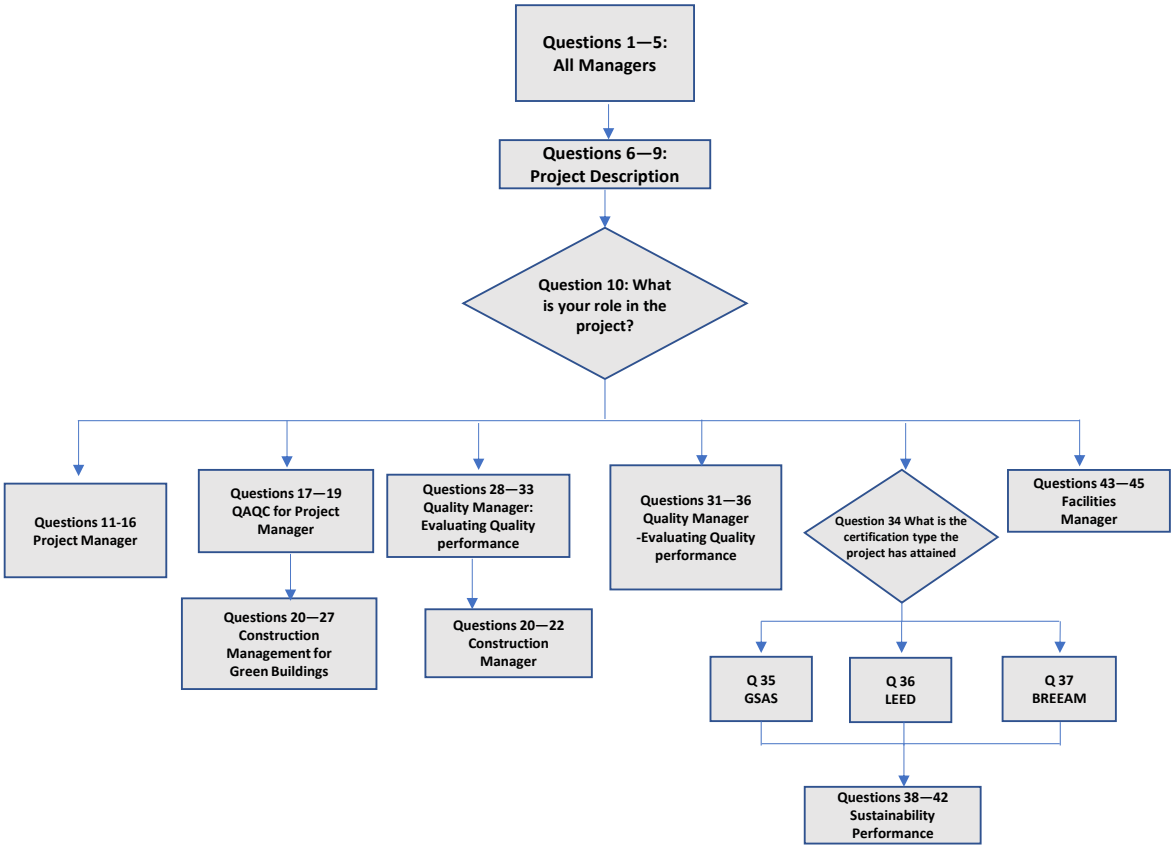
Supporting Information for the Article:

Managerial Practitioners' Perspectives on Quality Performance of Green-Building Projects

Ayman M. Raouf, Sami G. Al-Ghamdi

Summary of Questionnaire Results in the Article

1. Questionnaire Structure



2. Participant Demographics

Years of experience in construction industry in general:

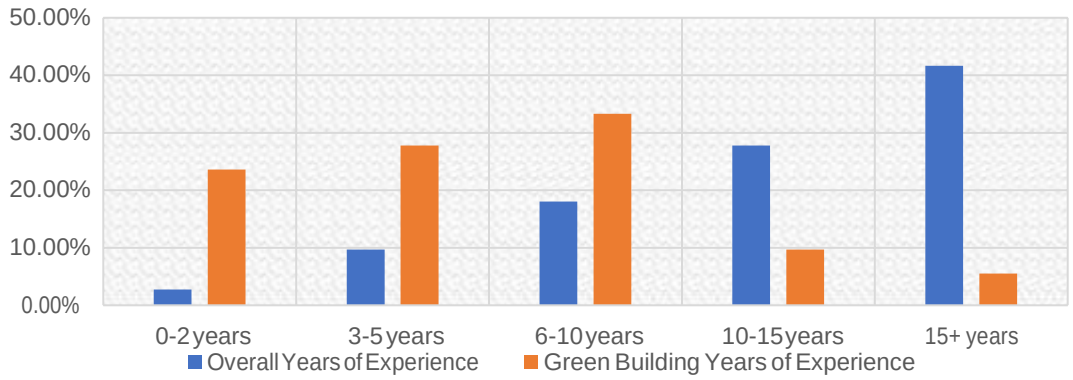
How many years of experience have you been involved in construction and/or operations?

Answer Choices	Responses	
0-2 years	2.35%	2
3-5 years	10.59%	9
6-10 years	20.00%	17
10-15 years	24.71%	21
15+ years	42.35%	36
	Answered	**85**
	Skipped	**11**

Years of experience in green buildings in particular

How long have you been involved with green buildings?

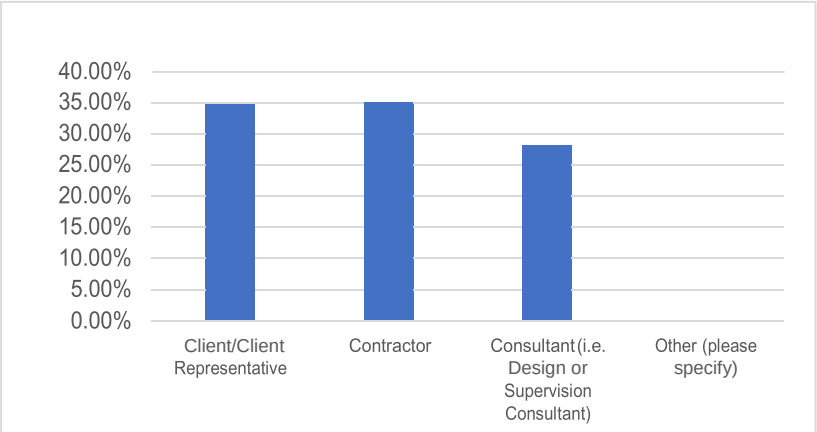
Answer Choices	Responses	
0-2 years	22.35%	19
3-5 years	32.94%	28
6-10 years	30.59%	26
10-15 years	9.41%	8
15+ years	4.71%	4
	Answered	**85**
	Skipped	**11**



3. Entity the respondent represents:

Which entity do you represent?

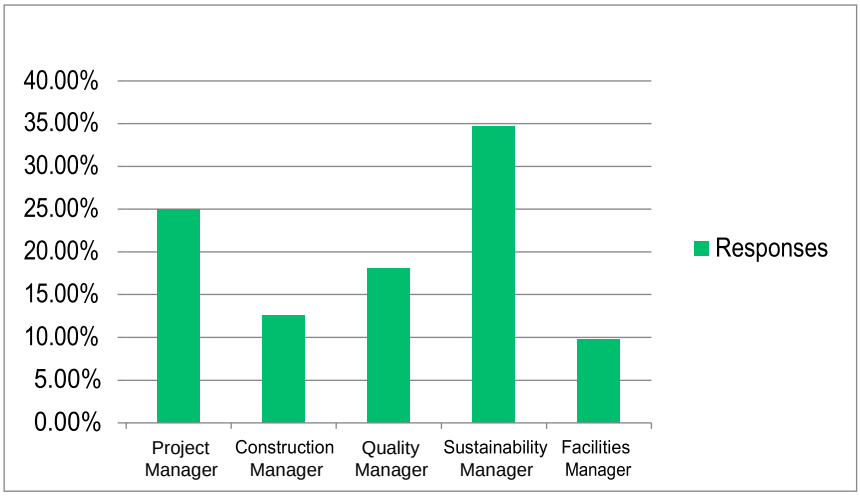
Answer Choices	Responses	
Client/Client Representative	29.76%	25
Contractor	32.14%	27
Consultant (i.e. Design or Supervision Consultant)	33.33%	28
Other (please specify)	4.76%	4
	Answered	**84**
	Skipped	**12**



Managerial Role In Project

What is your role in the project?

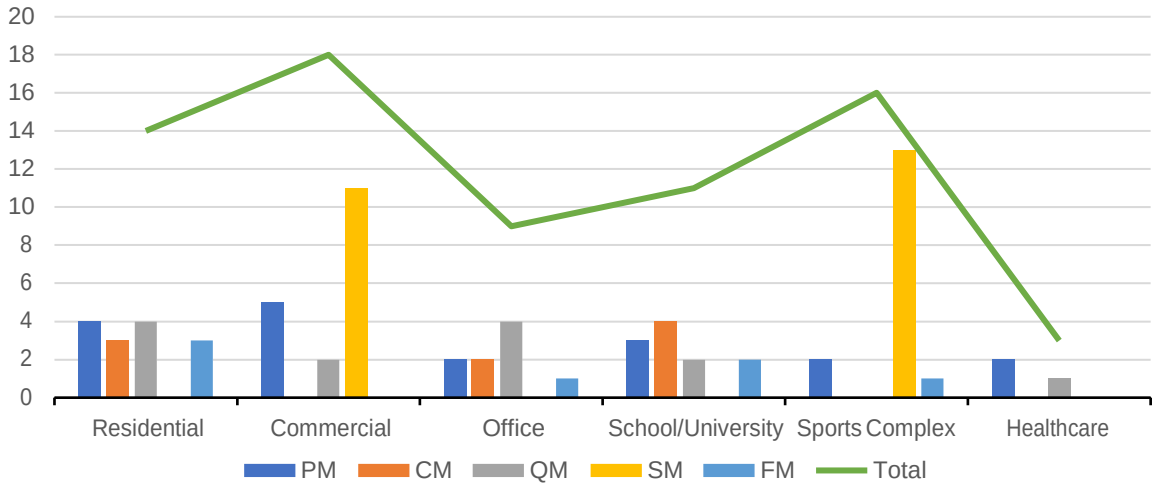
Answer Choices	Responses	
Project Manager	21.18%	18
Construction Manager	17.65%	15
Quality Manager	21.18%	18
Sustainability Manager	30.59%	26
Facilities Manager	9.41%	8
	Answered	**85**
	Skipped	**11**

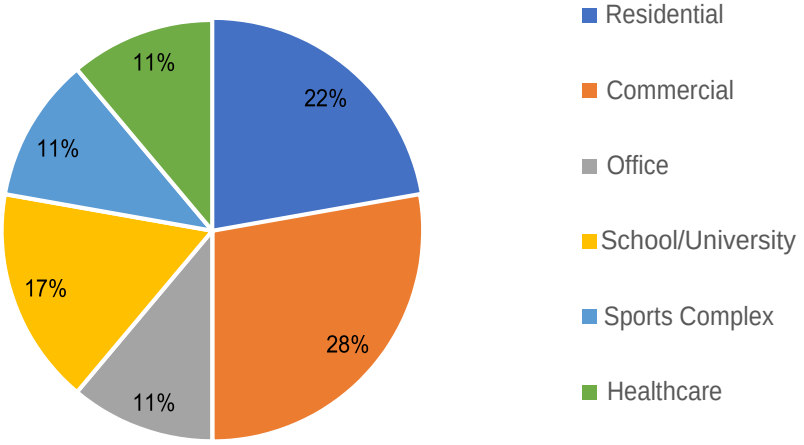


4. Projects Information

Project Type:

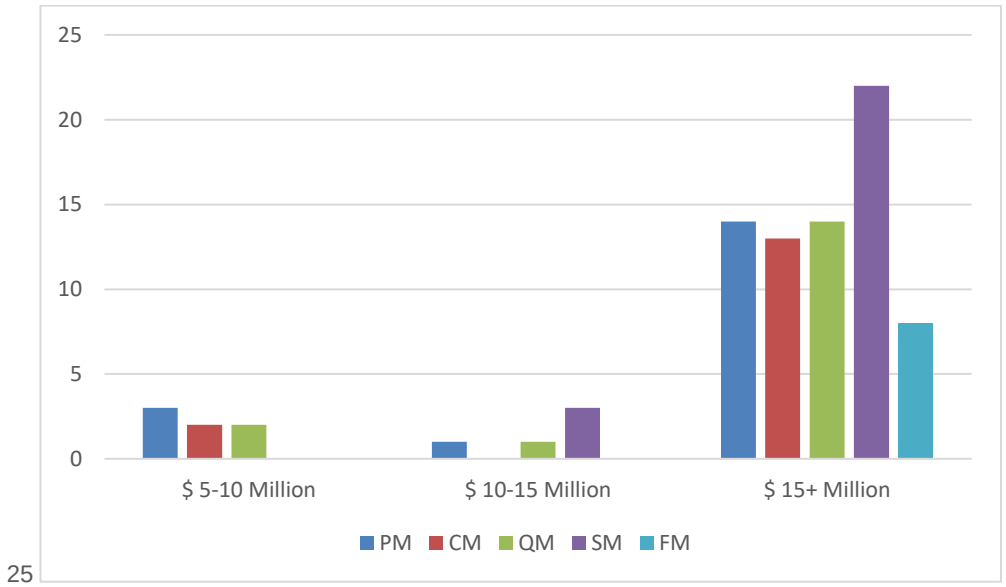
Project Type	PM	CM	QM	SM	FM	Total
Residential	4	3	4	0	3	14
Commercial	5	3	5	12	0	25
Office	2	4	5	0	1	12
School/University	3	4	2	0	2	11
Sports Complex	2	1	0	13	2	18
Healthcare	2	0	1	0	0	3





Project Size

Project Size in USD	PM	CM	QM	SM	FM
$ 5-10 Million	3	2	2	0	0
$ 10-15 Million	1	0	1	3	0
$ 15+ Million	14	13	14	22	8



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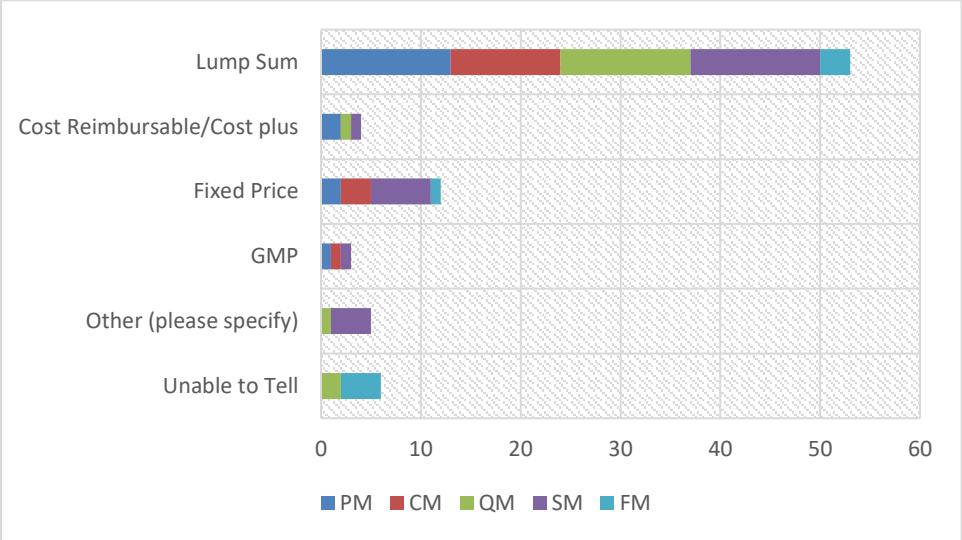
Delivery System Type

Delivery System	PM	CM	QM	SM	FM
Design Bid Build	5	4	5	3	1
Design and Build	12	8	10	19	5
Construction Management Agency/@Risk	1	3	1	0	0
Hybrid (please specify)	0	0	1	3	0
Unable to Tell	0	0	0	0	2
Total	**18**	**15**	**17**	25	**8**

Payment Mechanism

Payment Provision	PM	CM	QM	SM	FM
Unable to Tell	0	0	2	0	4
Other (please specify)	0	0	1	4	0
GMP	1	1	0	1	0
Fixed Price	2	3	0	6	1
Cost Reimbursable/Cost plus	2	0	1	1	0
Lump Sum	13	11	13	13	3



Green certification Types Pursued

Certification Type	PM	CM	QM*	SM	FM	Total
LEED	3	4	3	1	4	15
GSAS	5	5	11	14	3	38
BREEAM	0	0	0	0	0	0

*The QM results were collated based on the Collector of the online platform. Also important to note on occasions that the PM and QM worked on the same project so it was not feasible to separate the results on certification type for a project but rather on managerial type.

5. Quality Control and Assurance Awareness

Respondents' asked to respond correctly to the definitions of Quality Assurance and Quality Control:

Quality Assurance: "Owner/owner representative conducting planned, systematic actions to establish level of confidence that project design documents comply with applicable codes, standards and criteria, and that the resulting construction complies with the contract documents."

"Design or construction professional conducting plans, procedures, resources and organisation needed to monitor quality of the contract documents to ensure consistency with applicable codes, standards and criteria. This includes observations, inspections, tests and documentation that either confirm quality processes and systems are effective in ensuring achievement of quality."

Chi-Squared Test for QA QC Definitions

Actual			
Response	QA Correct Definition	QC Correct Definition	Total Number of Respondents
QM	10	10	20
CM	7	8	15
PM	7	7	14
Grand total	24	25	49

Expected			
Response	QA Correct Definition	QC Correct Defintion	Total number of respondents
QM	9.795918367	10.20408	*20*
CM	7.346938776	7.653061	*15*
PM	6.857142857	7.142857	*14*
Grand total	24	25	**49**

Ho is that there is no difference between managerial type and correct answer for Quality Control and Assurance

P to reject	0.05	less than 0.05 is strong evidence against null hypotheisis
P value:	0.977126762	Do not reject Null Hypothesis

Conclusion: no significant difference between the managers in the perception of the correct answer

6. Ranking of Quality Consequences

Rank 1: Greatest priority consequence that the manager influences

Rank 7: Lowest priority consequence that the manager influences

Managerial Type	Respondent Number	Liquidated Damages	Reputation Loss	Cost Overruns in Rectifying Mistakes	Schedule Delays	Material Loss	Labor Productivity Loss	Assigning Team to Work Overtime
QM	1	7	1	5	6	3	2	4
	2	7	5	2	4	6	1	3
	3	7	1	2	6	3	4	5
	4	7	1	2	6	5	3	4
	5	6	1	3	5	7	2	4
	6	3	1	5	4	6	7	2

Managerial Type	Respondent Number	Liquidated Damages	Reputation Loss	Cost Overruns in Rectifying Mistakes	Schedule Delays	Material Loss	Labor Productivity Loss	Assigning Team to Work Overtime
	7	4	3	1	2	5	6	7
	8	2	4	1	3	5	6	7
	9	3	7	2	1	4	5	6
	10	6	5	2	3	1	4	7
	11	4	3	1	2	5	6	7
PM	1	4	1	2	3	5	6	7
	2	1	2	3	4	7	6	5
	3	7	4	2	1	5	3	6
	4	5	1	2	4	3	6	7
	5	3	1	4	2	5	7	6
	6	6	7	3	5	4	1	2
	7	7	5	2	3	4	6	1
	8	4	3	6	1	5	2	7
	9	3	4	1	2	3	5	6
	10	6	4	2	1	7	5	3
	11	3	5	4	6	2	1	7
CM	1	3	5	4	1	2	7	6
	2	5	1	3	2	4	6	7
	3	6	7	5	3	4	1	2
	4	7	6	5	4	3	2	1
	5	6	7	1	3	4	2	5
	6	7	5	2	1	6	3	4
	7	1	2	3	5	6	4	7
	8	1	2	3	4	6	7	5
	9	6	7	5	1	2	3	4
	10	6	7	5	1	2	3	4
	11	6	7	5	2	1	4	3
	12	6	4	5	1	2	3	7
	13	6	7	5	1	2	4	3
	14	6	7	5	1	3	2	4

Relative Importance Index Calculations

Overall							
W	177	143	113	104	147	145	175
A	7	7	7	7	7	7	7
N	36	36	36	36	36	36	36
RII	0.7023817	0.567463	0.4484132	0.4126981	0.5833335	0.5753974	0.6944446
Quality Managers							
W	56	32	26	42	50	46	56
A	7	7	7	7	7	7	7
N	11	11	11	11	11	11	11
RII	0.7272727	0.415584	0.337662	0.545455	0.649351	0.597403	0.727273

	6	2	1	3	5	4	6
Project Managers							
W	49	37	31	32	50	48	57
A	7	7	7	7	7	7	7
N	11	11	11	11	11	11	11
RII	0.6363636	0.480519	0.402597	0.415584	0.649351	0.623377	0.74026
	5	3	1	2	6	4	7
Construction Managers							
W	72	74	56	30	47	51	62
A	7	7	7	7	7	7	7
N	14	14	14	14	14	14	14
RII	0.7346939	0.755102	0.571429	0.306122	0.479592	0.520408	0.632653
Rank	6	7	4	1	2	3	5

7. Mann Whitney Test

Quality Failure Consequences Ranked In Terms of Managerial Type Influence	Asymptotic Significance (2-tailed) of Pairwise Comparison		
	Test 1	Test 2	Test 3
	PM and CM	PM and QM	QM and CM
Liquidated Damages	0.3443	0.440	0.8234
Reputation Loss	0.0209	0.542	0.0133
Cost Overruns	0.040	0.315	0.0128
Schedule Delays	0.242	0.230	0.0201
Material Loss	0.0817	0.8128	0.0973
Labor Productivity Loss	0.456	0.8145	0.5075
Overtime	0.306	0.8658	0.4045

Mann Whitney Test results for each item shown in subsequent pages

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Institutional Review Board

September 2, 2018

Sami Al-Gahmdi
Assistant Professor
College of Science and Engineering
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Doha, Qatar

Ref.: Approval for QBRI-IRB
Review Type: Expedited Review
IRB Approval Date: September 2, 2018
IRB Expiration Date: September 2, 2019
IRB Project Number: 2018-025
Project Title: Managerial Perspectives on Green Building Projects' Delivery Processes

Dear Prof. Sami Al-Gahmdi,

The QBRI Institutional Review Board (IRB) has reviewed your research proposal that was submitted for the above referenced protocol (2018-0025). **It has been determined that your research proposal is eligible for expedited status and requires no further review.** This falls under the category two in MOPH guidelines, regulations and policies for research involving human subjects stating *that research the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.*

Although your research proposal falls under the exempt status, the research must be conducted according to the submitted research protocol outlined in the approved proposal. Please note that any changes/modifications to the original submitted protocol should be reported to the IRB committee for guidance and review. **Please consider that any modifications to the referenced research proposal may subject the proposal from qualifying for exempt review and require submission of a new IRB application.**

Request for a renewal, if required, should be submitted to IRB at least one month prior to the expiry date to allow the IRB sufficient time to review and approve the request. It is the sole responsibility of the investigator to ensure the timely renewal of the IRB.

Wishing you all the success in conducting your research.

QATAR BIOMEDICAL RESEARCH INSTITUTE
APPROVAL DATE 02 SEP 2018
APPROVAL Expires 02 SEP 2019
IRB APPROVED

Sincerely,

Dr. Khalid Al-Ali
Chairperson

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Managerial	Opinion	Rank	t_i	T_i
1	7	19.5	6	17.5
1	7	19.5		
1	7	19.5		
1	7	19.5		
1	6	14.5	4	5
1	3	5	5	10
1	4	9.5	4	5
1	2	2	1	0
1	3	5		
1	6	14.5		
1	4	9.5		
2	4	9.5		
2	1	1	1	0
2	7	19.5		
2	5	12	1	0
2	3	5		
2	6	14.5		
2	7	19.5		
2	4	9.5		
2	3	5		
2	6	14.5		
2	3	5		
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding
1 Quality Manager
2 Project Manager

Opinion coding
1 Highest
2
3
4
5
6
7 Lowest

UDF 72

UDF 0.771664

UDF 0.034226

UDF 0.440313

Mann-Whitney U test Liquidated Damages QM PM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Project Ma	11	
total	22	=SUM(M7:M8)

Step 2:

Group			
Quality Ma	66	=M7*(M7+1)/2	$\frac{n_i \times (n_i + 1)}{2}$
Project Ma	66		

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	12.54545	138	=SUMIF(A:A;G3;C:C)
Project Ma	10.45455	115	

Step 5: Determine difference with Max rank (U)

Group	Difference		
Quality Ma	72	=N24-M14	$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$
Project Ma	49		

Step 6: Determine numerator for Z

Group	Denom.		
Quality Ma	11.5	=M30-$M$7*$M$8/2	$U_i - \frac{n_1 \times n_2}{2}$
Project Ma	-11.5		

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12) $T_i = \frac{t_i^3 - t_i}{12}$

Step 9: Sum the results of step 8

Sum T_i 37.5 =SUM(E:E) $T = \sum T_i$

Step 10: Determine denominator (= SE)

denominator 14.90286 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$

Step 11: Determine Z

Z 0.771664 =M36/M53 $Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$

Step 12: Determine significance

sig 0.(M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.440313 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.440313 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	1	4.5	8	42
1	5	18.5	4	5
1	1	4.5		
1	1	4.5		
1	1	4.5		
1	1	4.5		
1	3	11	3	2
1	4	14.5	4	5
1	7	21.5	2	0.5
1	5	18.5		
1	3	11		
2	1	4.5		
2	2	9	1	0
2	4	14.5		
2	1	4.5		
2	1	4.5		
2	7	21.5		
2	5	18.5		
2	3	11		
2	4	14.5		
2	4	14.5		
2	5	18.5		
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Project Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF 51.5

UDF -0.61006

UDF 0.034226

UDF 0.541824

Mann-Whitney U test Reputation Loss QM PM

Step 1: Counts

Group	n	
Quality M	11	=COUNTIF(A:A;G3)
Project M	11	
total	22	=SUM(M7:M8)

Step 2:

Group		
Quality M	66	=M7*(M7+1)/2
Project M	66	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality M	10.68182	117.5	=SUMIF(A:A;G3;C:C)
Project M	12.31818	135.5	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality M	51.5	=N24-M14
Project M	69.5	

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality M	-9	=M30-$M$7*$M$8/2
Project M	9	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 54.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 14.75272 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z -0.61006 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.0[...] =2*(1-NOR[...]M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.541824 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.541824 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	5	20.5	2	0.5
1	2	9.5	10	82.5
1	2	9.5		
1	2	9.5		
1	3	16	3	2
1	5	20.5		
1	1	2.5	4	5
1	1	2.5		
1	2	9.5		
1	2	9.5		
1	1	2.5		
2	2	9.5		
2	3	16		
2	2	9.5		
2	2	9.5		
2	4	18.5	2	0.5
2	3	16		
2	2	9.5		
2	6	22	1	0
2	1	2.5		
2	2	9.5		
2	4	18.5		
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
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			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Project Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

Mann-Whitney U test Cost Overruns QM PM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Project Ma	11	
total	22	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Project Ma	66	

$$\frac{n_i \times (n_i+1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	10.18182	112	=SUMIF(A:A;G3;C:C)
Project Ma	12.81818	141	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	46	=N24-M14
Project Ma	75	

UDF 46

$$U_i = R_i - \frac{n_i \times (n_i+1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	-14.5	=M30-$M$7*$M$8/2
Project Ma	14.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 90.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 14.42963 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3-N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

UDF -1.00488

Z -1.00488 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

UDF 0.314956

sig 0.314956 =2*(1-NORM.S.DIST(ABS(M57);TRUE))

UDF 0.034226 0.314956 =2*(1-NORMSDIST(ABS(M57)))

sig 0.034226 =2*(1-NORM.S.DIST(ABS(M57);TRUE))

0.034226 =2*(1-NORMSDIST(ABS(M57)))

Manageri	Opinion	Rank	t_i	T_i
1	6	20.5	4	5
1	4	14.5	4	5
1	6	20.5		
1	6	20.5		
1	5	17.5	2	0.5
1	4	14.5		
1	2	6.5	4	5
1	3	10.5	4	5
1	1	2.5	4	5
1	3	10.5		
1	2	6.5		
2	3	10.5		
2	4	14.5		
2	1	2.5		
2	4	14.5		
2	2	6.5		
2	5	17.5		
2	3	10.5		
2	1	2.5		
2	2	6.5		
2	1	2.5		
2	6	20.5		
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Project Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

Mann-Whitney U test Schedule Delays QM PM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Project Ma	11	
total	22	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Project Ma	66	

$$\frac{n_i \times (n_i+1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	13.13636	144.5	=SUMIF(A:A;G3;C:C)
Project Ma	9.863636	108.5	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	78.5	=N24-M14
Project Ma	42.5	

UDF 78.5

$$U_i = R_i - \frac{n_i \times (n_i+1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	18	=M30-$M$7*$M$8/2
Project Ma	-18	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 25.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 15.00793 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

UDF 1.199366

Z 1.199366 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

UDF 0.034226

Step 12: Determine significance

sig 0.0[illegible] [illegible]M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

UDF 0.230386

sig 0.230386 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.230386 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	3	4.5	4	5
1	6	18.5	2	0.5
1	3	4.5		
1	5	13.5	8	42
1	7	21	3	2
1	6	18.5		
1	5	13.5		
1	5	13.5		
1	4	8	3	2
1	1	1	1	0
1	5	13.5		
2	5	13.5		
2	7	21		
2	5	13.5		
2	3	4.5		
2	5	13.5		
2	4	8		
2	4	8		
2	5	13.5		
2	3	4.5		
2	7	21		
2	2	2	1	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Project Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF 64

UDF 0.236817

UDF 0.812799

Mann-Whitney U test Material Losses QM PM

Step 1: Counts

Group	n	
Quality M	11	=COUNTIF(A:A;G3)
Project M	11	
total	22	=SUM(M7:M8)

Step 2:

Group		
Quality M	66	=M7*(M7+1)/2
Project M	66	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality M	11.81818	130	=SUMIF(A:A;G3;C:C)
Project M	11.18182	123	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality M	64	=N24-M14
Project M	57	

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality M	3.5	=M30-$M$7*$M$8/2
Project M	-3.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 51.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 14.77933 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

UDF

Step 11: Determine Z

Z 0.236817 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

UDF 0.034226

Step 12: Determine significance

sig 0.0[illegible] [illegible]M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.812799 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.812799 =2*(1-NORMSDIST(ABS(M57)))

Manageri	Opinion	Rank	t_i	T_i
1	2	5	3	2
1	1	2	3	2
1	4	9.5	2	0.5
1	3	7.5	2	0.5
1	2	5		
1	7	21.5	2	0.5
1	6	17	7	28
1	6	17		
1	5	12	3	2
1	4	9.5		
1	6	17		
2	6	17		
2	6	17		
2	3	7.5		
2	6	17		
2	7	21.5		
2	1	2		
2	6	17		
2	2	5		
2	5	12		
2	5	12		
2	1	2		
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Project Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF 57

UDF -0.23458

UDF 0.814536

UDF 0.034226

Mann-Whitney U test Labor Productivity QM PM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Project Ma	11	
total	22	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Project Ma	66	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)

C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	11.18182	123	=SUMIF(A:A;G3;C:C)
Project Ma	11.81818	130	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	57	=N24-M14
Project Ma	64	

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	-3.5	=M30-$M$7*$M$8/2
Project Ma	3.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D

D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E

E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 35.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 14.92042 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z -0.23458 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.814536 =2*(1-NORM.S.DIST(ABS(M57);TRUE))

0.814536 =2*(1-NORMSDIST(ABS(M57)))

sig 0.034226 =2*(1-NORM.S.DIST(ABS(M57);TRUE))

0.034226 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	4	7	3	2
1	3	4.5	2	0.5
1	5	9.5	2	0.5
1	4	7		
1	4	7		
1	2	2.5	2	0.5
1	7	18.5	8	42
1	7	18.5		
1	6	12.5	4	5
1	7	18.5		
1	7	18.5		
2	7	18.5		
2	5	9.5		
2	6	12.5		
2	7	18.5		
2	6	12.5		
2	2	2.5		
2	1	1	1	0
2	7	18.5		
2	6	12.5		
2	3	4.5		
2	7	18.5		
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Project Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

Mann-Whitney U test Labor Overtime QM PM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Project Ma	11	
total	22	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Project Ma	66	

$$\frac{n_i \times (n_i+1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	11.27273	124	=SUMIF(A:A;G3;C:C)
Project Ma	11.72727	129	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	58	=N24-M14
Project Ma	63	

UDF 58

$$U_i = R_i - \frac{n_i \times (n_i+1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	-2.5	=M30-\$M\$7*\$M\$8/2
Project Ma	2.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 50.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 14.78819 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3-N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

UDF -0.16905

Z -0.16905 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

UDF 0.034226 **Step 12: Determine significance**

sig 0.(M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

UDF 0.865754

sig 0.865754 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.865754 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	7	22.5	6	17.5
1	7	22.5		
1	7	22.5		
1	7	22.5		
1	6	14.5	7	28
1	3	5	3	2
1	4	7.5	2	0.5
1	2	3	1	0
1	3	5		
1	6	14.5		
1	4	7.5		
2	3	5		
2	5	9	1	0
2	6	14.5		
2	7	22.5		
2	6	14.5		
2	7	22.5		
2	1	1.5	2	0.5
2	1	1.5		
2	6	14.5		
2	6	14.5		
2	6	14.5		
2	6		0	0
2	6		0	0
2	6		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

Mann-Whitney U test Liquidated Damages QM CM

Step 1: Counts

Group	n	
Quality M	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Quality M	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality M	13.36364	147	=SUMIF(A:A;G3;C:C)
Constructi	12.22727	134.5	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality M	81	=N24-M14
Constructi	29.5	

UDF 81

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality M	4	=M30-$M$7*$M$8/2
Constructi	-47.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 48.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 17.92256 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

UDF 0.228207

Z 0.223182 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

UDF 0.034226

Step 12: Determine significance

sig 0.0… =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

UDF 0.819486

sig 0.823394 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.823394 =2*(1-NORMSDIST(ABS(M57)))

Managerial	Opinion	Rank	t_i	T_i
1	1	3.5	6	17.5
1	5	14.5	4	5
1	1	3.5		
1	1	3.5		
1	1	3.5		
1	1	3.5		
1	3	9.5	2	0.5
1	4	11.5	1	0
1	7	21.5	6	17.5
1	5	14.5		
1	3	9.5		
2	5	14.5		
2	1	3.5		
2	7	21.5		
2	6	17	1	0
2	7	21.5		
2	5	14.5		
2	2	7.5	2	0.5
2	2	7.5		
2	7	21.5		
2	7	21.5		
2	7	21.5		
2	4		0	0
2	7		0	0
2	7		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding
1 Quality Manager
2 Construction Manager

Opinion coding
1 Highest
2
3
4
5
6
7 Lowest

UDF 32.5

UDF -2.50045

UDF 0.034226

UDF 0.012404

Mann-Whitney U test Reputation Loss QM CM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	8.954545	98.5	=SUMIF(A:A;G3;C:C)
Constructi	15.63636	172	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	32.5	=N24-M14
Constructi	67	

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	-44.5	=M30-$M$7*$M$8/2
Constructi	-10	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i	41	=SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator	17.97619	=SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

Step 11: Determine Z

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Z	-2.4755	=M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig	0.(	M.S.DIST(ABS(M57);TRUE))
	0.034226	=2*(1-NORMSDIST(ABS(M57)))
sig	0.013305	=2*(1-NORM.S.DIST(ABS(M57);TRUE))
	0.013305	=2*(1-NORMSDIST(ABS(M57)))

Managerial	Opinion	Rank	t_i	T_i
1	5	20.5	7	28
1	2	7.5	6	17.5
1	2	7.5		
1	2	7.5		
1	3	12.5	4	5
1	5	20.5		
1	1	2.5	4	5
1	1	2.5		
1	2	7.5		
1	2	7.5		
1	1	2.5		
2	4	15	1	0
2	3	12.5		
2	5	20.5		
2	5	20.5		
2	1	2.5		
2	2	7.5		
2	3	12.5		
2	3	12.5		
2	5	20.5		
2	5	20.5		
2	5	20.5		
2	5		0	0
2	5		0	0
2	5		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding
1 Quality Manager
2 Construction Manager

Opinion coding
1 Highest
2
3
4
5
6
7 Lowest

UDF 32.5

UDF -2.54625

UDF 0.034226

UDF 0.010889

Mann-Whitney U test Cost Overruns QM CM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group			
Quality Ma	66	=M7*(M7+1)/2	$\frac{n_i \times (n_i + 1)}{2}$
Constructi	105		

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	8.954545	98.5	=SUMIF(A:A;G3;C:C)
Constructi	15	165	

Step 5: Determine difference with Max rank (U)

Group	Difference		
Quality Ma	32.5	=N24-M14	$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$
Constructi	60		

Step 6: Determine numerator for Z

Group	Denom.		
Quality Ma	-44.5	=M30-$M$7*$M$8/2	$U_i - \frac{n_1 \times n_2}{2}$
Constructi	-17		

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12) $T_i = \frac{t_i^3 - t_i}{12}$

Step 9: Sum the results of step 8

Sum T_i	55.5	=SUM(E:E)	$T = \sum T_i$

Step 10: Determine denominator (= SE)

denominator	17.87237	=SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

Step 11: Determine Z $SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$

Z	-2.48988	=M36/M53

$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$

Step 12: Determine significance

sig	0.(	M.S.DIST(ABS(M57);TRUE))
	0.034226	=2*(1-NORMSDIST(ABS(M57)))
sig	0.012779	=2*(1-NORM.S.DIST(ABS(M57);TRUE))
	0.012779	=2*(1-NORMSDIST(ABS(M57)))

Manageri	Opinion	Rank	t_i	T_i
1	6	24	3	2
1	4	18.5	4	5
1	6	24		
1	6	24		
1	5	21.5	2	0.5
1	4	18.5		
1	2	10.5	4	5
1	3	14.5	4	5
1	1	4.5	5	10
1	3	14.5		
1	2	10.5		
2	1	4.5		
2	2	10.5		
2	3	14.5		
2	4	18.5		
2	3	14.5		
2	1	4.5		
2	5	21.5		
2	4	18.5		
2	1	4.5		
2	1	4.5		
2	2	10.5		
2	1		0	0
2	1		0	0
2	1		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

Mann-Whitney U test Schedule Delay QM CM

Step 1: Counts

Group	n	
Quality M	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Quality M	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)

C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality M	16.81818	185	=SUMIF(A:A;G3;C:C)
Constructi	11.5	126.5	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality M	119	=N24-M14
Constructi	21.5	

UDF 35

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality M	42	=M30-$M$7*$M$8/2
Constructi	-55.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D

D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E

E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 27.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 18.07231 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

UDF -2.35378

Z 2.323998 =M36/M53

UDF 0.034226

Step 12: Determine significance

sig 0.0 M.S.DIST(ABS(M57);TRUE))

0.034226 =2*(1-NORMSDIST(ABS(M57)))

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

UDF 0.018584

sig	0.020126	=2*(1-NORM.S.DIST(ABS(M57);TRUE))
	0.020126	=2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	3	9.5	3	2
1	6	22	5	10
1	3	9.5		
1	5	17.5	4	5
1	7	25	1	0
1	6	22		
1	5	17.5		
1	5	17.5		
1	4	13.5	4	5
1	1	1.5	2	0.5
1	5	17.5		
2	2	5	3	2
2	4	13.5		
2	4	13.5		
2	3	9.5		
2	4	13.5		
2	6	22		
2	6	22		
2	6	22		
2	2	5		
2	2	5		
2	1	1.5		
2	2		0	0
2	2		0	0
2	3		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF	47
UDF	-1.66524
UDF	0.034226
UDF	0.095865

Mann-Whitney U test Material Losses QM CM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	15.72727	173	=SUMIF(A:A;G3;C:C)
Constructi	12.04545	132.5	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	107	=N24-M14
Constructi	27.5	

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	30	=M30-$M$7*$M$8/2
Constructi	-49.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 24.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 18.0936 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z 1.658045 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.0[illegible] [illegible]M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig	0.097308	=2*(1-NORM.S.DIST(ABS(M57);TRUE))
	0.097308	=2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	2	5	4	5
1	1	1.5	2	0.5
1	4	15	4	5
1	3	10	4	5
1	2	5		
1	7	24	3	2
1	6	20.5	4	5
1	6	20.5		
1	5	18	1	0
1	4	15		
1	6	20.5		
2	7	24		
2	6	20.5		
2	1	1.5		
2	2	5		
2	2	5		
2	3	10		
2	4	15		
2	7	24		
2	3	10		
2	3	10		
2	4	15		
2	3		0	0
2	4		0	0
2	2		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Quality Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF 89

UDF 0.666624

UDF 0.034226

UDF 0.505012

Mann-Whitney U test Labor Productivity QM CM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i+1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)

C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	14.09091	155	=SUMIF(A:A;G3;C:C)
Constructi	12.72727	140	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	89	=N24-M14
Constructi	35	

$$U_i = R_i - \frac{n_i \times (n_i+1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	12	=M30-$M$7*$M$8/2
Constructi	-42	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D

D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E

E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 22.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 18.10778 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z 0.662699 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.0[illegible] [illegible]M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.507524 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.507524 =2*(1-NORMSDIST(ABS(M57)))

Managerial	Opinion	Rank	t_i	T_i
1	4	10	6	17.5
1	3	5	2	0.5
1	5	15	3	2
1	4	10		
1	4	10		
1	2	2.5	2	0.5
1	7	22	6	17.5
1	7	22		
1	6	17.5	2	0.5
1	7	22		
1	7	22		
2	6	17.5		
2	7	22		
2	2	2.5		
2	1	1	1	0
2	5	15		
2	4	10		
2	7	22		
2	5	15		
2	4	10		
2	4	10		
2	3	5		
2	7		0	0
2	3		0	0
2	4		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding
1 Quality Manager
2 Construction Manager

Opinion coding
1 Highest
2
3
4
5
6
7 Lowest

UDF 92

UDF 0.841145

UDF 0.034226

UDF 0.400267

Mann-Whitney U test Overtime QM CM

Step 1: Counts

Group	n	
Quality Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Quality Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Quality Ma	14.36364	158	=SUMIF(A:A;G3;C:C)
Constructi	11.81818	130	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Quality Ma	92	=N24-M14
Constructi	25	

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Quality Ma	15	=M30-$M$7*$M$8/2
Constructi	-52	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i	38.5	=SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator	17.99403	=SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z	0.83361	=M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig	0.4	M.S.DIST(ABS(M57);TRUE))
	0.034226	=2*(1-NORMSDIST(ABS(M57)))
sig	0.404501	=2*(1-NORM.S.DIST(ABS(M57);TRUE))
	0.404501	=2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	4	8.5	2	0.5
1	1	2	3	2
1	7	23.5	4	5
1	5	10.5	2	0.5
1	3	5.5	4	5
1	6	16.5	7	28
1	7	23.5		
1	4	8.5		
1	3	5.5		
1	6	16.5		
1	3	5.5		
2	3	5.5		
2	5	10.5		
2	6	16.5		
2	7	23.5		
2	6	16.5		
2	7	23.5		
2	1	2		
2	1	2		
2	6	16.5		
2	6	16.5		
2	6	16.5		
2	6		0	0
2	6		0	0
2	6		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Project Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF 60

UDF -0.96685

UDF 0.034226

UDF 0.333617

Mann-Whitney U test Liquidated Damages PMCM

Step 1: Counts

Group	n	
Project Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Project Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)

C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Project Ma	11.45455	126	=SUMIF(A:A;G3;C:C)
Constructi	13.59091	149.5	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Project Ma	60	=N24-M14
Constructi	44.5	

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Project Ma	-17	=M30-$M$7*$M$8/2
Constructi	-32.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D

D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E

E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 41 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 17.97619 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z -0.9457 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.(M.S.DIST(ABS(M57);TRUE))

0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.344304 =2*(1-NORM.S.DIST(ABS(M57);TRUE))

0.344304 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	1	2.5	4	5
1	2	6	3	2
1	4	10.5	3	2
1	1	2.5		
1	1	2.5		
1	7	21.5	6	17.5
1	5	14.5	4	5
1	3	8	1	0
1	4	10.5		
1	4	10.5		
1	5	14.5		
2	5	14.5		
2	1	2.5		
2	7	21.5		
2	6	17	1	0
2	7	21.5		
2	5	14.5		
2	2	6		
2	2	6		
2	7	21.5		
2	7	21.5		
2	7	21.5		
2	4		0	0
2	7		0	0
2	7		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding
1 Project Manager
2 Construction Manager

Opinion coding
1 Highest
2
3
4
5
6
7 Lowest

Mann-Whitney U test Reputation Loss PMCM

Step 1: Counts

Group	n	
Project Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Project Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Project Ma	9.409091	103.5	=SUMIF(A:A;G3;C:C)
Constructi	15.27273	168	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Project Ma	37.5	=N24-M14
Constructi	63	

UDF 37.5

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Project Ma	-39.5	=M30-$M$7*$M$8/2
Constructi	-14	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 31.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 18.04388 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

UDF -2.21323

Z -2.18911 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

UDF 0.034226

Step 12: Determine significance

sig 0.0[illegible] [illegible]M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

UDF 0.026882

sig 0.028589 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.028589 =2*(1-NORMSDIST(ABS(M57)))

Managerial	Opinion	Rank	t_i	T_i
1	2	5.5	6	17.5
1	3	11	5	10
1	2	5.5		
1	2	5.5		
1	4	15	3	2
1	3	11		
1	2	5.5		
1	6	25	1	0
1	1	1.5	2	0.5
1	2	5.5		
1	4	15		
2	4	15		
2	3	11		
2	5	20.5	5	10
2	5	20.5		
2	1	1.5		
2	2	5.5		
2	3	11		
2	3	11		
2	5	20.5		
2	5	20.5		
2	5	20.5		
2	5		0	0
2	5		0	0
2	5		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding
1 Project Manager
2 Construction Manager

Opinion coding
1 Highest
2
3
4
5
6
7 Lowest

UDF 114

UDF 2.084096

UDF 0.037151

Mann-Whitney U test Cost Overruns PMCM

Step 1: Counts

Group	n	
Project Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group			
Project Ma	66	=M7*(M7+1)/2	$\frac{n_i \times (n_i + 1)}{2}$
Constructi	105		

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Project Ma	9.636364	106	=SUMIF(A:A;G3;C:C)
Constructi	14.31818	157.5	

Step 5: Determine difference with Max rank (U)

Group	Difference		
Project Ma	40	=N24-M14	$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$
Constructi	52.5		

Step 6: Determine numerator for Z

Group	Denom.		
Project Ma	-37	=M30-$M$7*$M$8/2	$U_i - \frac{n_1 \times n_2}{2}$
Constructi	-24.5		

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12) $T_i = \frac{t_i^3 - t_i}{12}$

Step 9: Sum the results of step 8

Sum T_i 40 =SUM(E:E) $T = \sum T_i$

Step 10: Determine denominator (= SE)

denominator 17.98333 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$

Step 11: Determine Z

Z -2.05746 =M36/M53

$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$

Step 12: Determine significance

sig 0.(M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.039642 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.039642 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	3	16.5	4	5
1	4	20.5	4	5
1	1	5.5	7	28
1	4	20.5		
1	2	12.5	4	5
1	5	23.5	2	0.5
1	3	16.5		
1	1	5.5		
1	2	12.5		
1	1	5.5		
1	6	25	1	0
2	1	5.5		
2	2	12.5		
2	3	16.5		
2	4	20.5		
2	3	16.5		
2	1	5.5		
2	5	23.5		
2	4	20.5		
2	1	5.5		
2	1	5.5		
2	2	12.5		
2	1		0	0
2	1		0	0
2	1		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Project Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF	56
UDF	-1.19559
UDF	0.034226
UDF	0.231857

Mann-Whitney U test Schedule Delays PMCM

Step 1: Counts

Group	n	
Project Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Project Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i+1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Project Ma	14.90909	164	=SUMIF(A:A;G3;C:C)
Constructi	13.13636	144.5	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Project Ma	98	=N24-M14
Constructi	39.5	

$$U_i = R_i - \frac{n_i \times (n_i+1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Project Ma	21	=M30-$M$7*$M$8/2
Constructi	-37.5	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 43.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 17.95833 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3-N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z 1.169374 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.034226 ...M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.242253 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.242253 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	5	18.5	4	5
1	7	24.5	2	0.5
1	5	18.5		
1	3	9.5	3	2
1	5	18.5		
1	4	14	5	10
1	4	14		
1	5	18.5		
1	3	9.5		
1	7	24.5		
1	2	4.5	4	5
2	2	4.5		
2	4	14		
2	4	14		
2	3	9.5		
2	4	14		
2	6	22	3	2
2	6	22		
2	6	22		
2	2	4.5		
2	2	4.5		
2	1	1	1	0
2	2		0	0
2	2		0	0
2	3		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Project Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

Mann-Whitney U test Material Loss PMCM

Step 1: Counts

Group	n	
Project Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Project Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i + 1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Project Ma	15.86364	174.5	=SUMIF(A:A;G3;C:C)
Constructi	12	132	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Project Ma	108.5	=N24-M14
Constructi	27	

UDF 45.5

$$U_i = R_i - \frac{n_i \times (n_i + 1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Project Ma	31.5	=M30-$M$7*$M$8/2
Constructi	-50	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 24.5 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 18.0936 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

UDF -1.75162

Z 1.740947 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

UDF 0.034226

Step 12: Determine significance

sig 0.0[illegible] [illegible]M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

UDF 0.079839

sig 0.081693 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.081693 =2*(1-NORMSDIST(ABS(M57)))

Manageri	Opinion	Rank	t_i	T_i
1	6	20	5	10
1	6	20		
1	3	10	4	5
1	6	20		
1	7	24	3	2
1	1	2	3	2
1	6	20		
1	2	5.5	3	2
1	5	16.5	2	0.5
1	5	16.5		
1	1	2		
2	7	24		
2	6	20		
2	1	2		
2	2	5.5		
2	2	5.5		
2	3	10		
2	4	14	2	0.5
2	7	24		
2	3	10		
2	3	10		
2	4	14		
2	3		0	0
2	4		0	0
2	2		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Project Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF	90.5
UDF	0.748176
UDF	0.034226
UDF	0.454354

Mann-Whitney U test Labor Productivity PMCM

Step 1: Counts

Group	n	
Project Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Project Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i+1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)

C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Project Ma	14.22727	156.5	=SUMIF(A:A;G3;C:C)
Constructi	12.63636	139	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Project Ma	90.5	=N24-M14
Constructi	34	

$$U_i = R_i - \frac{n_i \times (n_i+1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Project Ma	13.5	=M30-$M$7*$M$8/2
Constructi	-43	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D

D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E

E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 22 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 18.11132 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z 0.74539 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.0 ...M.S.DIST(ABS(M57);TRUE))

0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.456036 =2*(1-NORM.S.DIST(ABS(M57);TRUE))

0.456036 =2*(1-NORMSDIST(ABS(M57)))

Manageria	Opinion	Rank	t_i	T_i
1	7	22	6	17.5
1	5	13	3	2
1	6	16.5	4	5
1	7	22		
1	6	16.5		
1	2	3.5	2	0.5
1	1	1.5	2	0.5
1	7	22		
1	6	16.5		
1	3	6	2	0.5
1	7	22		
2	6	16.5		
2	7	22		
2	2	3.5		
2	1	1.5		
2	5	13		
2	4	9.5	3	2
2	7	22		
2	5	13		
2	4	9.5		
2	4	9.5		
2	3	6		
2	7		0	0
2	3		0	0
2	4		0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0
			0	0

Managerial Type Coding

1	Project Manager
2	Construction Manager

Opinion coding

1	Highest
2	
3	
4	
5	
6	
7	Lowest

UDF	95.5
UDF	1.029958
UDF	0.034226
UDF	0.30303

Mann-Whitney U test Labor Overtime PMCM

Step 1: Counts

Group	n	
Project Ma	11	=COUNTIF(A:A;G3)
Constructi	14	
total	25	=SUM(M7:M8)

Step 2:

Group		
Project Ma	66	=M7*(M7+1)/2
Constructi	105	

$$\frac{n_i \times (n_i+1)}{2}$$

Step 3: Determine ranks

Determine the rank for each respondent (use average rank)
C2: =RANK.AVG(B2;B:B;1)

Step 4: Determine average rank and sum of ranks per group

Group	Avg. Rank	Sum rank (R_i)	
Project Ma	14.68182	161.5	=SUMIF(A:A;G3;C:C)
Constructi	11.45455	126	

Step 5: Determine difference with Max rank (U)

Group	Difference	
Project Ma	95.5	=N24-M14
Constructi	21	

$$U_i = R_i - \frac{n_i \times (n_i+1)}{2}$$

Step 6: Determine numerator for Z

Group	Denom.	
Project Ma	18.5	=M30-$M$7*$M$8/2
Constructi	-56	

$$U_i - \frac{n_1 \times n_2}{2}$$

Step 7: Determine the number of tied scores (t_i)

See column D
D2: =IF(COUNTIF($C$1:C1;C2)>0;"";COUNTIF(C:C;C2))

Step 8: Determine the adjustment for ties per tied rank

See column E
E2: =IF(D2="";"";(D2^3-D2)/12)

$$T_i = \frac{t_i^3 - t_i}{12}$$

Step 9: Sum the results of step 8

Sum T_i 28 =SUM(E:E)

$$T = \sum T_i$$

Step 10: Determine denominator (= SE)

denominator 18.06876 =SQRT(M7*M8/(M9*(M9-1))*((M9^3-M9)/12-M49))

$$SE = \sqrt{\frac{n_1 \times n_2}{N(N-1)} \times \left(\frac{N^3 - N}{12} - \sum_i T_i\right)}$$

Step 11: Determine Z

Z 1.023867 =M36/M53

$$Z = \frac{U_i - \frac{n_1 \times n_2}{2}}{SE}$$

Step 12: Determine significance

sig 0.0 M.S.DIST(ABS(M57);TRUE))
0.034226 =2*(1-NORMSDIST(ABS(M57)))

sig 0.305898 =2*(1-NORM.S.DIST(ABS(M57);TRUE))
0.305898 =2*(1-NORMSDIST(ABS(M57)))

8. Complexity in Evaluating Quality Performance
Cronbach's Alpha Result:
Cronbach Alpha α= Total Number of Items/(Total Number of items – 1)*(1-Sum of Item Variances/Variance Total) Below is the Likert scale responses received by FM and QM.

Managerial Type	Item 1 Costs accounted with rectifying non-conformance through construction rework	Item 2 Costs accounted with rectifying non-conformance through design rework	Item 3 Total cost for QAQC personnel for a specific task (Activity-Based costing) -	Item 4 Inspection costs for Extra Low Voltage Systems (HVAC and Lighting Control)	Item 5 Revising Design Drawings to Achieve Code Compliance Before Construction Drawings	Item 6 Testing and Balancing of Water Systems	Item 7 Factory Tests for High Voltage Switchgears	Item 8 Repair of Green Building Technology Defects After Handover (e.g. HVAC/Greywater system/rainwater system)	Item 9 Indoor humidity and Mold Growth from Ventilation	Item 10 Installation errors from inexperienced sub- contractors	Item 11 Power surges affecting software glitches for building automation systems causing water systems' cistern malfunction	Item 12 6 Month Chemical and Bacterial Test of Drinking Water Systems	Item 13 Plumbing Defects: Water Hammer, Back-Siphonage
FM			3	2		2	2	5	3	3	2	2	2
FM			3	4		4	3	4	4	2	3	5	4
FM			1	2		3	3	3	4	3	4	3	3
FM			3	4		3	4	4	1	1	1	1	5
FM			3	1		1	1	4	4	2	1	1	3
FM			1	4		4	4	4	4	4	4	2	3
FM			2	2		4	3	5	4	4	3	4	3
QM	5	4	2	2	3	3	3	5	5	4	4		
QM	5	3	3	3	2	3	5	5	3	3	4		
QM	4	3	3	3	4	3	3	3	2	4	4		
QM	4	3	3	2	2	3	2	4	3	4	4		
QM	4	4	3	3	4	3	3	5	4	4	5		
QM	5	2	4	4	3	5	4	4	4	5	5		
QM	2	3	3	2	2	2	2	4	2	3	3		
QM	4	4	3	3	4	5	5	2	4	4	4		
QM	5	2	2	3	3	3	3	5	4	5	5		
QM	2	4	4	3	4	3	3	5	4	5	5		
QM	3	2	1	2	1	2	3	4	3	4	3		
QM	2	2	6	4	5	2	2	6	6	6	5		
QM	3	3	3	3	3	3	3	3	3	3	3		
QM	4	2	2	3	3	3	3	3	5	4	4		
Variances	1.109375	0.6875	1.859375	0.359375		1.359375	0.859375	0.75	1.5		1.359375	1.36	
Simple	3	4	6	4		3	4	2	2		1	3	
Complex	5	4	7	9		10	9	11	11		12	2	

# Items/Questions	13
Sum of item variances	13.04
Variance of Total Scores	41.06
Cronbach's alpha	0.7

Likert Scale

1	Very Simple
2	Somewhat Simple
3	Neutral
4	Complex
5	Very Complex
6	Not Feasible

9. T-test results for Complexity Comparisons between Managerial types

Item 1: Costs accounted with rectifying non-conformance through construction rework (QM Only)	
Mean	3.714285714
Variance	1.296703297
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	2.34701397
P(T<=t) one-tail	0.017711332
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.035422664
t Critical two-tail	2.160368656

Item 2: Costs accounted with rectifying non-conformance through design rework (QM Only)	
Mean	2.928571429
Variance	0.686813187
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	-0.32249031
P(T<=t) one-tail	0.376104494
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.752208987
t Critical two-tail	2.160368656

Item 3: Total cost for QAQC personnel for a specific task (Activity-Based costing) (QM and FM)	
Mean	2.761904762
Variance	1.29047619
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	-0.960473438
P(T<=t) one-tail	0.174142938
t Critical one-tail	1.724718243
P(T<=t) two-tail	0.348285875
t Critical two-tail	2.085963447

Item 3: Total cost for QAQC personnel for a specific task (Activity-Based costing) (QM Only)	
Mean	3
Variance	1.384615385
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	0
P(T<=t) one-tail	0.5
t Critical one-tail	1.770933396
P(T<=t) two-tail	1
t Critical two-tail	2.160368656

Item 3: Total cost for QAQC personnel for a specific task (Activity-Based costing) (FM Only)	
Mean	2.285714286
Variance	0.904761905
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	-1.986798536
P(T<=t) one-tail	0.047066383
t Critical one-tail	1.943180281
P(T<=t) two-tail	0.094132767
t Critical two-tail	2.446911851

Item 4: Inspection costs for Extra Low Voltage Systems (HVAC and Lighting Control) (QM and FM)	
Mean	2.8095238
Variance	0.7619048
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	-1
P(T<=t) one-tail	0.1646283
t Critical one-tail	1.7247182
P(T<=t) two-tail	0.3292566
t Critical two-tail	2.0859634

Item 4: Inspection costs for Extra Low Voltage Systems (HVAC and Lighting Control) (QM Only)	
Mean	2.857142857
Variance	0.43956044
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	-0.806225775
P(T<=t) one-tail	0.217306935
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.434613871
t Critical two-tail	2.160368656

Item 4: Inspection costs for Extra Low Voltage Systems (HVAC and Lighting Control) (FM Only)	
Mean	2.714285714
Variance	1.571428571
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	-0.603022689
P(T<=t) one-tail	0.284285628
t Critical one-tail	1.943180281
P(T<=t) two-tail	0.568571257
t Critical two-tail	2.446911851

Item 5: Revising Design Drawings to Achieve Code Compliance before issuing Issue for Construction designs (QM Only)	
Mean	3.071428571
Variance	1.148351648
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	0.249401197
P(T<=t) one-tail	0.403473882
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.806947764
t Critical two-tail	2.160368656

Item 6: Testing and Balancing of Water Systems (QM and FM)	
Mean	3.047619048
Variance	0.947619048
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	0.22416792
P(T<=t) one-tail	0.412450396
t Critical one-tail	1.724718243
P(T<=t) two-tail	0.824900791
t Critical two-tail	2.085963447

Item 6: Testing and Balancing of Water Systems (QM Only)	
Mean	3.071428571
Variance	0.840659341
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	0.291491544
P(T<=t) one-tail	0.387637299
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.775274599
t Critical two-tail	2.160368656

Item 6: Testing and Balancing of Water Systems (FM Only)	
Mean	3
Variance	1.3333333
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	0
P(T<=t) one-tail	0.5
t Critical one-tail	1.9431803
P(T<=t) two-tail	1
t Critical two-tail	2.4469119

Item 7: Factory Tests for High Voltage Switchgears	
Mean	3.047619048
Variance	0.947619048
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	0.22416792
P(T<=t) one-tail	0.412450396
t Critical one-tail	1.724718243
P(T<=t) two-tail	0.824900791
t Critical two-tail	2.085963447

Item 8: Factory Tests for High Voltage Switchgears (QM and FM)	
Mean	3.142857143
Variance	0.901098901
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	0.563092506
P(T<=t) one-tail	0.291476902
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.582953803
t Critical two-tail	2.160368656

Item 8: Factory Tests for High Voltage Switchgears (QM Only)	
Mean	2.857142857
Variance	1.142857143
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	-0.353553391
P(T<=t) one-tail	0.36788243
t Critical one-tail	1.943180281
P(T<=t) two-tail	0.73576486
t Critical two-tail	2.446911851

Item 9: Repair of Green Building Technology Defects After Handover (e.g. HVAC/Greywater system/rainwater system) (QM and FM)	
Mean	4.142857143
Variance	0.928571429
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	5.434929764
P(T<=t) one-tail	1.27521E-05
t Critical one-tail	1.724718243
P(T<=t) two-tail	2.55041E-05
t Critical two-tail	2.085963447

Item 9: Repair of Green Building Technology Defects After Handover (e.g. HVAC/Greywater system/rainwater system) (QM Only)	
Mean	4.142857143
Variance	1.208791209
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	3.889379478
P(T<=t) one-tail	0.000931619
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.001863239
t Critical two-tail	2.160368656

Item 9: Repair of Green Building Technology Defects After Handover (e.g. HVAC/Greywater system/rainwater system) (FM Only)	
Mean	4.1428571
Variance	0.4761905
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	4.3817805
P(T<=t) one-tail	0.0023296
t Critical one-tail	1.9431803
P(T<=t) two-tail	0.0046592
t Critical two-tail	2.4469119

Item 10: Indoor humidity and mold growth from ventilation (QM and FM)	
Mean	3.619047619
Variance	1.247619048
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	2.539760162
P(T<=t) one-tail	0.009750431
t Critical one-tail	1.724718243
P(T<=t) two-tail	0.019500862
t Critical two-tail	2.085963447

Item10: Indoor humidity and mold growth from ventilation (QM Only)	
Mean	3.714285714
Variance	1.296703297
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	2.34701397
P(T<=t) one-tail	0.017711332
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.035422664
t Critical two-tail	2.160368656

Item 10: Indoor humidity and mold growth from ventilation (FM Only)	
Mean	3.428571429
Variance	1.285714286
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	1
P(T<=t) one-tail	0.177958842
t Critical one-tail	1.943180281
P(T<=t) two-tail	0.355917684
t Critical two-tail	2.446911851

Item 11: Installation errors from inexperienced sub-contractors (QM and FM)	
Mean	3.666666667
Variance	1.333333333
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	2.645751311
P(T<=t) one-tail	0.007754512
t Critical one-tail	1.724718243
P(T<=t) two-tail	0.015509024
t Critical two-tail	2.085963447

Item 11: Installation errors from inexperienced sub-contractors (QM Only)	
Mean	4.142857143
Variance	0.747252747
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	4.946775539
P(T<=t) one-tail	0.00013348
t Critical one-tail	1.770933396
P(T<=t) two-tail	0.00026696
t Critical two-tail	2.160368656

Item 11 Installation errors from inexperienced sub-contractors (FM Only)	
Mean	2.7142857
Variance	1.2380952
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	-0.6793662
P(T<=t) one-tail	0.2611182
t Critical one-tail	1.9431803
P(T<=t) two-tail	0.5222364
t Critical two-tail	2.4469119

Item 12: Power surges affecting software glitches for building automation systems causing water systems' cistern malfunction (QM and FM)	
Mean	3.619047619
Variance	1.447619048
Observations	21
Hypothesized Mean Difference	3
df	20
t Stat	2.357797813
P(T<=t) one-tail	0.01433977
t Critical one-tail	1.724718243
P(T<=t) two-tail	0.028679541
t Critical two-tail	2.085963447

Power surges affecting software glitches for building automation systems causing water systems' cistern malfunction (QM Only)	
Mean	4.142857143
Variance	0.593406593
Observations	14
Hypothesized Mean Difference	3
df	13
t Stat	5.551109332
P(T<=t) one-tail	4.68355E-05
t Critical one-tail	1.770933396
P(T<=t) two-tail	9.36709E-05
t Critical two-tail	2.160368656

Power surges affecting software glitches for building automation systems causing water systems' cistern malfunction (FM Only)	
Mean	2.571428571
Variance	1.619047619
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	-0.891132789
P(T<=t) one-tail	0.203585254
t Critical one-tail	1.943180281
P(T<=t) two-tail	0.407170508
t Critical two-tail	2.446911851

6 Month Chemical and Bacterial Test of Drinking Water Systems (FM Only)	
Mean	2.571428571
Variance	2.285714286
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	-0.75
P(T<=t) one-tail	0.240808907
t Critical one-tail	1.943180281
P(T<=t) two-tail	0.481617814
t Critical two-tail	2.446911851

Plumbing defects: Water hammer, back-siphonage (FM Only)	
Mean	3.285714286
Variance	0.904761905
Observations	7
Hypothesized Mean Difference	3
df	6
t Stat	0.794719414
P(T<=t) one-tail	0.228525824
t Critical one-tail	1.943180281
P(T<=t) two-tail	0.457051648
t Critical two-tail	2.446911851