CHAPTER 6

CONTINGENCY ESTIMATION MODEL

6.0 Introduction

We have concluded that there is significant relationship between the perceptions of the stakeholder pertaining to contingency on project performance resulting from the analysis and interpretation made in the previous chapter concluding the Objective # 1 & 2 of this study.

The formulation of a mitigation strategy, being part of the Objective # 3 of this study, was conceived as a Contingency Estimation Model suitable for application in the projects for Construction of Substation in UAE.

However, for formulation of this Model, the input data are obtained by means of analysis of the already collected responses as well as obtaining further details again from the respondents of earlier response for each category based project allocation. These input data were then utilized along with the regression formula obtained after regression analysis and applying the factor loading values of the risk variables from factor analysis output from Objective # 1 and reference range of the cost performance as represented in the Questionnaire # 2 for Objective # 2. This resultant output is the % Contingency that the model has estimated for application in the projects for Construction of Substation in UAE.

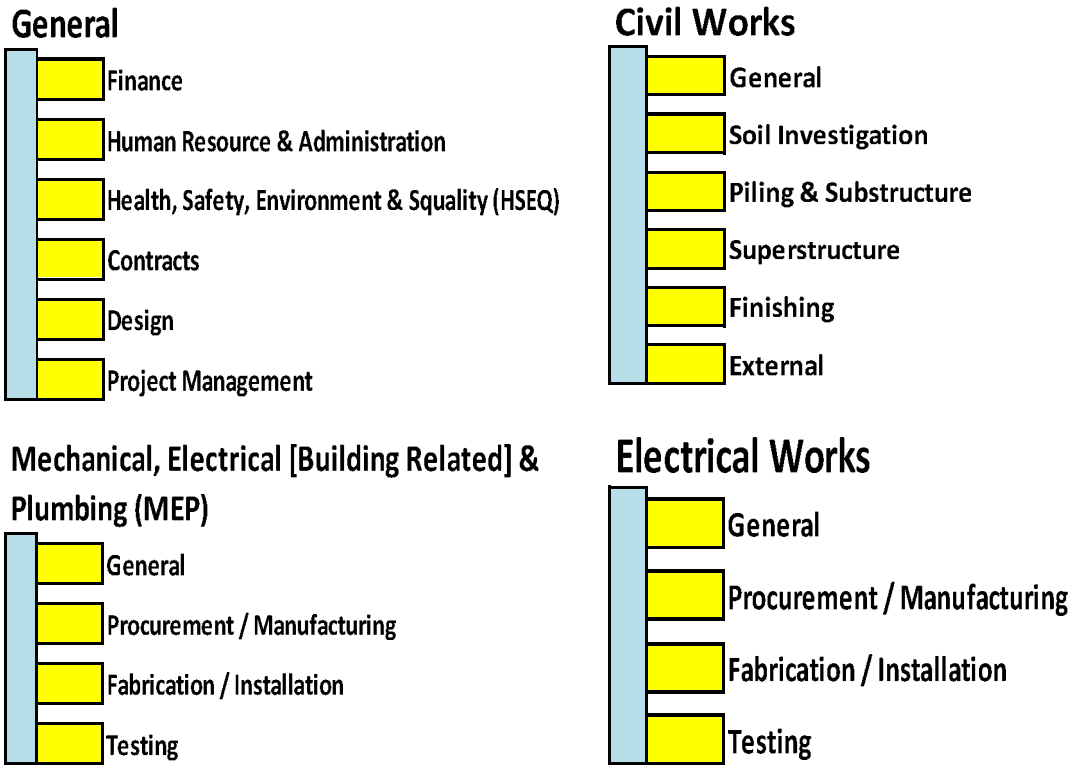
A process of validation of the output has been taken up with the data of one of the executed project by putting the piece of available information into the form of the Contingency Estimation Model to equate the viability of the contingency perception of various stakeholders resulted in the % Contingency as output of the

model and the actual Contingency as incurred for completing the referred project executed; providing us with a glimpse of the importance of the Contingency requirement and its impact on the performance outcome of the project, which are further detailed in the subsequent sections.

6.1 Allocation of Project Value to Various Categories

The Work Break Down categorization as suggested and implemented in the initial stages of this study binds the basis for further model development under this section; while the categorization has been evolved earlier, their percentage of allocation against the overall project value still remains a fact to be taken up.

The basic categorization as carried out and detailed at Chapter 4 is further utilized for the percentage allocation of the project value, which is attained in 2 steps, first for the Technical Categories, i.e. Civil, Electrical & MEP and then for the General Categories or so called Non-Technical Categories.



The % allocation of the project value for the Technical categories was considered to be obtained from the Contract Bill of Quantities which indicates the break up for all the works involved in the project. However, there is no such data available for the % allocation of project value for the non-technical categories. In order to overcome this situation, it was suggested by experts to arrange for another Questionnaire to obtain the required data from the project professionals. Subsequently, the suggestions of the members who had participated in the Nominal Group Technique session have to be utilized to finalize the allocation. The following steps details the process of allocation of the project value for the Technical & Non-Technical (Support) categories.

6.1.1 Allocation of Project Value - Technical Categories (Step 1)

The Contract Bill of Quantities of various executed projects was collected and is reviewed for their allocation against the various technical categories. It was noted from the available data that the major grouping of Electrical, Civil and MEP works are reflected in same way in the Contract Bill of Quantities, however, further Categorization as done for each of the Electrical, Civil & MEP works as shown above are not completely available as absolute value. Hence, based on the Contract Bill of Quantities, the three major Technical Activities were grouped together for some of its categories from earlier 14 categories into six categories within them matching with the project value allocation, as listed below in Table 6.1.

The Contract Bill of Quantities of 10 projects ranging from a value of around 20 Million USD to 200 Million USD was taken up and the values of individual items were grouped based on the above group of technical categories as shown in Table 6.1. The result of such data is as given in Table 6.2.

Table 6.1 – Summary of Categories Grouped based on Contract Bill of Quantities

S. NO.	GROUP	CATEGORIES AS PER WORK BREAKDOWN STRUCTURE	CATEGORIES AS PER CONTRACT BILL OF QUANTITIES (PROJECT VALUE ALLOCATION)
6	CIVIL	Civil - General	CIVIL - General + Soil Investigation + Piling / Sub Strucuture
7		Civil - Soil Investigation	
8		Civil - Piling / Sub Structure	
9		Civil - Super Structure	CIVIL - Super Structure / Finishing
10		Civil - Finishing	
11		Civil - External	CIVIL - External Works
12	MEP	MEP - General	MEP Works
13		MEP - Procurement / Manufacturing	
14		MEP - Fabrication / Installation	
15		MEP - Testing	
16	ELECTRICAL	Electrical - General	ELECTRICAL - General + Procurement / Manufacturing
17		Electrical - Procurement / Manufacturing	
18		Electrical - Installation	ELECTRICAL - Installation + Testing & Commissioning
19		Electrical - Testing	

Table 6.2 – % Allocation of Value of Contract Bill of Quantities against Technical categories

SL NO	CATEGORIES	PROJ-1	PROJ-2	PROJ-3	PROJ-4	PROJ-5	PROJ-6	PROJ-7	PROJ-8	PROJ-9	PROJ-10	MIN	MAX	MEDIAN	AVERAGE
6,7,8	CIVIL - General / SI / Piling / Sub Stru	6.804%	6.867%	4.405%	3.074%	5.510%	3.323%	8.741%	5.502%	4.385%	3.835%	3.074%	8.741%	4.953%	5.245%
9,10	Civil - Super structure / Finishing	10.875%	7.936%	7.175%	2.721%	4.596%	8.381%	17.896%	14.518%	10.233%	8.948%	2.721%	17.896%	8.664%	9.328%
11	Civil - External	2.762%	3.940%	3.268%	2.178%	3.531%	1.698%	3.437%	3.729%	2.985%	2.814%	1.698%	3.940%	3.127%	3.034%
12,13,14, 15	Mechanical, Electrical & Plumbing - Complete	6.706%	4.490%	4.921%	4.002%	5.019%	4.062%	10.764%	9.747%	6.315%	7.022%	4.002%	10.764%	5.667%	6.305%
16,17	ELEC - General / Proc & Mfg	59.191%	65.480%	74.715%	70.826%	70.945%	75.370%	56.572%	63.399%	67.118%	71.994%	56.572%	75.370%	68.972%	67.561%
18,19	ELEC - Installation / T&C	13.661%	11.288%	5.516%	17.199%	10.399%	7.166%	2.591%	3.105%	8.964%	5.387%	2.591%	17.199%	8.065%	8.528%
	TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	70.66%	133.91%	99.45%	100.00%

Since the % allocation of the project value as per the Contract Bill of quantities varies, a detailed review of the Minimum, Maximum, Median and Average value of the % allocation of the 10 projects against technical categories groups were

made. The data as available were taken up for a discussion with the members who had participated in the Nominal Group Technique session while finalizing the Risk Variables and their grouping. It was suggested by the NGT members to consider the Average value as obtained which in their view is more realistic for application in the Model development to reach the Contingency estimate.

The % project value allocation towards the Technical Categories, (which were earlier grouped based on the available breakdown for various Work Group Categories), as obtained from the secondary data related to the executed projects. This % project value allocation result as tabulated above were considered for the model development duly concurring along with the suggestions as received from the various members of the NGT session.

6.1.2 Allocation of Project Value – Non-Technical Categories (Step 2)

Since there is no specific data available for the Non-Technical categories (Support functions), it was suggested to send a separate Questionnaire to various project professionals to obtain their opinion on the % allocation of the project value towards these support function categories. Accordingly, a Questionnaire was prepared listing out these six support functions, i.e. Finance, Human Resource / Administration, HSEQ, Contracts, Design & Project Management, the same was sent to various project professionals, specifically working on the overall implementation of the project, who can provide an insight on the complete project not only on any specific part and are independently managing the project, so as to have a much suitable responses for taking up further analysis and utilization for the model formulation.

The % project value allocation, as received from the respondents along with the average value calculated, is tabulated and appended at Table 6.3 below.

Table 6.3 - % project value allocation as received from the respondents

RESPONSE TO QUESTIONNAIRE # 4

% ALLOCATION OF SUPPORT FUNCTIONS COST IN THE OVERALL PROJECT COST

RESPONSES / % ALLOCATION

SL NO	CATEGORIES	1	2	3	4	5	6	7	8	9	10	11	12	Average
1	FINANCE	2.00	1.00	1.00	10.00	1.00	1.00	2.00	3.50	5.00	1.50	2.00	5.00	**2.917**
2	HUMAN RESOURCE / ADMINISTRATION	3.00	1.00	1.00	5.00	1.00	1.00	4.00	2.50	5.00	3.50	3.00	2.00	**2.667**
3	Health, Safety, Environment & Quality (HSEQ)	2.00	1.00	1.00	5.00	2.00	-	1.00	5.50	5.00	1.00	2.00	3.00	**2.375**
4	CONTRACTS	2.00	1.00	2.00	5.00	1.00	5.00	1.50	9.00	5.00	1.00	1.00	5.00	**3.208**
5	DESIGN	8.00	6.00	15.00	10.00	10.00	3.00	6.50	8.00	5.00	6.00	7.00	15.00	**8.292**
20	PROJECT MANAGEMENT	3.00	2.00	5.00	20.00	5.00	30.00	3.00	11.00	10.00	2.50	3.00	5.00	**8.292**

The data as available were taken up for a discussion with the members who had participated in the Nominal Group Technique session while finalizing the Risk Variables and their grouping. It was suggested by the NGT members to consider the Average value as obtained which in their view should be suitable for utilization in the Model development to reach the Contingency estimate.

6.1.3 Allocation of Project Value – Re-Allocation inclusive of both Technical & Non-Technical Categories (Step 3)

Since the % allocation of the project value for the Technical categories as obtained are referred to with the 100% value of the project without any consideration towards the non-technical categories and % allocation of the project value for the non-technical categories as obtained are referred to their % allocation for each of the non-technical categories referred to overall project value inclusive of the technical categories, it requires needful recalculation of the % allocation for the Technical Categories. The non-technical categories upon averaging works out to be 27.75% of the project value allocation towards them,

which results in the technical categories ending up with 72.25% of the project value (100 – 27.75), which results in re-allocation of these technical category values to 72.25% by proportioning the already obtained value. The same has been taken up and the resultant of the overall % allocation of the project value is appended at Table 6.4 below.

Table 6.4 – Overall % allocation of project value

		Step 1	Step 2	Step 3
S. NO.	CATEGORIES	% Allocation for Main Categories from Project Value	% Allocation for Support Categories	Allocation to Overall Project %
1	FINANCE	Not Applicable	2.92%	2.92%
2	Human Resource / Administration	Not Applicable	2.67%	2.67%
3	Health, Safety, Environment & Quality	Not Applicable	2.38%	2.38%
4	CONTRACTS	Not Applicable	3.21%	3.21%
5	Design	Not Applicable	8.29%	8.29%
6	Civil - General	5%	Not Applicable	3.61%
7	Civil - Soil Investigation			
8	Civil - Piling / Sub Structure			
9	Civil - Super Structure	9%	Not Applicable	6.50%
10	Civil - Finishing			
11	Civil - External	3%	Not Applicable	2.17%
12	MEP - General	6%	Not Applicable	4.34%
13	MEP - Procurement / Manufacturing			
14	MEP - Fabrication / Installation			
15	MEP - Testing			
16	Electrical - General	68%	Not Applicable	49.13%
17	Electrical - Procurement / Manufacturing			
18	Electrical - Installation	9%	Not Applicable	6.50%
19	Electrical - Testing			
20	Project Management	Not Applicable	8.29%	8.29%
	Total	100%	27.75%	100%

This allocation as above was utilized as input for the Contingency Estimation Modelling in the subsequent sections of this chapter.

6.2 Multivariate Analysis

For the formulation of the Contingency Estimation Model, the data as received during the Objective # 2, i.e. while concurring the significant relationship between the perception of the stakeholder pertaining to contingency on project performance, the Probability of occurrence of risk variables & the associated Cost Performance are considered for further analysis and utilization. Multivariate Analysis using SPSS was carried out for each Category as obtained from the project value allocation table, with Cost Performance as Dependent variable while the Probability of occurrence of risk variables as Independent variable.

The respondent data were taken up and the analysis was carried out and the following checks were carried out to confirm to the statistically significance of the output that is being worked out:

- Significance value to be kept below 0.05
- The R2 / Adjusted R2 values to be as much as larger.

In order to achieve the above requirement of the Significance & the R2/Adjusted R2 values, various data manipulation be means of re-analysis of the data of each category were carried out until we get an output which confirms to the following criteria which confirms to statistically significance:

- Significance value was checked & re-analyzed until the value reaches below 0.05.
- The R2 / Adjusted R2 values were made as much as larger.

The output of the data analysis is attached as Appendix A11, while the summary of the output is as appended in the ensuing Table 6.5.

TABLE 6.5 - SUMMARY OF REGRESSION ANALYSIS OUTPUT				COST PERFORMANCE DATA ANALYSIS								
CATEGORIES	Seq. No.	RISK VARIABLES	No. of Risk Variables	R^2	Adj R^2	Durban Watson	F	Sig.	B (Constant)(unstd.)	Sig. (Constant)	B (Ind.Var) (unstd.)	Ind. Var. Sign.
FINANCE	1	Invoicing by Contractor to Client	6	0.849	0.828	1.977	39.504	0.000	0.523	0.018		
	2	Cash In Flow [i.e. Liquidity]									0.203	0.000
	3	Inflation / Price Fluctuation										
	4	High Interest Rate									0.218	0.001
	5	Exchange Rate Fluctuation									0.252	0.000
	6	Periodic Audits									0.224	0.000
HR / ADMIN	1	Requirement for No Objection (NOC) / Approvals from Statutory Bodies	5	0.654	0.61	1.794	15.094	0	0.903	0.027	0.250	0.015
	2	Cultural Impact / Personality Impact / Language Impact									0.210	0.018
	3	Resources Deployment										
	4	Utilization of Resources										
	5	Natural Calamity									0.376	0.000
HSEQ	1	Natural Calamity	9	0.715	0.694	1.976	33.488	0.000	1.108	0.000	0.147	0.019
	2	Laws and Regulations and the changes during the tenure of the contract									0.206	0.003
	3	HSE Plan at site, Induction of Site team, Awaraness Program, Training & Safety Signs.									0.341	0.000
	4	Inspection & Audits, Housekeeping & Control, Risk Assessment & Method Statements										
	5	Shutdown for carrying out Modification / Tie-in										
	6	Warranty requirements										
	7	Periodic Medical Checks / Physical Exercise / Fitness										
	8	Quality of Material										
	9	Quality of Workmanship										

TABLE 6.5 - SUMMARY OF REGRESSION ANALYSIS OUTPUT				COST PERFORMANCE DATA ANALYSIS								
CATEGORIES	Seq. No.	RISK VARIABLES	No. of Risk Variables	R^2	Adj R^2	Durban Watson	F	Sig.	B (Constant) (unstd.)	Sig. (Constant)	B (Ind.Var) (unstd.)	Ind. Var. Sign.
CONTRACTS	1	Variation to the Contract	5	0.583	0.559	1.919	24.245	0.000	1.011	0.004	0.253	0.003
	2	Suspension of Work by Client									0.239	0.000
	3	Acceptance of Work by Client / Consultant									0.260	0.001
	4	Default of the Vendor										
	5	Accidents & Injuries										
DSGN	1	Laws and Regulations and the changes during the tenure of the contract	8	0.689	0.662	1.811	25.532	0.000	0.690		0.176	0.011
	2	Geo-Technical conditions										
	3	Input from Client / Consultant / Other Contractors										
	4	Provision of Interfaces details by Client / Consultant for Tie-ins									0.300	0.002
	5	Approval of Design Documents									0.168	0.038
	6	Decision making by Client										
	7	Employee Turnover & Availability of Skilled Personnel									0.190	0.016
	8	Dependence on external sources										

TABLE 6.5 - SUMMARY OF REGRESSION ANALYSIS OUTPUT				COST PERFORMANCE DATA ANALYSIS								
CATEGORIES	Seq. No.	RISK VARIABLES	No. of Risk Variables	R^2	Adj R^2	Durban Watson	F	Sig.	B (Constant) (unstd.)	Sig. (Constant)	B (Ind.Var) (unstd.)	Ind. Var. Sign.
CIVIL - Gen / Sub Stru	CI-A.1	Default of the Vendor	5	0.809	0.795	1.981		0.000	1.122	0.000		
	CI-A.2	Claims / Variation / Litigation by Supplier / Subcontractor (Vendors)										
	CI-A.3	Dependence on external sources										
	CI-A.4	Laws and Regulations and the changes during the tenure of the contract									0.352	0.000
	CI-A.5	Requirement for No Objection (NOC) / Approvals from Statutory Bodies										
	CI-B.1	Input from Client / Consultant / Other Contractors	2									
	CI-B.2	Site Level & Access road confirmation										
	CI-C.1	Requirement for Building Permits / Civil Defence Approvals	8									
	CI-C.2	Site Level & Access road confirmation										
	CI-C.3	Geo-Technical conditions									0.206	0.000
	CI-C.4	Duration is short / Un realistic										
	CI-C.5	Dependence on external sources										
	CI-C.6	Quality of Workmanship										
	CI-C.7	Accidents & Injuries										
	CI-C.8	Inflation / Price Fluctuation									0.169	0.000

TABLE 6.5 - SUMMARY OF REGRESSION ANALYSIS OUTPUT				COST PERFORMANCE DATA ANALYSIS								
CATEGORIES	Seq. No.	RISK VARIABLES	No. of Risk Variables	R^2	Adj R^2	Durban Watson	F	Sig.	B (Constant) (unstd.)	Sig. (Constant)	B (Ind.Var) (unstd.)	Ind. Var. Sign.
CIVIL - Sup. Stru	CI-D.1	Availability of Raw Materials / Construction Materials	4	0.685	0.667	2.010	39.078	0.000	1.044			
	CI-D.2	Duration is short / Un realistic										
	CI-D.3	Accidents & Injuries										
	CI-D.4	Inflation / Price Fluctuation									0.482	0.000
	CI-E.1	Availability of Raw Materials / Construction Materials	5									
	CI-E.2	Inflation / Price Fluctuation										
	CI-E.3	Quality of Material										
	CI-E.4	Quality of Workmanship									0.242	0.003
	CI-E.5	Accidents & Injuries										
CIVIL - Ext Works	CI-F.1	Competency Approval / Work Permits from Competent Authorities	4	0.675	0.657	1.804	37.335	0.000	0.985	0.001	0.270	0.002
	CI-F.2	Dependence on external sources										
	CI-F.3	Accidents & Injuries										
	CI-F.4	Inflation / Price Fluctuation									0.475	0.000

TABLE 6.5 - SUMMARY OF REGRESSION ANALYSIS OUTPUT				COST PERFORMANCE DATA ANALYSIS								
CATEGORIES	Seq. No.	RISK VARIABLES	No. of Risk Variables	R^2	Adj R^2	Durban Watson	F	Sig.	B (Constant) (unstd.)	Sig. (Constant)	B (Ind.Var) (unstd.)	Ind. Var. Sign.
MEP	MEP-A.1	Vendor Selection	5	0.766	0.744	1.435	33.613	0.000		0.003		
	MEP-A.2	Vendor Performance and Relationship									0.174	0.012
	MEP-A.3	Claims / Variation / Litigation by Supplier / Subcontractor (Vendors)										
	MEP-A.4	Dependence on external sources										
	MEP-A.5	Requirement for No Objection (NOC) / Approvals from Statutory Bodies										
	MEP-B.1	Delivery of Materials / Equipment / Execution of Work	4									
	MEP-B.2	Material Handling / Storing									0.360	0.000
	MEP-B.3	Sub Vendor Performance and Relationship										
	MEP-B.4	Default of the Sub-Vendor										
	MEP-C.1	Duration is short / Un realistic	5									
	MEP-C.2	Quality of Material										
	MEP-C.3	Quality of Workmanship										
	MEP-C.4	Accidents & Injuries									0.155	0.019
	MEP-C.5	Natural Calamity										
	MEP-D.1	Decision making by Client	6									
	MEP-D.2	Witness Engineer by Client for Factory Tests / Type Tests / Site Tests										
	MEP-D.3	Failure of Equipment									0.132	0.049
	MEP-D.4	Dependence on external sources										
	MEP-D.5	Air Quality / Noise Level / Waste around the work place										
	MEP-D.6	Operation & Maintenance during Warranty Period including Training to Client										

TABLE 6.5 - SUMMARY OF REGRESSION ANALYSIS OUTPUT				COST PERFORMANCE DATA ANALYSIS								
CATEGORIES	Seq. No.	RISK VARIABLES	No. of Risk Variables	R^2	Adj R^2	Durban Watson	F	Sig.	B (Constant) (unstd.)	Sig. (Constant)	B (Ind.Var) (unstd.)	Ind. Var. Sign.
ELECTRICAL WORKS (GEN / SUPPLY)	EL-A.1	**Vendor Selection**	5	0.517	0.490		19.289	0.000	1.524	0.000		
	EL-A.2	**Vendor Performance and Relationship**										
	EL-A.3	**Default of the Vendor**									0.255	0.000
	EL-A.4	**Claims / Variation / Litigation by Supplier / Subcontractor (Vendors)**										
	EL-A.5	**Dependence on external sources**									0.136	0.030
	EL-B.1	**Exchange Rate Fluctuation**	5								0.192	0.001
	EL-B.2	**Material Handling / Storing**										
	EL-B.3	**Delivery of Materials / Equipment**										
	EL-B.4	**Vendor Performance and Relationship**										
	EL-B.5	**Default of the Vendor**										

TABLE 6.5 - SUMMARY OF REGRESSION ANALYSIS OUTPUT

CATEGORIES	Seq. No.	RISK VARIABLES	No. of Risk Variables	R^2	Adj R^2	Durban Watson	F	Sig.	B (Constant) (unstd.)	Sig. (Constant)	B (Ind.Var) (unstd.)	Ind. Var. Sign.
ELECTRICAL WORKS (INST / TESTING)	EL-C.1	Duration is short / Un realistic	4	0.419	0.397	1.766	19.793	0.000	1.868	0.000		
	EL-C.2	Material Handling / Storing									0.303	0.001
	EL-C.3	Accidents & Injuries										
	EL-C.4	Natural Calamity										
	EL-D.1	Decision making by Client	8									
	EL-D.2	Provision of Interfaces details by Client / Consultant for Tie-ins										
	EL-D.3	Witness Engineer by Client for Factory Tests / Type Tests / Site Tests										
	EL-D.4	Testing Equipment Availability										
	EL-D.5	Dependence on external sources										
	EL-D.6	Quality of Material									0.163	0.042
	EL-D.7	Quality of Workmanship										
	EL-D.8	Accidents & Injuries										
PROJ MGMT	1	Project Charter / Project Management Plan	5	0.272	0.240	1.929	8.584	0.001	2.128	0.000	0.192	0.045
	2	Duration is short / Un realistic										
	3	Testing Equipment / Commissioning Spares Availability										
	4	Failure of Equipment										
	5	Reporting on LESSONS LEARNED & Action Taken									0.235	0.018
		OVERALL	108								35	

6.3 Model Formulation

The formulation of the Contingency Estimation Model as shown in Table 6.6 has been taken up based on the input data as available until now from the beginning of this study as listed below:

a. The output of the Multivariate Analysis has resulted out in the number of Risk Variables to 35 numbers which are having values of "B" Unstandardized Coefficients spread across the 12 categories as per the % allocation of the project value for consideration in the model formulation against the 108 numbers of Risk Variables utilized for data analysis. These Unstandardized Coefficients of each risk variables are utilized in the calculation of the Regression formula.

b. The "B" Unstandardized Coefficients of each 12 numbers of Category's Constant is utilized for the Regression formula.

c. The Factor loading value as obtained during the Factor Analysis during the objective # 1 of this study was taken for all the 35 numbers of the Risk Variables as identified in the Multivariate Analysis output.

d. The % allocation of the project value for each category as calculated in section 6.1.3 above is utilized as part of the Regression formula.

e. The reference value against the range of Scale for the "Cost Impact" as being utilized for the response reference in the Questionnaire # 2 during the collection of response from various respondents on their contingency perception is utilized for deriving the % contingency value from the constant value obtained from the Regression formula.

TABLE 6.6 - CONTINGENCY ESTIMATION MODEL			From Multivariate Analysis Output		From Factor Analysis (Objective # 1)	7 = 4 + sumproduct (5*6)	From Table 6.2 in Chapter 6	9 = (7 * 8)
CATEGORIES	Seq. No.	RISK VARIABLES	B (Constant) (unstd.)	B (Ind.Var) (unstd.)	Factor Loading	Overall Category Constant	% Allocation for Each Cateogry on Overall	Allocation Value for Each Category on Overall
1	2	3	4	5	6	7	8	9
FINANCE	2	Cash In Flow [i.e. Liquidity]	0.523	0.203	0.77	1.26629	2.9200	0.0370
	4	High Interest Rate		0.218	0.87			
	5	Exchange Rate Fluctuation		0.252	0.83			
	6	Periodic Audits		0.224	0.84			
HR / ADMIN	1	Requirement for No Objection (NOC) / Approvals from Statutory Bodies	0.903	0.250	0.75	1.5279	2.6700	0.0408
	2	Cultural Impact / Personality Impact / Language Impact		0.210	0.74			
	5	Natural Calamity		0.376	0.75			
HSEQ	1	Natural Calamity	1.108	0.147	0.80	1.6720	2.3800	0.0398
	2	Laws and Regulations and the changes during the tenure of the contract		0.206	0.76			
	3	HSE Plan at site, Induction of Site team, Awaraness Program, Training & Safety Signs.		0.341	0.85			
CONTRACTS	1	Variation to the Contract	1.011	0.253	0.77	1.5781	3.2100	0.0507
	2	Suspension of Work by Client		0.239	0.72			
	3	Acceptance of Work by Client / Consultant		0.260	0.77			
DSGN	1	Laws and Regulations and the changes during the tenure of the contract	0.690	0.176	0.73	1.354	8.2900	0.1123
	4	Provision of Interfaces details by Client / Consultant for Tie-ins		0.300	0.79			
	5	Approval of Design Documents		0.168	0.85			
	7	Employee Turnover & Availability of Skilled Personnel		0.190	0.82			
CIVIL - Gen / Sub Stru	CI-A.4	Laws and Regulations and the changes during the tenure of the contract	1.122	0.352	0.81	1.7023	3.6100	0.0615
	CI-C.3	Geo-Technical conditions		0.206	0.76			
	CI-C.8	Inflation / Price Fluctuation		0.169	0.82			
CIVIL - Sup. Stru	CI-D.4	Inflation / Price Fluctuation	1.044	0.482	0.75	1.611	6.5000	0.1047
	CI-E.4	Quality of Workmanship		0.242	0.85			
CIVIL - Ext Works	CI-F.1	Competency Approval / Work Permits from Competent Authorities	0.985	0.270	0.80	1.567	2.1700	0.0340
	CI-F.4	Inflation / Price Fluctuation		0.475	0.77			
MEP	MEP-A.2	Vendor Performance and Relationship	0.769	0.174	0.75	1.38347	4.3300	0.0599
	MEP-B.2	Material Handling / Storing		0.360	0.76			
	MEP-C.4	Accidents & Injuries		0.155	0.71			
	MEP-D.3	Failure of Equipment		0.132	0.76			
ELECTRICAL WORKS - GEN / MATERIALS	EL-A.3	Default of the Vendor	1.524	0.255	0.71	1.9787	49.1300	0.9721
	EL-A.5	Dependence on external sources		0.136	0.84			
	EL-B.1	Exchange Rate Fluctuation		0.192	0.83			
ELECTRICAL WORKS - INST / T&C	EL-C.2	Material Handling / Storing	1.868	0.303	0.70	2.225	6.5000	0.1446
	EL-D.6	Quality of Material		0.163	0.89			
PROJ MGMT	1	Project Charter / Project Management Plan	2.128	0.192	0.81	2.460	8.2900	0.2039
	5	Reporting on LESSONS LEARNED & Action Taken		0.235	0.75			
		OVERALL						1.8612
								4.65%

The regression formula is

Y (Individual Category) =

[B (of Constant)] +

([B (of Risk Variable 1) x Factor Loading of Risk Variable 1] +

[B (of Risk Variable 2) x Factor Loading of Risk Variable 2] +

[B (of Risk Variable 3) x Factor Loading of Risk Variable 3] +

[B (of Risk Variable 4) x Factor Loading of Risk Variable 4])

The following reference to the Model table 6.3 is given below:

- Column 4 - B (of Constant) as obtained from Multivariate Analysis
- Column 5 - B (of individual Risk Variable) as obtained from Multivariate Analysis
- Column 6 - B (of individual Risk Variable) Factor Loading value as obtained during Factor Analysis
- Column 7 - Y (Individual Category) as calculated based on Column 4, 5 & 6.

The value as obtained for individual category as available at Column 7 of the table is further multiplied with the % Allocation of the project value in Column 8 as obtained for individual category at as detailed earlier in this chapter at 6.1.3.

These two values of individual category at Column 7 and Column 8 are multiplied to get the "Allocation Value for Each Category" at Column 9. The summation of the individual categories value obtained at Column 9 results in the "Overall Allocation Value of Contingency" for the project, resulting in a value of **1.8612**.

This Overall categories resultant value of 1.8612 lies between the reference Scale value of 1 & 2 as detailed at input data "e" above and appended below:

Reference		Probability		Impacts		
Scale	Rating	Range	Detail	Cost	Schedule	Performance
1	Very Low	Upto 10%	Highly unlikely to occur. May occur in exceptional situations.	No increase	No change	Will still achieve all mandatory requirements
2	Low	11% - 25%	Most likely will not occur. Infrequent occurrence in past projects.	< 5% increase	< 1 week delay	Minor shortfalls in desirable requirements
3	Moderate	26% - 50%	Possible to occur.	5-10% increase	1 - 2 weeks delay	Minor shortfalls in one or more key requirements
4	High	51% - 75%	Likely to occur. Has occurred in past projects.	10-20% increase	2 - 4 weeks delay	Major shortfalls in one or more key requirements
5	Very High	76% - 100%	Highly likely to occur. Has occurred in past projects.	> 20% increase	> 4 weeks delay	Major shortfall in mandatory requirements

As per the reference scale value "1" has "No cost increase", while scale value "2" has "<5% increase in cost".

∴ Contingency % =

(1.862 [overall value as obtained at 3 above] / 2 [reference scale]) *

(5% [reference scale showing 5% increase in cost])

Thereby we have obtained a % cost contingency of the project as **4.65%**

6.4 Validation of Model

For the validation of the Contingency Estimation Model as formulated, following data are required from the already executed project, duly providing with the complete breakdown of the cost estimates considered during the initial Budgeting for the project along with the cost recorded during the course of the project and the resultant cost details:

a. Project Value (Sales)
b. Budget with the Contingency provision
c. Allocation of the Project value to various Technical categories
d. Cost incurred for various categories

Accordingly, one of the medium sized projects valuing around USD 90 Million (AED 332.5 Million); where the required data are available was taken up and the required data were collected. The model as formulated above was applied against the actual project data and the result as obtained is summarized in below Table 6.7 (All amounts are in UAE Dirhams [AED]), while the complete details of the workings is attached as Annexure A12:

Table 6.7 – Summary of Contingency Estimation Model Validation

SUMMARY	PROJECT VALUE (SALES)	332,500,000.00
	PROJECT COST WITH 15% EST. GROSS MARGIN	282,625,000.00
	PLANNED CONTINGENCY (THUMB RULE - % OF THE PROJECT VALUE)	1.20%
	PLANNED CONTINGENCY AMOUNT	3,990,000.00
	CONTINGENCY % BASED ON ABOVE MODEL	4.65%
	CONTINGENCY AMOUNT BASED ON ABOVE MODEL	15,461,250.00
	ACTUAL COST OVERRUN IN THE PROJECT	14,841,000.00
	% ACTUAL COST OVERRUN IN THE PROJECT	4.46%
	ACTUAL OVERRUN Vs PLANNED CONTINGENCY PROVISION	371.95%
	ACTUAL COST OVERRUN Vs CONTINGENCY ESTIMATES FROM MODEL	95.99%
	SAVINGS IN THE CONTINGENCY AFTER TAKING INTO ACCOUNT OF COST OVERRUN	0.19%

Considering the confidentiality of the data, the details of the project is not included as part of this report.

6.5 Interpretation of the Model Validation

The project taken for analysis was valuing at AED 332.5 Million; estimated Budget with a Gross Margin of 15% including a Contingency value of 1.2% being a Thumb rule applied resulting in a Contingency amount of AED 3.99 Million. The Actual cost overrun of the project over and above the budgeted value being the project Contingency amount is AED 14.841 Million; resulting in exceeding the budgeted contingency by AED 10.851 Million (AED 14.841 Million – AED 3.99 Million).

Applying the 4.65% of Contingency as obtained by the Contingency Estimation Model, the project under review provides an estimated Contingency amount of AED 15.461 Million (4.65% of AED 332.5 Million).

Comparing this value with the actual cost overrun amount of AED 14.841 Million results in an overall saving of AED .62 Million, which is .19% of the project value, compared to the actual cost overrun of 371.95% with reference to the Budgeted Contingency amount of 1.2 % of the project value being a thumb rule provision applied.

Considering that there is a large variance in the initial contingency estimate w.r.t. the actual cost overrun, the model which has been formulated had provided a very close estimate to the actual cost overrun.

Hence this model shall be considered for future projects taking into account of all the limitations on this study.

6.6 Chapter Summary

This chapter provides the validation of the Contingency Estimation Model formulated as part of this Research by applying the model to a project earlier executed; while comparing the outcome based on the earlier estimated contingency based on thumb rule and the contingency estimated based on the model and their validation with the actual cost overrun occurred in the project.

The validation confirming to the very nearness of the Model resultant Contingency value and the actual Cost overrun beyond the budgeted value of the reference project, had provided a way forward for the project professionals in the Construction of Substations in UAE to have a thought of utilizing the presently established Contingency Estimation Model, however, with all the restrictions and limitations for their consideration, while implementing them.