \frac{\sum x_i \sum y_i}{n} = \quad (1)$$

$$1108644 - \frac{77192.6x2589.6}{160} = -140718.231$$

$$S_{xx} = \sum x_i^2 - \frac{(\sum x_i)^2}{n} = \quad (2)$$

$$45221877 - \frac{77192.6^2}{160} = 7980017.658$$

$$S_{yy} = \sum y_i^2 - \frac{(\sum y_i)^2}{n} = \quad (3)$$

$$46761.81 - \frac{2589.6^2}{160} = 4849.134$$

$$r = \frac{-140718.231}{\sqrt{7980017.658x4849.134}} = -0.715 \quad (4)$$

An r value of -0.715 indicates that there is a strong negative correlation between the estimated cost of the tenders and the % mark-up. This demonstrates that as the estimated cost increases the % mark-up decreases. Moreover, figure 8 visually represents the value of R^2, which is 0.5118 and y = -0.0176x + 24.693. In addition, the regression has been carried out for each sector and is presented in (Appendix) figures 11, 14, 17 and 20 with respect to sector A, B, C and D. Although the case is similar for sectors A, B, C and D to that of the overall regression as the estimated cost increases the % mark-up decreases, each of the regression plots carried out for sectors had different slope. For example, sector C had the steeper slope with y = -0.0204x + 27.054 and R^2 value of 0.3322. Alternatively, sector A had the gentlest slope with y = -0.0289x + 26.354 and R^2 value of 0.1515.

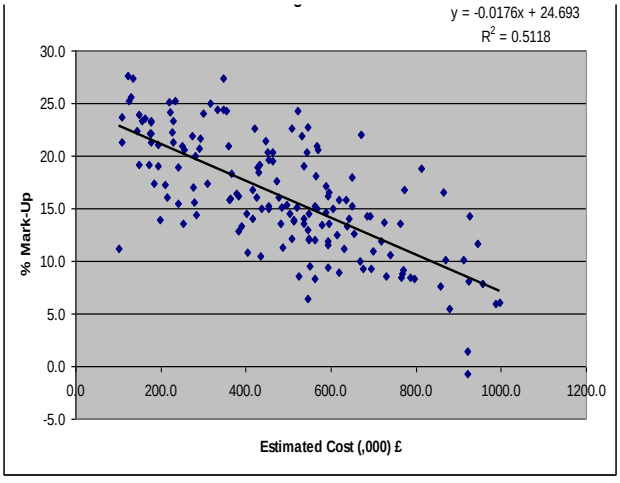

Figure 8. Overall regression chart plot estimated cost vs. % mark-up

Table 3 (a and b) shows the overall regression analysis, while, Table 4 presents the correlation coefficient for each sector and overall. The correlation analysis was carried out between the estimated cost and the % mark-up. It was found that sector A has the highest correlation coefficient with a value of -0.38924 and sector C has the lowest with a value of -0.57635. Generally speaking, the correlation coefficient values for all sector as well as for overall is fairly low.

Table 3.

Overall regression table being (a) summary output and (b) Anova

(a) SUMMARY OUPUT

Regression Statistics	
Multiple R	0.715395408
R Square	0.51179059
Adjusted R Square	0.508700657
Standard Error	3.870705952
Observations	160

(b) ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2481.553	2481.553	165.6316	2.21162E-26
Residual	158	2367.213	14.98236		
Total	159	4848.766			

Table 3. (b) ANOVA continuation

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	24.69281097	0.728452865	33.89760981	2.16974E-74	23.25404952	26.13157243	23.25404952	26.13157243
X Variable 1	-0.017634322	0.00137021	-12.86979469	2.21162E-26	-0.020340613	-0.014928031	-0.020340613	-0.014928031

Table 4.

Estimated cost vs. % mark-up correlation for each sector and overall

Estimated Cost vs. % Mark-Up Correlation	
Sector	**Correlation Coefficient**
A	-0.38924
B	-0.45908
C	-0.57635
D	-0.41617
Overall	-0.7154

4.2. Hypothesis Testing

4.2.1. Z-test for Estimated Cost

Hypothesis:

- H0: No difference exists between the mean estimated cost between contracts won and contracts lost.

- Ha: A difference exists between the mean estimated cost between contracts won and contracts lost.

Rejection Criteria: From the z-distribution table, Alpha. 0.5, $z_{a/2} = 1.96$, the z value is calculated using equation (5).

$$z = \frac{(x_1 - x_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \tag{5}$$

$$\frac{(465.2 - 489.2)}{\sqrt{\frac{210^2}{45} + \frac{230^2}{115}}} = -0.632$$

$$z < z_{0.05} = 1.96$$

$$-0.632 < 1.96$$

The value of z is less than z critical value which is 1.96.

Thus, at the 5% significance level the samples show no significant difference and so the null hypothesis cannot be rejected.

4.2.2. Z-test for % Mark-up

Hypothesis:

- H0: No difference exists between the mean % mark-up between contracts won and contracts lost.
- Ha: A difference exists between the mean % mark-up between contracts won and contracts lost.

Rejection Criteria: From the z-distribution table, Alpha. 0.5, $z_{a/2} = 1.96$

The value of z (Table 5) is less than the z critical value (1.96). Therefore, at the 5% significance level the samples demonstrate no significant difference and so cannot reject the null hypothesis.

Table 5.

z-test for % mark-up variables win and loss

z-Test: Two Sample for Means

% Mark-up

	Variable 1	*Variable 2*
Mean	15.07912315	16.61783275
Known Variance	45	115
Observations	45	115
Hypothesized Mean Difference	0	
z	-1.088031993	
P(Z<=z) one-tail	0.138290492	
z Critical one-tail	1.644853627	
P(Z<=z) two-tail	0.276580984	
z Critical two-tail	1.959963985	

$z < z_{0.05} = 1.96$

Table 6.

Summary of t-test results (Estimated cost and % mark-up) for each sector

Sector	Estimated Cost t-tests		% Mark-Up t-tests	
	t-test Stat	t Critical two-tail	t-test Stat	t Critical two-tail
A	0.70257882726742	2.05953853565859	-1.65939751630777	2.08596344129554
B	-0.7720545303928	2.03951343844151	0.478610911459202	2.03010791544831
C	0.237640727563404	2.17881282716507	-2.08086179260983	2.26215715817358
D	1.95630650593535	2.10092203686118	-1.68096220521439	2.07387305831561

t Stat < t Critical two-tail

Since all ***t Stat*** values (Table 6) are less than the t critical two-tail value at the 5% significance level there is no statistical difference existing. Thus, the null hypothesis cannot be rejected for win and loss in all sectors.

-1.088 < 1.96

4.2.3. T-test

Hypothesis:

- H0: No difference exists between the mean % mark-up between contracts won and contracts lost for each sector.
- Ha: There is a difference between the mean % mark-up between contracts won and contracts lost for each sector.

4.2.4. Further Analysis

Figures 9 and 10 illustrates the % Mark-up vs. sector of successful and unsuccessful bids.

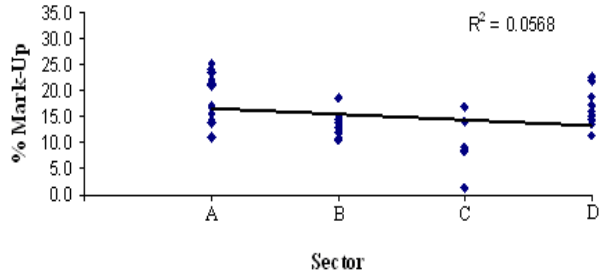

Figure 9. % Mark-up vs. sector of successful bids

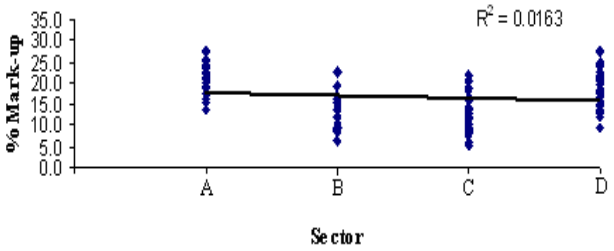

Figure 10. % Mark-up vs. sector of unsuccessful bids

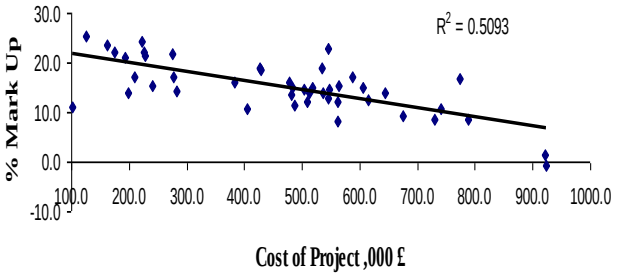

Figure 11. % Mark-up vs. project cost of successful bids

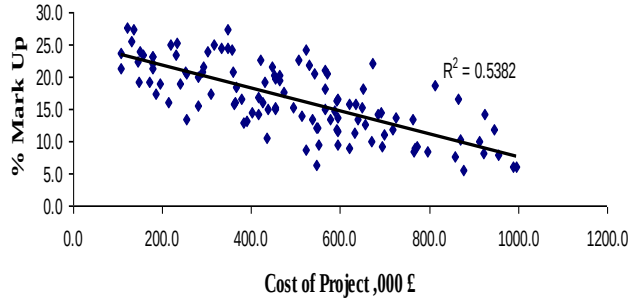

Figure 12. % Mark-up vs. project cost of unsuccessful bids

After plotting the cost of the project against the % mark-up for the contracts won or contracts lost as revealed in Figures 11 and 12 it seem that there is a stronger correlation existing for the successful bids.

Finally, after plotting the estimated cost of the project bids for each sector it seem that for both successful and unsuccessful bids as shown in Figures 13 and 14, a strong correlation exists with R^2 of greater than 0.32.

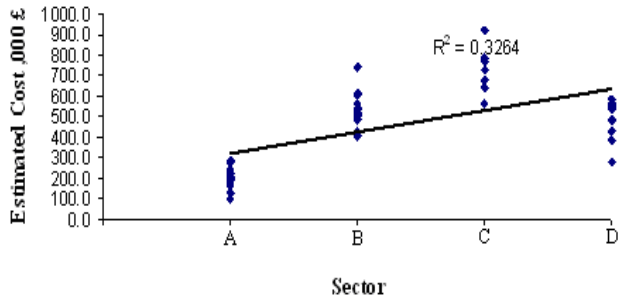

Figure 13. Project cost for each sector of successful bids

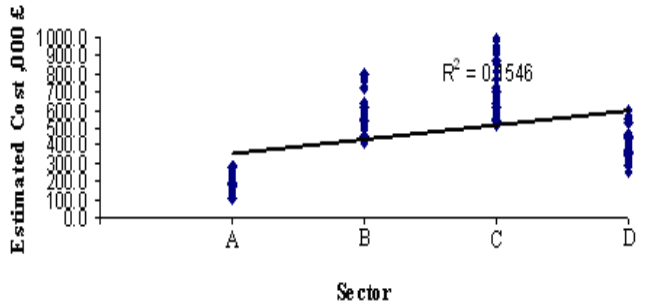

Figure 14. Project cost for each sector of unsuccessful bids

5. Conclusions

In the conclusion the % mark-up percentage had a minor effect on the win or loss of the contract bid between different sectors. The various hypothesis testing carried out showed no variation which, could be used by Discovery Contracts to assist in improving the success rates. This was corroborated by the inferential statistics at the 5% significance level. According to results of various hypothesis tests (Analysis shown in Appendix 1 to 4, Figures 15 to 26 and Tables 7 to 30 for sector A, B, C and D respectively) carried out the following has been concluded:

- Sector B had the highest success rate of winning bids among all other sectors and sectors A and B is more successful in winning contracts than sectors C and D.
- The null hypothesis cannot be rejected at the 5% significance level the samples showed no significant proof to which of the sectors is more successful in winning bids than other.
- The regression analysis indicated that as the estimated cost increases the % mark-up decrease for all sectors.
- The regression plot diagram showed that sector C had the steeper slope of $y = -0.0204x + 27.054$ and R^2 value of 0.3322 compared with regression plot diagram for other sectors.
- The correlation coefficient values for all sector as well as for overall was fairly low.
- The z-test showed no difference existing between the mean estimated cost and mean % mark-up between contracts won and contracts lost since the value of z was less than z-critical (1.96) the null hypothesis can not be rejected at the 5% significance level.
- The t-test illustrated no significant difference existing between the mean estimated cost and mean % mark-up between contracts won and contracts lost for all sectors, since the value of t Stat was less than t-critical two tailed the null hypothesis can not be rejected.
- There is a stronger correlation existing for the successful bids than unsuccessful.

Finally, more highlight of the differences may be established by refining the level but findings would show insignificant.

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Appendix

The appendix shows the classifications of the bids according to sector and contract won or not. Moreover, the appendix includes some general descriptions of the data, interpretation and main features for each sector.

Appendix 1 (Sector A)

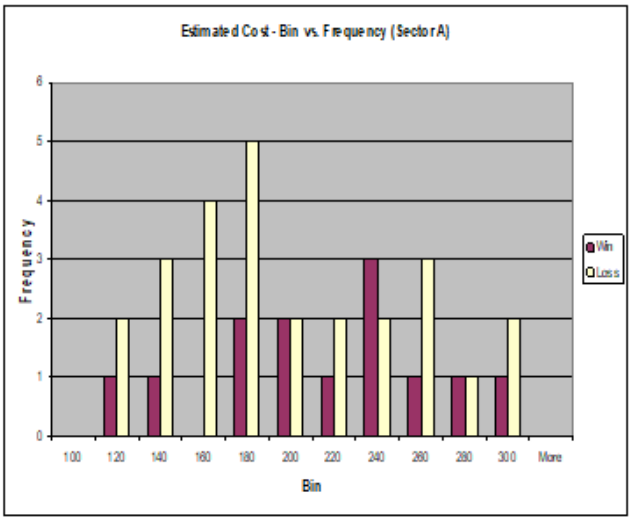

Figure 15. Estimated cost – bin vs. frequency (sector A)

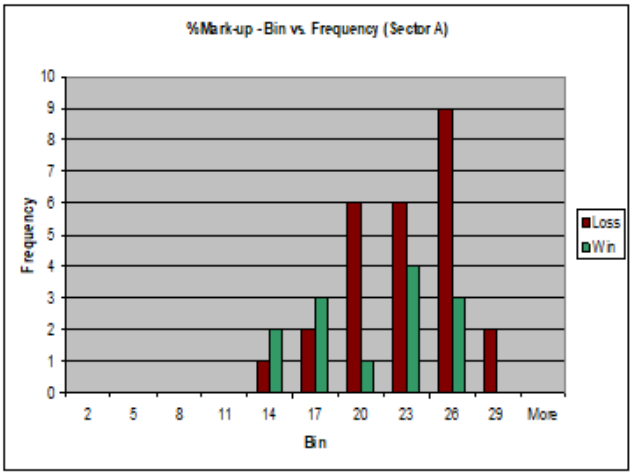

Figure 16. % mark-up – bin vs. frequency (sector A)

Table 7. Set of data for *sector A* sorted according to contracts won and contracts loss

Bid #	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price	**Bid #**	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price
9	101.3	11.2	A	yes	112.7	***63***	218.6	25.1	A	no	273.5
13	222.0	24.1	A	yes	275.5	***66***	144.1	22.4	A	no	176.5
25	241.3	15.4	A	yes	278.5	***68***	281.5	20.0	A	no	337.7
27	126.2	25.3	A	yes	158.1	***72***	232.9	25.2	A	no	291.5
50	228.2	21.3	A	yes	276.7	***79***	107.7	23.6	A	no	133.2
53	199.4	14.0	A	yes	227.3	***90***	185.3	17.4	A	no	217.5
78	226.4	22.2	A	yes	276.7	***96***	279.4	15.6	A	no	323.1
94	209.7	17.2	A	yes	245.8	***103***	130.6	25.6	A	no	164.0

106	162.2	23.5	A	yes	200.4	***110***	254.3	20.6	A	no	306.6
135	277.1	17.0	A	yes	324.1	***111***	194.2	19.0	A	no	231.2
145	175.5	22.2	A	yes	214.3	***121***	172.0	19.2	A	no	205.1
150	193.7	21.1	A	yes	234.5	***123***	241.1	18.9	A	no	286.7
157	282.4	14.4	A	yes	323.0	***126***	289.6	20.7	A	no	349.5
8	156.2	23.3	A	no	192.7	***136***	177.3	21.3	A	no	215.1
16	108.1	21.4	A	no	131.1	***141***	149.5	24.0	A	no	185.4
21	229.4	23.4	A	no	283.0	***148***	214.9	16.1	A	no	249.5
30	134.5	27.4	A	no	171.3	***154***	148.4	19.1	A	no	176.8
41	177.8	23.2	A	no	219.1	***158***	178.3	23.3	A	no	219.8
42	177.7	22.1	A	no	217.1	***159***	121.9	27.6	A	no	155.6
51	253.7	13.5	A	no	288.0						

Table 8. Summary of properties of data for *sector A*

Sector A	**Estimated Cost**	**%Mark Up**	**Bid Price**
Mean	195	20.7	234.6
Std_dev	53.6082	3.983031	61.69315
Minimum	101.3	11.2	112.7
Maximum	289.6	27.6	349.5
Number	39	39	39
Confidence	16.82468774	1.250056	6.663157
% Pass Rate	33.333	33.333	33.333
Std_dev^2	2873.839107	15.864536	3806.045
Number Won	13	13	13

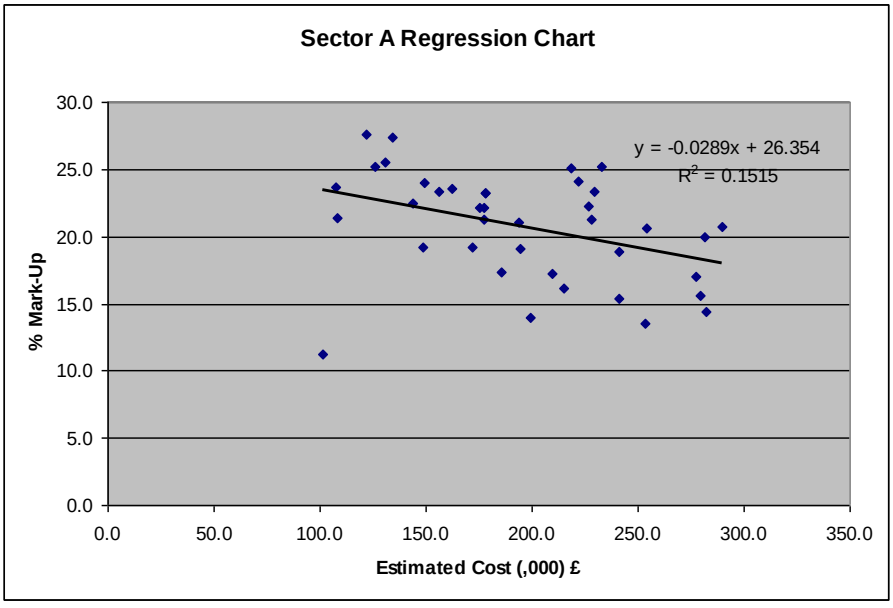

Figure 17. *Sector A* regression chart plot Estimated cost vs. % mark-up

Table 9. Summary of data properties (win and loss) for *sector A*

Sector A	**Win**			**Loss**		
	Estimated Cost	**%Mark-up**	**Bid price**	**Estimated Cost**	**%Mark-up**	**Bid price**
Bids	13			26		
Mean	203.5	19.1	242.1	190.7	21.5	230.8
St_dev	52.92038562	4.492453316	61.05032814	54.47538635	3.533592837	62.86193146
St_dev^2	2800.567214	20.1821368	3727.142566	2967.567718	12.48627834	3951.622427
$t_{\alpha/2}$	2.178812827			2.059538536		
Confidence	28.76732071	2.442080567	33.18672659	20.9392796	1.358244399	24.16290452
Lower	174.7	16.7	208.9	169.8	20.1	206.6
Upper	232.3	21.6	275.3	211.7	22.9	255
Interval	(174.7, 232.3)	(16.7, 21.6)	(208.9, 275.3)	(169.8, 211.7)	(20.1, 22.9)	(206.6, 255)

Table 10. *Sector A* regression table being (a) summary output and (b) Anova

(a)

SUMMARRY OUTPUT

Regression Statistics	
Multiple R	0.389242172
R Square	0.151509468
Adjusted R Square	0.128577292
Standard Error	3.718160403
Observations	39

(b)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	91.33784089	91.33784089	6.606850781	0.014318021
Residual	37	511.5145211	13.82471679		
Total	38	602.852362			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	26.3538547	2.273231705	11.59312297	7.03401E-14	21.74784979	30.95985961	21.74784979	30.95985961
X Variable 1	-0.02892027	0.011251362	-2.570379501	0.014318021	-0.051717695	-0.006122846	-0.051717695	-0.006122846

Table 11. t-test estimated cost - *sector A* estimate win and loss

Estimated cost

Estimate A: Win loss

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	203.490855	190.7362825
Variance	2800.567214	2967.567718

Observations	13	26
Hypothesized Mean Difference	0	
df	25	
t Stat	0.702578827	
P(T<=t) one-tail	0.244404585	
t Critical one-tail	1.708140745	
P(T<=t) two-tail	0.48880917	
t Critical two-tail	2.059538536	

Table 12. t-test % mark-up - *sector A* estimate win and loss

% Mark-up

Estimate A: Win Loss

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	19.13751649	21.50337368
Variance	20.1821368	12.48627834
Observations	13	26
Hypothesized Mean Difference	0	
df	20	
t Stat	-1.659397516	
P(T<=t) one-tail	0.056317891	
t Critical one-tail	1.724718218	
P(T<=t) two-tail	0.112635782	
t Critical two-tail	2.085963441	

Appendix 2 (Sector B)

Table 13. Set of data for sector B sorted according to contracts won and contracts loss

Bid #	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price	**Bid #**	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price
1	545.7	13.0	B	yes	616.7	**56**	762.1	13.5	B	no	865.2
35	740.3	10.6	B	yes	818.6	**57**	431.1	19.2	B	no	513.8
36	502.9	14.5	B	yes	575.7	**59**	416.6	16.8	B	no	486.3
46	605.1	15.0	B	yes	695.9	**69**	648.6	15.3	B	no	747.6
47	518.7	15.1	B	yes	597.2	**71**	593.7	9.4	B	no	649.5
61	404.6	10.8	B	yes	448.3	**76**	765.2	8.4	B	no	829.6
83	508.7	12.1	B	yes	570.4	**77**	495.0	15.3	B	no	570.9
97	561.5	12.0	B	yes	629.1	**80**	717.1	11.9	B	no	802.6
102	483.6	15.1	B	yes	556.4	**84**	619.5	8.9	B	no	674.8
107	428.7	18.5	B	yes	508.0	**85**	565.8	15.0	B	no	650.4
109	535.5	14.0	B	yes	610.5	**88**	546.6	6.4	B	no	581.7
125	512.6	13.8	B	yes	583.2	**89**	415.7	14.1	B	no	474.3

155	615.3	12.5	B	yes	692.2	**112**	536.1	13.5	B	no	608.8
7	506.9	22.7	B	no	621.8	**147**	587.8	14.6	B	no	673.8
10	523.9	8.6	B	no	568.7	**152**	797.0	8.3	B	no	863.1
18	425.0	16.0	B	no	493.1	**153**	638.7	13.4	B	no	724.0
24	452.8	15.2	B	no	521.8	**160**	434.9	10.4	B	no	480.2
31	453.9	15.0	B	no	522.0						
40	593.9	11.6	B	no	662.7						
43	547.7	12.1	B	no	614.0						

Table 14. Summary of data properties (win and loss) for *sector B*

Sector B	**Win**			**Loss**		
	Estimated Cost	**%Mark-up**	**Bid price**	**Estimated Cost**	**%Mark-up**	**Bid price**
Bids	13			24		
Mean	535.6	13.6	607.9	561.5	13.2	633.4
St_dev	85.52194123	2.127580957	91.76739005	115.7823192	3.778071774	121.7265507
St_dev^2	7314.002431	4.526600729	8421.253877	13405.54543	14.27382633	14817.35316
$t_{\alpha/2}$	2.178812827			2.068657599		
Confidence	46.48940256	1.156544931	49.88440483	46.321724	1.511515741	48.69986823
Lower	489.1	12.5	558	515.2	11.6	584.7
Upper	582.1	14.8	657.7	607.8	14.7	682.1
Interval	(489.1, 582.1)	(12.5, 14.8)	(558, 657.7)	(515.2, 607.8)	(11.6, 14.7)	(584.7, 682.10)

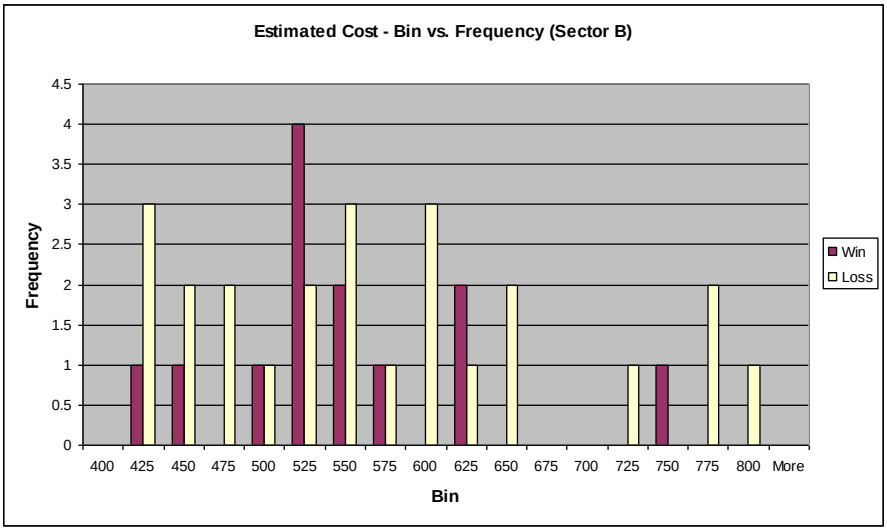

Figure 18. Estimated cost – bin vs. frequency (sector B).

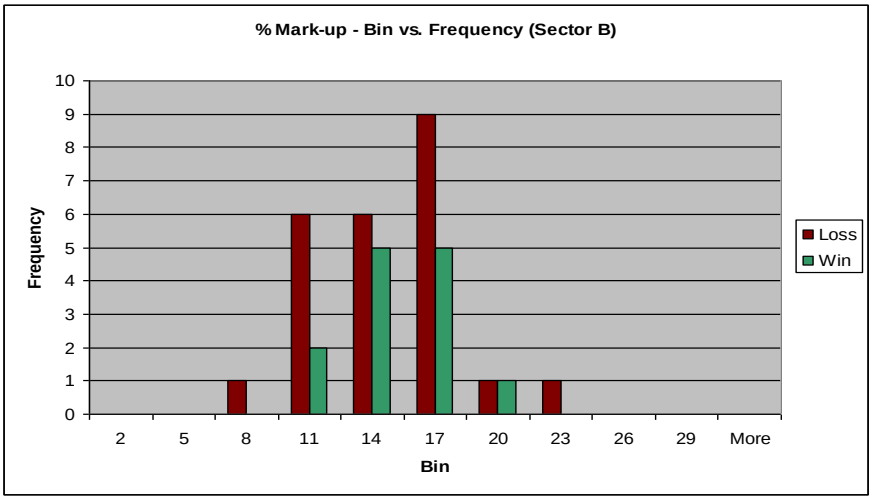

Figure 19. % mark-up – bin vs. frequency (sector B).

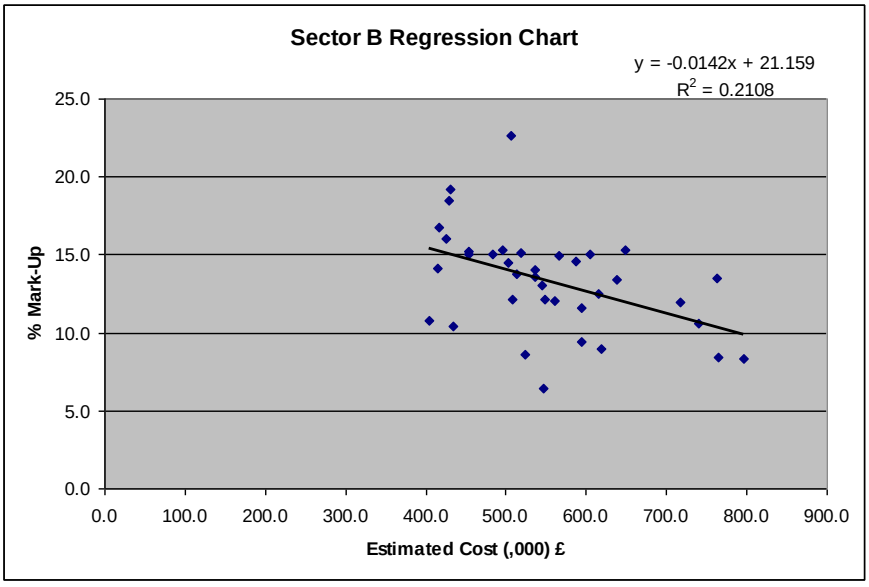

Figure 20. *Sector B* regression chart plot Estimated cost vs. % mark-up

Table 15. *Sector B* regression table being (a) summary output and (b) Anova

(a)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.459077766
R Square	0.210752396
Adjusted R Square	0.188202464
Standard Error	2.944327471
Observations	37

(b)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*

Regression	1	81.0213572	81.0213572	9.346032603	0.004262456
Residual	35	303.417241	8.669064259		
Total	36	384.4386063			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	21.1592759	2.611309593	8.102936535	1.53075E-09	15.85803563	26.46051618	15.85803563	26.46051618
X Variable 1	-0.014201431	0.00464535	-3.057128163	0.004262456	-0.023631993	-0.004770869	-0.023631993	-0.004770869

Table 16. t-test estimated cost - *sector B* estimate win and loss

Estimated cost

Estimate B: Pass Fail

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	535.623642	561.4751356
Variance	7314.002431	13405.54543
Observations	13	24
Hypothesized Mean Difference	0	
df	31	
t Stat	-0.77205453	
P(T<=t) one-tail	0.222964149	
t Critical one-tail	1.695518742	
P(T<=t) two-tail	0.445928298	
t Critical two-tail	2.039513438	

Table 17. t-test % mark-up - *sector B* estimate win and loss

% Mark-up

Estimate B: Pass Fail

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	13.61598014	13.15122385
Variance	4.526600729	14.27382633
Observations	13	24
Hypothesized Mean Difference	0	
df	35	
t Stat	0.478610911	
P(T<=t) one-tail	0.317595945	
t Critical one-tail	1.68957244	
P(T<=t) two-tail	0.635191889	
t Critical two-tail	2.030107915	

Appendix 3 (Sector C)

Table 18. Set of data for sector C sorted according to contracts won and contracts loss

Bid #	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price	**Bid #**	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price
17	562.0	8.3	C	yes	608.8	**67**	513.2	13.9	C	no	584.4
55	787.8	8.5	C	yes	854.6	**70**	542.4	20.4	C	no	653.2
60	675.1	9.3	C	yes	737.9	**81**	912.2	10.1	C	no	1004.4
91	922.4	-0.7	C	yes	916.1	**87**	869.9	10.2	C	no	958.2
118	772.8	16.8	C	yes	902.7	**95**	877.6	5.4	C	no	925.3
127	729.3	8.5	C	yes	791.5	**100**	635.6	15.8	C	no	736.3
133	922.2	1.4	C	yes	934.9	**101**	654.8	12.6	C	no	737.4
138	643.5	14.1	C	yes	734.0	**104**	564.9	18.1	C	no	667.0
2	771.2	9.2	C	no	842.2	**113**	683.9	14.3	C	no	781.5
4	578.4	13.5	C	no	656.4	**114**	592.2	16.2	C	no	688.3
5	619.7	15.9	C	no	717.9	**116**	691.3	14.3	C	no	790.4
6	724.3	13.7	C	no	823.2	**117**	671.8	22.0	C	no	819.5
12	988.3	6.0	C	no	1047.1	**130**	925.2	14.3	C	no	1057.5
14	923.1	8.1	C	no	998.1	**132**	865.5	16.6	C	no	1009.2
15	569.9	20.7	C	no	687.6	**134**	630.9	11.2	C	no	701.8
20	669.4	10.0	C	no	736.5	**137**	956.4	7.9	C	no	1031.9
26	996.5	6.1	C	no	1057.2	**139**	858.0	7.6	C	no	923.3
34	694.3	9.3	C	no	758.8	**142**	650.8	18.0	C	no	768.1
38	945.6	11.7	C	no	1056.4	**144**	767.0	8.8	C	no	834.7
48	698.9	11.0	C	no	775.8	**149**	813.3	18.8	C	no	965.8
52	549.0	12.1	C	no	615.2						

Table 19. Summary of properties of data for *sector C*

Sector C	**Estimated Cost**	**%Mark Up**	**Bid Price**
Mean	742	11.9	826.6
Std_dev	142.1105	5.019588	139.9928
Minimum	513.2	-0.7	584.4
Maximum	996.5	22	1057.5
Number	41	41	41
Confidence	43.4993062	1.5364705	14.7465
% Pass Rate	19.5122	19.5122	19.5122
Std_dev^2	20195.39421	25.196264	19597.98
Number Won	8	8	8

Table 20. Summary of data properties (win and loss) for *sector C*

Sector C	Win			Loss		
	Estimated Cost	**%Mark-up**	**Bid price**	**Estimated Cost**	**%Mark-up**	**Bid price**
Bids	8			33		
Mean	751.9	8.3	810.1	739.6	12.8	830.6
St_dev	127.6373231	5.799339164	112.9038414	147.1391015	4.466394039	147.0510052
St_dev^2	16291.28625	33.63233474	12747.27739	21649.9152	19.94867571	21623.99812
$t_{\alpha/2}$	2.364624251			2.036933334		
Confidence	88.4465271	4.018663163	78.23693276	50.2017921	1.523870832	50.17173487
Lower	663.4	4.3	731.8	689.4	11.3	780.5
Upper	840.3	12.3	888.3	789.8	14.4	880.8
Interval	(663.4, 840.3)	(4.3, 12.3)	(731.8, 888.3)	(689.4, 789.8)	(11.3, 14.4)	(780.5, 880.8)

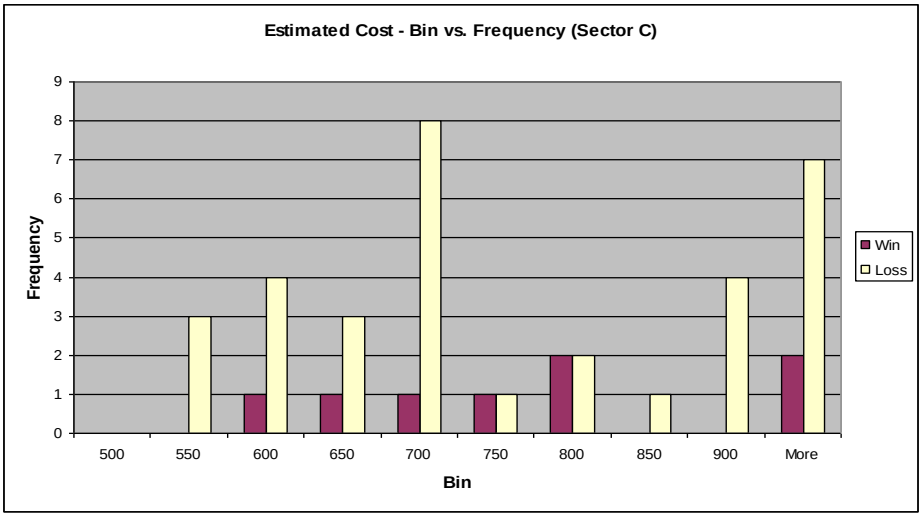

Figure 21. Estimated cost – bin vs. frequency (sector C)

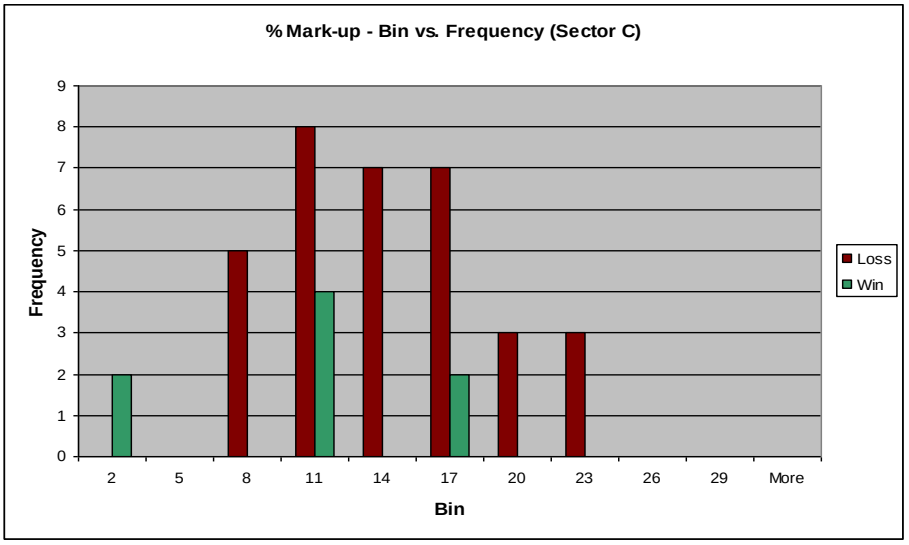

Figure 22. % mark-up – bin vs. frequency (sector C)

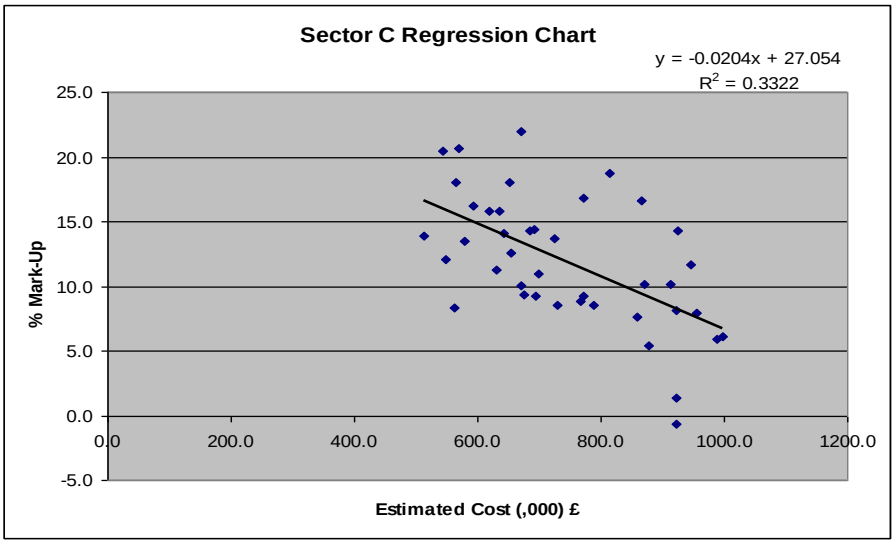

Figure 23. *Sector C* regression chart plot Estimated cost vs. % mark-up

Table 21. *Sector C* regression table being (a) summary output and (b) Anova

(a)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.576346356
R Square	0.332175123
Adjusted R Square	0.315051408
Standard Error	4.154292328
Observations	41

(b)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	334.7828675	334.7828675	19.39854327	8.02809E-05
Residual	39	673.067645	17.25814474		
Total	40	1007.850513			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	27.05407619	3.490268188	7.751288651	2.03908E-09	19.99434249	34.1138099	19.99434249	34.1138099
X Variable 1	-0.020357552	0.004622118	-4.404377739	8.02809E-05	-0.029706668	-0.011008437	-0.029706668	-0.011008437

Table 22. t-test estimated cost - *sector C* estimate win and loss

Estimated cost

Estimate C: Pass Fail

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	751.8872966	739.5563557
Variance	16291.28625	21649.9152
Observations	8	33

Hypothesized Mean Difference	0
df	12
t Stat	0.237640728
P(T<=t) one-tail	0.40808436
t Critical one-tail	1.782287548
P(T<=t) two-tail	0.816168719
t Critical two-tail	2.178812827

Table 23. t-test % mark-up - *sector C* estimate win and loss

% Mark-up

Estimate C: Pass Fail

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	8.276881886	12.83987881
Variance	33.63233474	19.94867571
Observations	8	33
Hypothesized Mean Difference	0	
df	9	
t Stat	-2.080861793	
P(T<=t) one-tail	0.033585639	
t Critical one-tail	1.833112923	
P(T<=t) two-tail	0.067171278	
t Critical two-tail	2.262157158	

Appendix 4 (Sector D)

Table 24. Set of data for *sector D* sorted according to contracts won and contracts loss

Bid #	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price	**Bid #**	Estimated Cost	% Mark-up	Sector	Contract Won?	Bid Price
3	477.7	16.1	D	yes	554.7	**58**	346.3	24.4	D	no	430.6
19	426.4	18.9	D	yes	506.9	**62**	333.5	24.4	D	no	414.8
22	563.4	15.3	D	yes	649.5	**73**	446.5	21.5	D	no	542.4
49	545.6	22.7	D	yes	669.4	**74**	451.1	20.3	D	no	542.8
64	535.3	19.0	D	yes	637.1	**75**	347.0	27.4	D	no	442.1
65	588.0	17.1	D	yes	688.6	**82**	309.4	17.4	D	no	363.1
86	383.5	16.2	D	yes	445.5	**92**	389.4	13.3	D	no	441.1
108	487.8	11.3	D	yes	542.9	**93**	522.1	24.3	D	no	648.9
115	547.2	14.5	D	yes	626.5	**98**	363.1	16.0	D	no	421.0
120	275.1	21.9	D	yes	335.4	**99**	453.9	19.6	D	no	543.0
124	481.5	13.6	D	yes	547.1	**105**	595.1	16.5	D	no	693.2
11	592.0	11.9	D	no	662.4	**119**	566.1	21.0	D	no	684.7
23	473.1	17.6	D	no	556.6	**122**	438.0	15.0	D	no	503.9
28	383.4	12.8	D	no	432.5	**128**	366.4	18.3	D	no	433.5
29	359.7	20.9	D	no	434.9	**129**	355.5	24.3	D	no	441.8

32	291.9	21.6	D	no	355.0	**131**	402.2	14.6	D	no	460.8
33	301.2	24.0	D	no	373.5	**140**	315.6	25.0	D	no	394.5
37	531.1	21.9	D	no	647.2	**143**	550.6	9.5	D	no	602.9
39	463.8	19.5	D	no	554.3	**146**	250.8	20.9	D	no	303.2
44	421.0	22.6	D	no	516.1	**151**	377.4	16.5	D	no	439.6
45	595.1	13.6	D	no	675.9	**156**	361.7	15.8	D	no	418.9
54	463.8	20.4	D	no	558.4						

Table 25. Summary of data properties (win and loss) for *sector D*

Sector D	**Win**			**Loss**		
	Estimated Cost	**%Mark-up**	**Bid price**	**Estimated Cost**	**%Mark-up**	**Bid price**
Bids	11			32		
Mean	482.9	17	563.9	419.3	19.1	497.9
St_dev	92.0034471	3.442504276	106.6	95.72726943	4.427500027	107.3865662
St_dev^2	8464.634279	11.85083569	11357.40136	9163.710113	19.60275649	11531.87461
$t_{\alpha/2}$	2.228138842			2.039513438		
Confidence	54.36956369	2.03435264	62.97834376	33.1671972	1.534022305	37.20686321
Lower	428.5	14.9	501	386.1	17.6	460.7
Upper	537.2	19	626.9	452.5	20.7	535.1
Interval	(428.5, 537.2)	(14.9, 19)	(501, 626.9)	(386.1, 452.5)	(17.6, 20.7)	(460.7, 535.1)

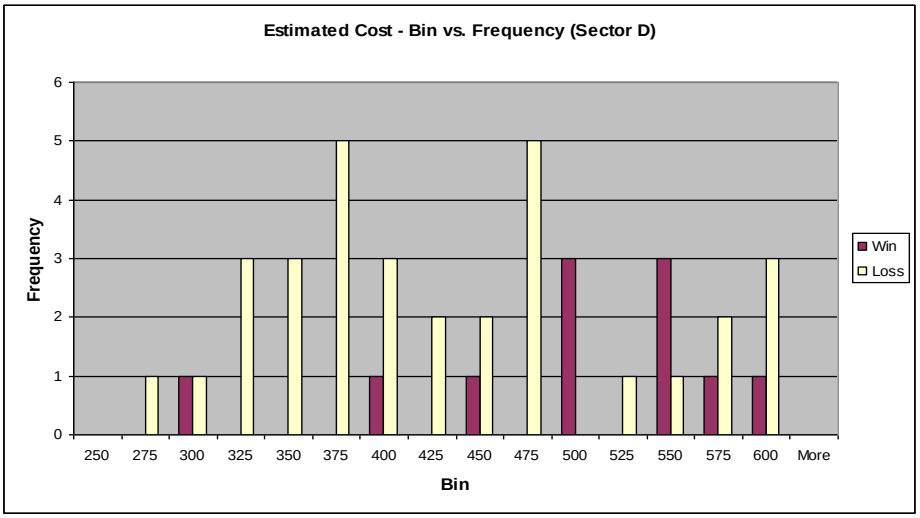

Figure 24. Estimated cost – bin vs. frequency (sector D)

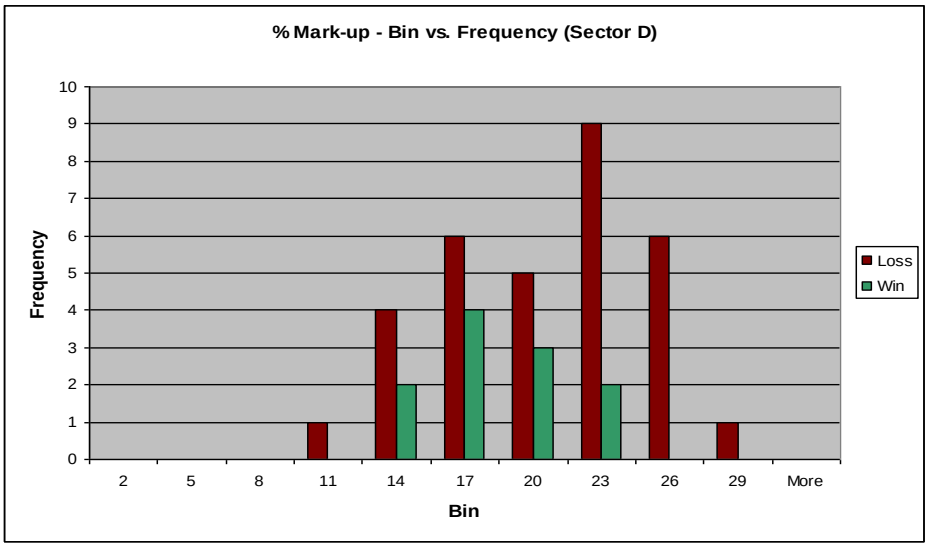

Figure 25. % mark-up – bin vs. frequency (sector D)

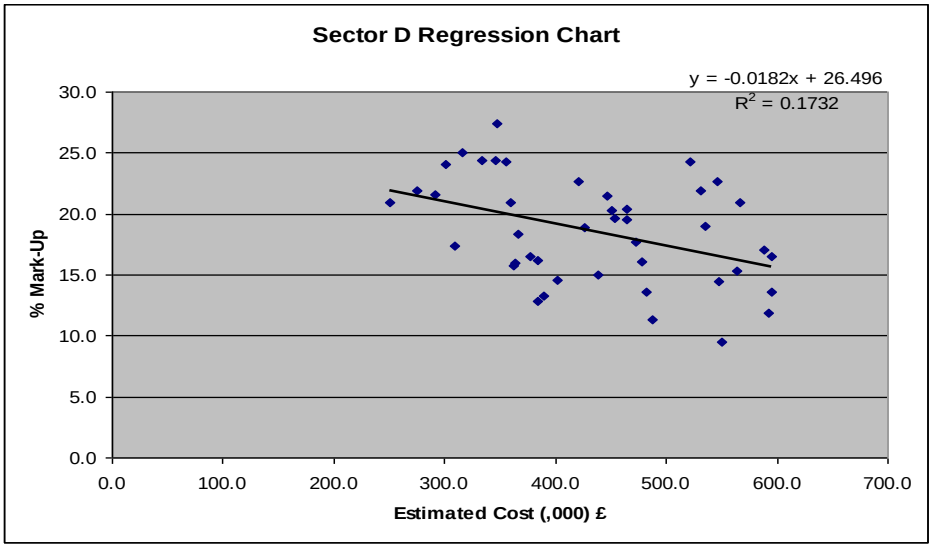

Figure 26. *Sector D* regression chart plot estimated cost vs. % mark-up

Table 26. *Sector D* regression table being (a) summary output and (b) Anova

(a)

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.416169721
R Square	0.173197237
Adjusted R Square	0.153031316
Standard Error	3.928440235
Observations	43

(b)

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	132.5449537	132.5449537	8.588610285	0.005507565

Residual	41	632.7383499	15.43264268
Total	42	765.2833036	

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	26.49615555	2.76504819	9.582529392	5.0524E-12	20.91202751	32.0802836	20.91202751	32.0802836
X Variable 1	-0.018162518	0.006197472	-2.930633086	0.005507565	-0.030678567	-0.005646468	-0.030678567	-0.005646468

Table 27. t-test estimated cost - *sector D* estimate win and loss

Estimated cost

Estimate D: Pass Fail

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	482.8666483	419.2978795
Variance	8464.634279	9163.710113
Observations	11	32
Hypothesized Mean Difference	0	
df	18	
t Stat	1.956306506	
P(T<=t) one-tail	0.033064022	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	0.066128045	
t Critical two-tail	2.100922037	

Table 28. t-test % mark-up - *sector D* estimate win and loss

% Mark-up

Estimate D: Pass Fail

t-Test: Two-Sample Assuming Unequal Variances

	Variable 1	*Variable 2*
Mean	16.95909369	19.14430243
Variance	11.85083569	19.60275649
Observations	11	32
Hypothesized Mean Difference	0	
df	22	
t Stat	-1.680962205	
P(T<=t) one-tail	0.053457267	
t Critical one-tail	1.717144335	
P(T<=t) two-tail	0.106914534	
t Critical two-tail	2.073873058	