CHAPETR 4

4 RESULTS AND DISCUSSION

Data gathered from personnel having varying experience from altogether 70 oil and gas companies in India covering oil and gas sectors upstream, refineries, downstream, pipeline and company organisations like owner, operators, EPC contractors, PMC, large equipment supplier, oilfield services, inspection agnecies in the form of questionnaires collected by Likert scale is analysed. Feedback responses of 420 personnel from these Oil and Gas projects were analyzed using SPSS software. KMO and Bartlett's test is used to check adequacy of sample size. Communality is checked to understand Principle Component Analysis is appropriate for data. (Brett Williams, 2010).

Data was collected for the importance of parameters based on customer feedback for Contract Award parameters and Project Performance parameters by Likert scale. Descriptive analysis was run to get various exploratory data analysis.

Findings were drawn based on below basis:

1. Parameters which are correlated with underlying factor with correlation coefficient more than 0.5 are taken as component of the Factor. If majority parameters have correlation coefficient >0.9, factor analysis will not be successful as there is a trouble of multi-collinearity.

2. Component score of the factor analysis is the weight assigned to that component. Component Value is calculated as Component Index which is calculated using Index method referred from UNDP. Product of Component weight and Component Index gives Composite component Index.

3. Each factor score is a linear combination of all its components which is summation of its entire Composite component Indices.

4. A cumulative Index score is calculated from all Factors using geometric mean (as per UNDP HDI Index framing) because Poor performance in any dimension is directly reflected in the geometric mean. So a low achievement

in one dimension is not anymore linearly compensated for by high achievement in another dimension.

5. Regression analysis will tell us is PPI (success of project Index) has any impact from Contract Award Factors and Contract Award Index as a whole.

4.1 RESULTS AND DISCUSSION FOR OBJECTIVE 1 CONTRACT AWARD INDEX:

For the First Output of correlation matrix, we scanned the matrix for any coefficient value if greater than 0.9. There was no correlation coefficient falling into >0.9. Determinant of the matrix was 4.430E-039 (which is 0.000443) and is greater than the necessary value of 0.00001. Therefore multi collinearity is not a problem for this data. Hence all questions correlate fairly well, none of the coefficients were particularly large and there was no need to eliminate any questions at the stage.

Second output is for Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy and Bertlett's test of spericity.

KMO statistic varies between 0 and 1. A value of 0 indicates that the sum of partial correlations is large relative to sum of correlations, indicating diffusion in pattern of correlations, making factor analysis inappropriate.

KMO value	Remark
> 0.5	Acceptable
0.5-0.7	Mediocre
0.7-0.8	Good
0.8-0.9	Very good
> 0.9	Superb

Table 4.1

KMO Value and Acceptable Range

KMO and Bartlett's test:

Our KMO value 0.802 is in the range of **'Good'** indicating sufficiency of data samples.

Bartlett's test with significance 0.0000 giving study confidence that the data collected would be acceptable and would yield good results making factor analysis appropriate for data.

KMO Table for Contract Award Parameters

KMO and Bartlett's Test- Contract Award Components		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.802
Bartlett's Test of Sphericity	Approx. Chi-Square	11855.297
	df	630
	Sig.	0.000

Table 4.3

To determine reliability of scale, Cronbach's alpha coefficient was calculated using tool

SPSS:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

Where N –Number of items, c-bar – The average inter-item covariance among the items, v-bar – the average variance.

The most appropriate reliability coefficient for a two-item scale is the Spearman-Brown statistic that together with standardized coefficient alpha, its equivalent for two-item measures, is offered by software such as SPSS, SAS and R. (Rob Eisinga, October 2012) (Devellis, 2012) (Peters)

Cronbach Alpha indicated relaibility of scale.

Reliability Statistics

Table 4.2

Cronbach's Alpha	N of Items
.961	103

For selecting and interpreting inferential statistics, variables are normal/scale, the Pearson product moment correlation is selected. As study has clearly directional hypothesis with an independent and dependent variable, hence, Multiple Regression was used.

Communality:

Below table of communalities shows communality before and after extraction. "Before extraction" all communalities were 1, indicating all variance common before extraction. Communalities "After extraction" reflected common variance in data structure which is largely between 0.6 to 0.85. Average Communality is 0.741. Communality greater than 0.6 is acceptable to perform Factor Analysis.

Communalities		
	Initial	Extraction
VAR00001	1.000	.771
VAR00002	1.000	.742
VAR00003	1.000	.718
VAR00004	1.000	.709
VAR00005	1.000	.751
VAR00006	1.000	.674
VAR00007	1.000	.769
VAR00008	1.000	.771
VAR00009	1.000	.767
VAR00010	1.000	.699
VAR00011	1.000	.687
VAR00012	1.000	.787
VAR00013	1.000	.763
VAR00014	1.000	.693

VAR00015	1.000	.810
VAR00016	1.000	.839
VAR00017	1.000	.855
VAR00018	1.000	.765
VAR00019	1.000	.644
VAR00020	1.000	.668
VAR00021	1.000	.616
VAR00022	1.000	.695
VAR00023	1.000	.801
VAR00024	1.000	.729
VAR00025	1.000	.687
VAR00026	1.000	.789
VAR00027	1.000	.762
VAR00028	1.000	.735
VAR00029	1.000	.738
VAR00030	1.000	.757
VAR00031	1.000	.714
VAR00032	1.000	.685
VAR00033	1.000	.796
VAR00034	1.000	.765
VAR00035	1.000	.686
VAR00036	1.000	.716

Table 4.4

'Principle Component Analysis' was run in SPSS software for the data collected from 420 cases for contract award parameters. Initial solution was extracted to display 'Unrotated Factor Solution' and 'Scree plot' to assess improvement of interpretation due to rotation. Scree plot has 9 factors with Eigen value greater than 1. Total variance of 9 factors explained is 75.46%

The plot given below shows Eigen values associated with each linear component and the amount of variance explained by that particular linear component.

Total Variance Table before Rotation displays the Eigen values in terms of percentage of variance explained. First component explains 33% of total variance. Factors with Eigen value greater than 1 are retained numbering 9 factors. The Eigen values associated with these factors are again displayed in the extraction sums of square loadings. The values of this part of the Table are the same as the values before extraction, except the values for the discarded factors are ignored.

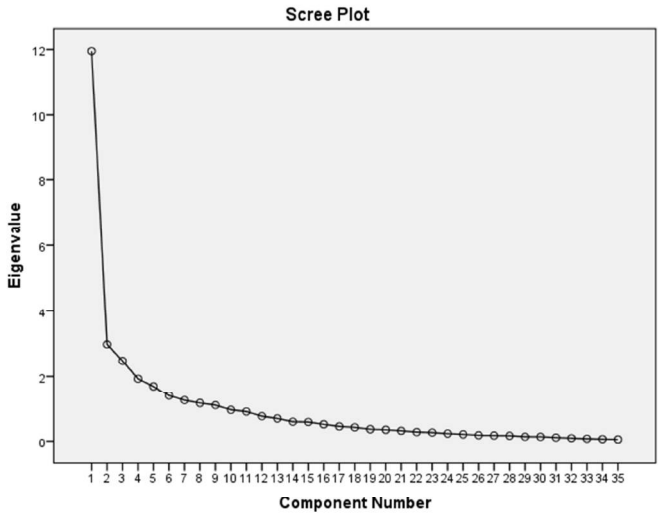

Fig 4.1

Total Variance explained for Contract Award Index

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.970	33.250	33.250	11.970	33.250	33.250
2	3.021	8.391	41.642	3.021	8.391	41.642
3	2.632	7.312	48.954	2.632	7.312	48.954
4	2.059	5.719	54.672	2.059	5.719	54.672
5	1.774	4.928	59.600	1.774	4.928	59.600
6	1.552	4.311	63.911	1.552	4.311	63.911
7	1.266	3.515	67.426	1.266	3.515	67.426
8	1.163	3.232	70.658	1.163	3.232	70.658
9	1.118	3.107	73.765	1.118	3.107	73.765
10	.961	2.668	76.433			
11	.903	2.508	78.941			
12	.769	2.135	81.076			
13	.696	1.934	83.010			
14	.613	1.701	84.712			
15	.592	1.643	86.355			
16	.540	1.500	87.855			
17	.451	1.253	89.108			
18	.430	1.195	90.302			
19	.370	1.028	91.330			
20	.349	.969	92.299			

Extraction Method: Principal Component Analysis.

Table 4.5

Rotated Solution maximises loading of each variable on one of the extracted factors while minimising the loading on all other factors. We expected the factors to be independent hence we chosen orthogonal rotation 'Verimax'. Rotation has the effect of optimising the factor structure and consequence of this solution was relative importance of these 9 factors was equalized.

Total Variance Explained after Rotation:

In the final table rotation Sums of Squared Loadings shows the Eigen values after rotation optimizing the factor structure to 8 factors.

Total Variance Explained			
Component	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	5.977	16.604	16.604
2	3.803	10.564	27.167
3	3.532	9.811	36.979
4	3.120	8.668	45.647
5	2.502	6.950	52.597
6	2.148	5.967	58.564
7	2.058	5.716	64.280
8	1.736	4.823	69.103
9	1.678	4.662	73.765
Extraction Method: Principal Component Analysis.			

Table 4.6

Rotation of the factor structure clarified to retain 8 factors and variables load very highly on 2 factors.

We suppressed loadings less than 0.5 and ordering variables by loading size made our interpretation much easy. Component matrix shows amount of variance in each variable that can be explained by retained factors.

Component Matrix shown in below Table 4.7

Rotated Component Matrix[a]									
	Component								
	1	2	3	4	5	6	7	8	9
VAR00084	.812	.210	.262	.136	.187				
VAR00099	.757			.235	.115	.226		.112	
VAR00094	.752	.239	-.179		.208		.107		.261
VAR00072	.713	.110	.235	-.291	.113	-.157			
VAR00080	.711	.159	.176	.304		.129		-.327	.132
VAR00085	.635	.353	.272	.411		-.199	.106	.163	
VAR00101	.634	.282	-.111	.274	.239	.359		.115	.143
VAR00081	.622	.225	.156	.236	.119	.303		.309	.207
VAR00095	.548	.306		.263	.327	.185	.112	.374	
VAR00088	.542	.164	.187	.210	.356	.220		.277	.125
VAR00073	.124	.763	.227	.201		.134		.194	
VAR00091	.405	.739	.129			-.122		.137	-.176
VAR00074		.640	.211	.179	.173	.360			.194
VAR00102	.391	.608		.195	.227		.179	.331	.120
VAR00089	.275	.498		.109	.314	.238	.176		.298
VAR00098	.178	.153	.816		.134				
VAR00078		.168	.792	.104	-.110	.120			
VAR00092			.661	.217	.161	-.207	-.106	.400	
VAR00083	.477		.480			.452		.103	-.360
VAR00075	.137	.193		.726	.213	.328			-.110
VAR00076	.354	.124		.668	.313	.167		.226	
VAR00100	-.111	.373	.455	.530		-.116			.146
VAR00096	.334	.487		.526			.184		.198
VAR00086	.233	.256	-.114	.503	-.228	.106	.133	.223	.498
VAR00087	.106		.431	.470	.277	.102		.253	.256

VAR00071	.194	.142	.155	.177	.752	-.102			.138
VAR00070	.339	.198	-.114	.169	.732			-.113	
VAR00082	.305	-.167	.395		.463	.347	.257	.156	.181
VAR00090		.358		.219	.116	.662	.214		
VAR00093	.123		.461	.270	-.222	.563			.153
VAR00069		.168					.849	-.109	
VAR00103				.162			.834		
VAR00077	.237	.323	.235	.154		.107		.712	
VAR00097	.189		.404		.202	.152			.681
VAR00079	.203	.424	-.121		.236			.396	.488

Findings of Rotated Solution for Significant Factors during Contract Award:

Rotated Component Matrix and extracted components are detailed in Appendix 1.

Rotated Component Matrix:

This matrix is a matrix of the factor loadings for each variable onto each factor and is calculated after rotation. Values less than (0.5) were suppressed.

Principle component Analysis extracted 9 significant Factors and further rotation retained 8 Factors with eigen value more than 1. From Rotated component Matrix, parameters with coefficient >0.5 are retained and altogether 32 parameters showed significant correlations with underlying Factors. Below are the important factors along with its weight for calculating Contract Award Index.

- The Factor which contributes highest for Contract Award is 'Bidder's (supplier's/contractor's) contribution for sustainable development'. This

indicates today's business culture shifting towards global benefit for complete development rather than traditional outlook of profitability of stakeholders and development of a company. This factor having parameters reflecting sustainable development hence is named 'Contribution to Sustainable development.' Parameters contributing to this factor involved in the descending order of score are 'Environmental policy', 'Training & development to manpower', 'Top management support and involvement in project', 'Working Capital', 'Technical development Strategy', 'Update with regulatory & statutory system', 'Accreditations with various bodies', 'Capability to address political changes', 'empowerment of manpower' and 'Social responsibility'.

- Second Factor arrived during Contract Award is 'bidder's (supplier's/contractor's) efficiency in Risk Management.' Significance of this factor is learnt from below contributing parameters which are related to various risks involved during execution of a project and hence bidder's or supplier's capability in handling risk is found out by parameters as per their factor loading in decreasing order of score as 'Financial risk handling capability', 'Capability to handle unforeseen contingency', 'Financial management in terms of Cost saving', 'Approval from International and National bodies' and 'Capability to handle regulatory changes'. Hence this factor is significant in selecting suppliers and contractors in entire supply chain who have history and records for effective risk management control contributing value to contract award framework.

- Third important factor next in line which is contributing to Contract Award is bidder's 'Specific competency for project need.' The parameter which are describing this factor are 'Communication efficiency within bidder's organization,' 'Engineering capability' and 'Number of manpower as human resource capability' which shows organization's basic capability to perform the project.

- Fourth factor which has come for selecting suppliers and contractors is 'Efficiency of management' in bidder's organization and parameters contributing to this factor are 'Management's financial efficiency' understood from P/E ratio (Profit/Earning ratio), Earning per share of the organization, 'Attrition rate', 'Ethical values' and 'Cross functional communication within organization'.

- Fifth factor which is contributing to 'Financial competency of a bidder (or supplier /contractor)' and this is judged from the parameters 'Return on capital employed' and 'Return on investment'.

- Sixth factor which is significant to the framework is 'Past performance and history of bidder' and basic parameters to learn success in handling such similar experiences is 'past performance of successful records', 'Project Owner's self experience in similar such projects' and 'Lessons learnt from past experience by the Owner and shared with contractor'.

- Seventh factor which has come in the framework is 'Quality of manpower'. Deploying number of manpower for a project is not enough for successful execution but quality of manpower enhances

efficiency, quality and schedule of a project. Hence 'Quality of manpower' is one of the factors during Contract award framework.

- The last factor which is eighth factor and is contributing to contract award framework is 'Research, Technology & Innovation activity of a bidder'. This not only adds advances and innovations to the project performance but reflects bidder's vision for future growth, contribution to technology and promote sustainability by way of innovations, research & new technologies. Parameters contributed to this factor are 'Use of technology and science' and 'Emphasis on research and development.'

Each factor is linear combination of its components with component score as variance of each component within the factor and hence each factor is expressed in terms of all its components. All factors contributing to contract award frameworks are shown in terms of percentage of variance contributed by each of the factors below.

Fig 4.2

Contract Award Factors with Total variance contributed

4.2 RESULTS AND FINDINGS FOR OBJECTIVE 2 PROJECT PERFORMANCE INDEX:

For the First Output of correlation matrix, we scanned the matrix for any coefficient value if greater than 0.9. There was no correlation coefficient falling into >0.9 . Determinant of the matrix was 4.799E-038 (which is 0.000479) and is greater than the necessary value of 0.00001. Therefore multicollinearity is not a problem for this data. Hence all questions correlate fairly well, none of the coefficients were particularly large and there was no need to eliminate any questions at the stage.

Second output is for Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy and Bertlett's test of spericity.

KMO table for Project Performance Components

KMO and Bartlett's Test- PPI		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.699**
Bartlett's Test of Sphericity	**Approx. Chi-Square**	**50569.696**
	Df	**2278**
	Sig.	**0.000**

Table 4.7

KMO and Bartlett's test with value 0.699 indicating sufficiency of data samples and assuring factor analysis will yield good results making factor analysis appropriate for data.

'Communalities' output is Tables of Communality before and after extraction. All variance is common; therefore before extraction all communalities are 1. The communalities in the column "Extraction" reflect the common variance in the data structure. After extraction, average common variance in data structure is 0.779 which is between 0.6 to 0.88 so is in acceptable limit to perform Factor Analysis.

Communalities		
	Initial	Extraction
VAR00001	1.000	.539
VAR00002	1.000	.692
VAR00003	1.000	.766
VAR00004	1.000	.722
VAR00005	1.000	.819
VAR00006	1.000	.804
VAR00007	1.000	.530
VAR00008	1.000	.782
VAR00009	1.000	.734
VAR00010	1.000	.870
VAR00011	1.000	.843
VAR00012	1.000	.796
VAR00013	1.000	.748
VAR00014	1.000	.826
VAR00015	1.000	.791
VAR00016	1.000	.857
VAR00017	1.000	.797
VAR00018	1.000	.802
VAR00019	1.000	.760
VAR00020	1.000	.740
VAR00021	1.000	.874
VAR00022	1.000	.802
VAR00023	1.000	.727
VAR00024	1.000	.762
VAR00025	1.000	.752
VAR00026	1.000	.842

VAR00027	1.000	.720
VAR00028	1.000	.797
VAR00029	1.000	.759
VAR00030	1.000	.742
VAR00031	1.000	.752
VAR00032	1.000	.790
VAR00033	1.000	.797
VAR00034	1.000	.791
VAR00035	1.000	.770
VAR00036	1.000	.797
VAR00037	1.000	.830
VAR00038	1.000	.793
VAR00039	1.000	.765
VAR00040	1.000	.724
VAR00041	1.000	.792
VAR00042	1.000	.803
VAR00043	1.000	.734
VAR00044	1.000	.791
VAR00045	1.000	.718
VAR00046	1.000	.799
VAR00047	1.000	.749
VAR00048	1.000	.770
VAR00049	1.000	.777
VAR00050	1.000	.749
VAR00051	1.000	.894
VAR00052	1.000	.837
VAR00053	1.000	.802
VAR00054	1.000	.851
VAR00055	1.000	.473

VAR00056	1.000	.873
VAR00057	1.000	.870
VAR00058	1.000	.835
VAR00059	1.000	.854
VAR00060	1.000	.807
VAR00061	1.000	.648
VAR00062	1.000	.848
VAR00063	1.000	.864
VAR00064	1.000	.870
VAR00065	1.000	.834
VAR00066	1.000	.742
VAR00067	1.000	.882
VAR00068	1.000	.744
Extraction Method: Principal Component Analysis.		

Table 4.8

Screen Plot helps to decide upon the number of factors that should be retained. The curve begins to even out after extraction of 15 factors.

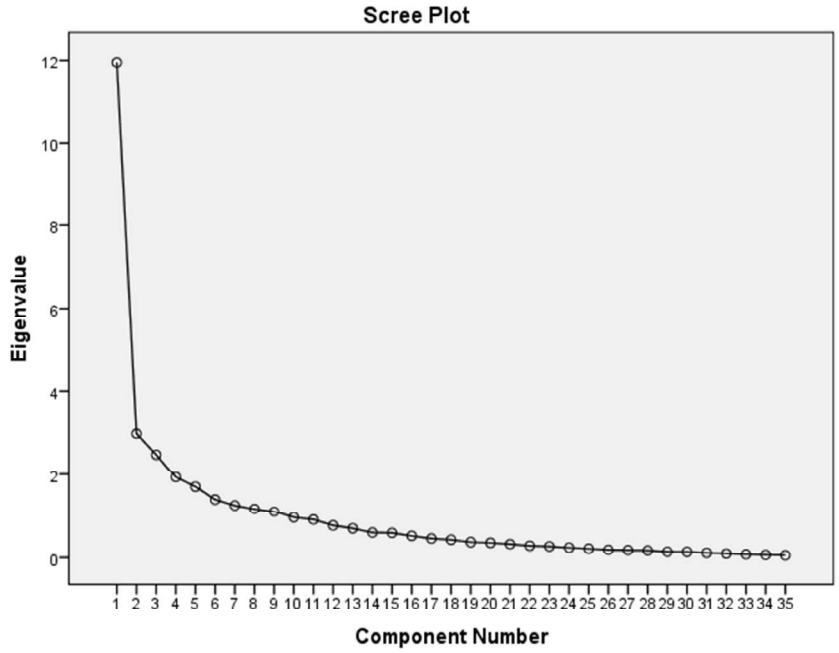

Fig 4.3

So only 15 factors are retained. Total variance showing 15 Factors with Eigen value more than 1 and Total variance explained by these factors amounting to 78%.

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	18.720	27.529	27.529	18.720	27.529	27.529
2	7.708	11.335	38.864	7.708	11.335	38.864
3	4.246	6.245	45.109	4.246	6.245	45.109
4	3.665	5.390	50.499	3.665	5.390	50.499
5	2.862	4.209	54.708	2.862	4.209	54.708

6	2.435	3.582	58.290	2.435	3.582	58.290
7	2.365	3.478	61.767	2.365	3.478	61.767
8	1.790	2.632	64.399	1.790	2.632	64.399
9	1.698	2.497	66.896	1.698	2.497	66.896
10	1.565	2.301	69.198	1.565	2.301	69.198
11	1.380	2.030	71.227	1.380	2.030	71.227
12	1.297	1.907	73.134	1.297	1.907	73.134
13	1.124	1.653	74.787	1.124	1.653	74.787
14	1.084	1.594	76.381	1.084	1.594	76.381
15	1.074	1.579	77.960	1.074	1.579	77.960
16	.962	1.414	79.374			
17	.892	1.312	80.686			
18	.865	1.272	81.958			
19	.784	1.153	83.111			
20	.754	1.108	84.219			
21	.717	1.055	85.274			
22	.674	.991	86.266			
23	.626	.920	87.185			
24	.579	.851	88.036			
25	.567	.834	88.871			

Table 4.10

Rotated solution for significant factors during Project Performance

Principle component Analysis extracted 15 significant Components and further rotation retained 10 components (contributing to 71%). From Rotated Component Matrix, altogether 49 parameters with significant correlations with underlying Component and with coefficient >0.5 are retained. (Table 5)

- The First Factor contributing 27 % is for '**Effective Project Plan**'. A project well begun will set well. Hence Project plan is like a 'blue print' of project execution. Parameters which will measure effectiveness of the plan are 'Integration of entire project plan on a paper', 'Integrated project charter', 'Clear project scope statement', 'Defined project management and project execution plan', 'Arrangement of change control plan', 'Focused scope statement', 'Cost/Benefit analysis' and 'Project Constraints'. All these parameters when taken care will make Project Plan effective.
- Second Factor is '**Project Implementation Plan**' which contributes to 11% in Total Variance. Under this, parameters involve are 'Responsibility breakdown', 'Scope Change Control', 'Time Management by various parameters like PERT, GANTT chart', 'Network model', 'Critical path', 'Resource loading' and 'Cost Management'.
- Third Factor is '**Cost and Quality Management'** involving 'Forecasting', 'Cost control', 'Cost reporting', 'Quality management', 'Quality assurance', 'Quality Control' and 'Cost of Quality'.
- Fourth Factor tracks '**Human Resource Management**' by measuring parameters 'Development of Leadership skill', 'Motivation', Compensation', 'Conflict management', 'Team building'.
- Fifth Factor is for '**Communication Protocol**' by measuring parameters 'Communication Matrix', 'Communication mode's, 'Facilities to remove barrier'.
- Sixth '**Risk Handling and Contingency planning**' and Parameters are 'Risk analysis', 'Risk mitigation', 'Contingency planning' and 'Procurement and subcontracting efficiency'

- Seventh Factor extracted is '**Subcontracting Efficiency**' by material selection, Vendor Pre-qualification, Contract types.
- Eighth Factor takes care of '**Soft Skill**' required in project management like 'Contract negotiation', 'Contract change order'.
- Ninth Factor lists '**Benefit to Project Owner/Stakeholders Achieved**' in terms of 'Stakeholder retention', 'Market share achieved', 'Use of the project to stakeholders'.
- Tenth Factor lists '**Benefit to Contractor or Project Performing Organisation**' in terms of 'Employee satisfaction', 'Employee motivation', 'Employee empowerment'.

All these factors with their parameters are shown in Appendix 2 along with rotated component score.

4.3 RESULTS FOR OBJECTIVE 3 CONSTRUCTION OF CONTRACT AWARD INDEX (CAI) AND PROJECT PERFORMANCE INDEX (PPI):

Construction of Contract Award Index:

Each Factor is linear combination of its components and is represented by:

$$F_{ji} = \sum W_{kj} Z_{ik} \text{ where i is } (1....k.)$$

Where F_{ji} is Component score for j^{th} factor with i component

W_{kj} is weight of the component from factor analysis

Z_{ik} is value of component Index

Each Composite Component Index is calculated using sum total of all its component scores as:

- FC1 =0.812 CC_{11} + 0.755 CC_{12} +0.744 CC_{13} + 0.726 CC_{14} +0.704 CC_{15} + 0.635 CC_{16} + 0.627 CC_{17} + 0.616 CC_{18} + 0.543 CC_{19} + 0.525 CC_{110}
- FC2 =0.761 CC_{21} + 0.744 CC_{22} +0.732 CC_{23} + 0.622 CC_{24} + 0.506 CC_{25}
- FC3 =0.808 CC_{31} + 0.791 CC_{32}+ 0.663 CC_{33}
- FC4 =0.730 CC_{41} + 0.663 CC_{42} +0.561 $C4_{43}$ + 0.514 CC_{44} + 0.504 CC_{45}
- FC5 =0.751 CC_{51} + 0.731 CC_{52}
- FC6 =0.841 CC_{61} + 0.806 CC_{62} + 0.783 CC_{63}
- FC7 =0.580 CC_{71}
- FC8 = 0.713 CC_{81} +0.654 CC_{83} + 0.510 CC_{84}

CC_i is Component Index and was calculated using below Index formula:

$$\frac{C_{I\,actual} - C_{I\,min}}{C_{i\,max} - C_{i\,min}}$$

Where $C_{I\,min}$ and $C_{i\,max}$ are defined by stakeholders (Project Owners) as per objective of project at the beginning of the RFQ/Bid.

$C_{I\,actual}$ is the value of each bidder during evaluation of bids by owner/operator evaluation team.

Using component score and component Index value, Composite Component Index is constructed as above where factor score for each factor is Composite Component Index. Using this Factor score for each factor, a single point Index named as Contract Award Index is calculated using Geometric mean. (Geometric Mean is selected to normalize variation in the input value.)

$$\textbf{Contract Award Index} = \sqrt[n]{(FC_1 \times FC_2 \times FC_3 \times \ldots \times FC_8.)}$$

This single point Index score is suggested for Contract evaluation and award which is quantitative in nature, involves all significant components and weight of components is computed from the study as a holistic quantitative approach. Below comparison can show how different and beneficial this framework than the conventional framework based on competitive bidding.

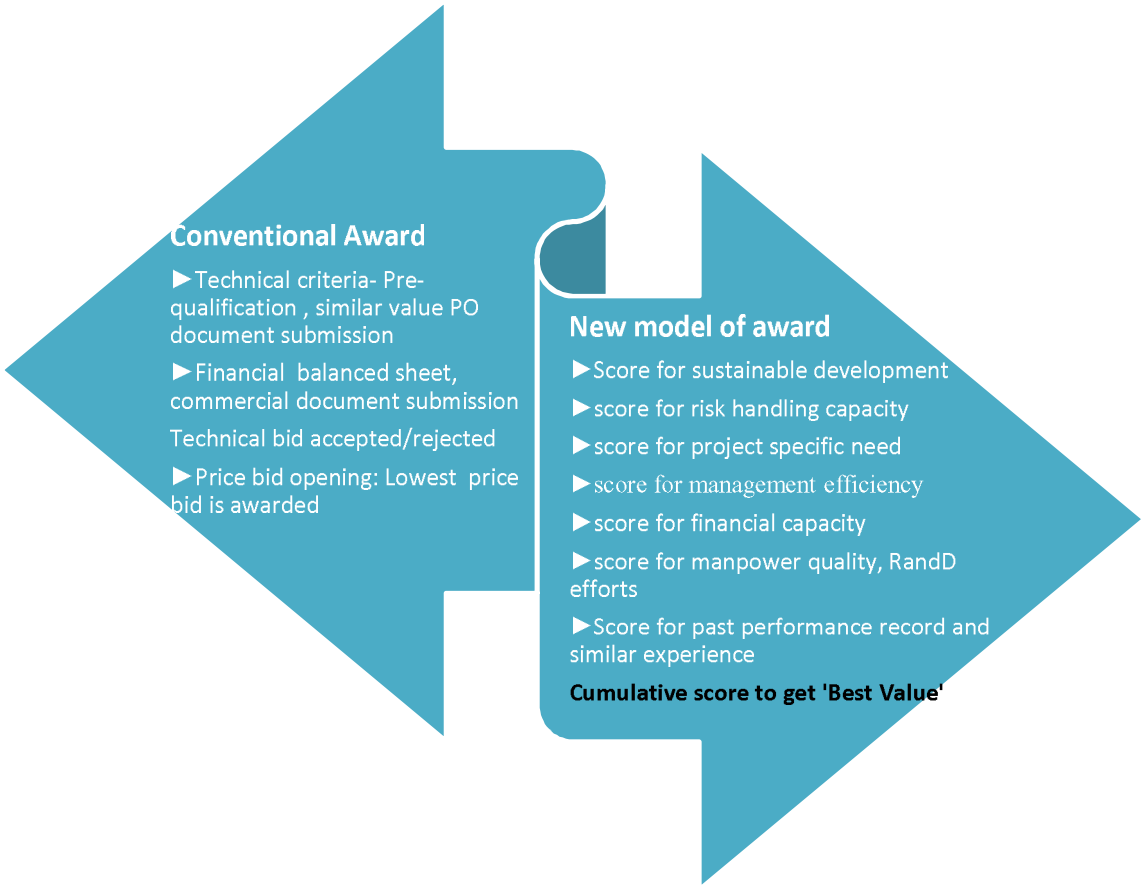

Fig 4.4 Conventional vs New model of contract award

Construction of Project Performance Index:

Similarly, Project Performance Index is constructed.

Each factor is linear combination of its components. Each factor score of Project Performance is calculated using its component Index and component score as:

- FP1 =0.884 PP11 + 0. 856PP12 +0.832 PP13 + 0.787 PP14 +0.745 PP15 + 0.700 PP16 + 0.645 PP17 + 0.620 PP18 + 0.617 PP19 + 0.566 PP110
- FP2 =0.896 PP21 + 0.894 PP22 +0.860 PP23 + 0.833 PP24 + 0.832 PP25+ 0.814 PP26 + 0.794 PP27 0.738 PP28+ 0.607 PP29 + 0.562

- FP3 =0.838 PP31 + 0.801 PP32 + 0.797 PP33 + 0.778 PP34+ 0.667 PP35 + 0.561 PP36 + 0.543 PP37
- FP4 =0.782 PP41 + 0.756 PP42 +0.674 PP43 + 0.602 PP44 +0.527 PP45+ 0.526 PP46
- FP5 =0.777 PP51 + 0.678 PP52 +0.530 PP53 +0.521 PP53
- FP6 =0.741 PP61 + 0.704 PP62 +0.657 PP63 +0.573 PP63
- FP7 =0.781 PP51 + 0.705 PP52 +0.500 PP53
- FP8 =0.756 PP81 + 0.672 PP82 + 0.532 PP83
- FP9 =0.690 PP91 + 0.668 PP92 +0.535 PP93 +0.535 PP94
- FP10 =0.729 PP101
- FP11 =0.681 PP_{111} + 0.601 PP_{112}
- FP12 =0.704 PP_{121} + 0.582 PP_{122}

PP_i is parameter Index and was calculated using Index formula.

PP_i Value is calculated as: $$\frac{PP_{i\,actual} - PP_{I\,min}}{PP_{i\,max} - PP_{i\,min}}$$

Composite Performance Score is calculated using geometric mean for all factors. (GM is selected to normalize variation in the input value.)

Project Performance Index PPI = $\sqrt[n]{(FP_1 \times FP_2 \times FP_3 \times \ldots \times FP_{12.})}$

Fig 4.5

Project Performance Factors with variance contributed

Third objective of our study was to find out, is there any significant relation exist between Contract award Factors and Project Performance Index? And is there any significant relation exist between Contract Award Index and Project Performance Index? Or is there any impact of Contract Award Index on Project Performance Index?

To find our causal relationship, regression model is framed.

Statistical test-Regression Analysis:

Regression analysis is a statistical tool for the investigation of relationships between variables. Usually, the investigator seeks to ascertain the causal effect of one variable upon another. (Sykes, 1986).

Model Summery of regression analysis shows 'Contract Award Factors' obtained from principal component analysis when regressed against 'Project

Performance Index' (PPI), ANOVA shows how Contract Award Factors are affecting Project Performance Index:

R-Square which is an overall measure of the strength of association indicates proportion of variance of Factors FC1, FC2, FC3, F4, F5, F6, F6 and FC8 in the dependent variable PPI.

ANOVA shows significance <0.01 confirming goodness of fit of the model. This confirms that there is impact of Contract Award Factors on Project performance Index

The predicted value of Project Performance, $\mathbf{Y_{predicted}}$ using all Contract Award Factors is presented by the regression equation:

$$\mathbf{Y_{predicted} = b0 + b1* FC1 + b2* FC2 + b3*FC3 + b4*FC4 + ... + b8*FC8 + \varepsilon_8}$$

Main purpose of the study is to know relationship between Contract award components with Project performance Index, hence R square which is 0.313 and regression showing significance between Contract Award Factors on PPI. As *N- 42*0, even $r = .313$ is statistically significant, indicating the association is not zero, and the effect size will be medium.

Model Summery

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.560[a]	.313	.300	.31743	1.672

Table 4.11

ANOVA

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.607	8	2.326	23.083	.000[b]
	Residual	40.809	405	.101		
	Total	59.416	413			

Table 4.12

Beta value, F-statistic, p-value

Coefficients								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.763	.072		24.379	.000	1.620	1.905
	VAR00011	-.016	.012	-.075	-1.266	.206	-.040	.009
	VAR00012	.064	.027	.111	2.343	.020	.010	.118
	VAR00013	-.002	.042	-.002	-.041	.967	-.084	.080
	VAR00014	.089	.038	.144	2.365	.018	.015	.163
	VAR00015	.342	.055	.367	6.267	.000	.235	.449
	VAR00016	.026	.057	.024	.452	.652	-.086	.138
	VAR00017	-.359	.070	-.216	-5.104	.000	-.497	-.221
	VAR00018	.180	.158	.071	1.144	.253	-.130	.491

Table 4.13

The significance or p-value for each component tests the null hypothesis that the coefficient is equal to zero (no effect). A low p-value (< 0.05) of FC2, FC4, FC5, FC7 indicate that we can reject the null hypothesis and hence these components are a meaningful addition to the model because changes in their values are related to change the project performance.

The column of unstandardized coefficients provides the values for b0, b1, b2, b3, … b8 for the equation.

- (Component FC1) - The coefficient for FC1 is -.016. So for every unit increase in FC1 (i.e. Competency & Contribution to Sustainable development) consider - 0.016 points below Project performance , holding all other variables constant. The significance for FC1 is 0.206 (which is < 0.05) so we accept null hypothesis. Hence bidder's contribution to Sustainable Development is not included in the model of Project Performance Index. Similar hypothesis testing for remaining seven contract evaluation components leads us to conclude components :

- FC2: 'bidder's competency in Risk Management' measured in terms of (Financial risk handling capability, capability to handle unforeseen contingency, Cost saving, Update with National & International approval bodies and capability to handle regulatory changes) has impact on success of a project having significance 0.020 which is <0.05.

- FC4 'Efficiency of management' measured in terms of (Profit/Earning Ratio, Earning per share, Attrition rate, Ethical values, cross functional

communication within bidder's Organisation) has significance 0.018 which is <0.050.

FC5: 'Financial efficiency' measured in terms of (Return on Capital employed and Return on Investment) has significance 0.000 which is < 0.05.

- FC7: 'Quality of manpower' of Bidder has significance 0.000 which is <0.05.

Model developed for project performance involving Contract Award Factors are:

Project Performance $_{(predicted)}$ = 1.763 + 0.064*FC2 + 0.089*FC4 + 0.342*FC4- 0.359*FC7

When Contract Award Index, CAI is regressed on Project Performance Index, PPI; it is showing positive beta coefficient and significance 0.000 indicating relationship of Contract Award Index on Project Performance Index.

Model Summary of Contract Evaluation Index on Project Performance Index

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.477[a]	0.228	0.226	0.37635	1.641
a. Predictors: (Constant), VAR00001					
b. Dependent Variable: VAR00002					

Table 4.14

ANOVA

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.219	1	17.219	121.568	.000[b]
	Residual	58.355	412	.142		
	Total	75.574	413			
a. Dependent Variable: VAR00002						
b. Predictors: (Constant), VAR00001						

Table 4.15

Beta value, F-statistic, p-value of Contract Evaluation Index on Project Performance Index

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.007	0.056		35.817	0.000
	VAR00001	0.486	0.044	0.477	11.026	0.000
a. Dependent Variable: VAR00002						

Table 4.16

Study indicated significant relationship of Contract Award Framework on Project Performance Framework. Research intention was not in measuring prediction but analyzing significant relationship exists or not. R square of value 0.228 indicate apart from Contract Award there are other factors which affect Project Performance which is not in the scope of the study. Regression of CAI on PPI has shown positive beta coefficient of 0.486 and regression equation formed is:

Project Performance Index = 2.007 + 0.486 Contract Award Index.

(As real world testing of the model was not possible during the span of the study hence a case study verification was carried out which is as per Exhibit 19.)

A CASE STUDY FOR HOLISTIC APPROACH

The case study was taken for two bidders bidding for Certifying a design and engineering work for developing facilities for deepwater exploration & production work of an oil and gas operator. Being rough sea, frequent cyclonic conditions and steep gradient of the seabed, designing these deepwater facilities are very critical and needed utmost care & precaution. Hence while design & engineering work is going on, operator wanted to get it reviewed by a third party certification body and get the entire design at the end of it certified for compliance to international standards, local regulation and operator practices. A bid was floated as international competitive bidding. It is not justifiable to evaluate such critical work bid using competitive bidding where bid award is to bidder quoting for 'lowest cost.' CAI framework is applied to this where multi-dimensional competencies of bidders are compared. These dimensions cover HSE capability, Technical competency, knowledge of regulations & accreditations, Risk management capability, Ethical values, Human resource development, R&D and innovation involvement, financial capability, past performance, Contribution to society etc. The score is given for each component out of 100 with descending options in order of 80,60,40 marks based on documentary proof and criteria for each component which is defined in the bid. Weight for each component is taken from study. Component Index is calculated using (Actual score given to the bidder), (Maximum score which is 100) and (Minimum score to qualify to bid which is decided here by operator as 40). Composite component Index is calculated by product of component Index and weight of the component.

Factor score is calculated as linear combination of all composite component Indices of a factor. Geometric mean of all these factors will be Contract Award Index (CAI). This composite Index for bidder A & B can rank each bid during evaluation. Bidder having highest CAI is awarded the contact. During performance, Project Performance Index PPI is calculated in the similar way using Project Performance Component Index, Component weight, Composite component Index and finally Project Performance Index, PPI. This PPI is input score for factor "Past Performance" during next CAI and so on. Hence instead of operators assigning random weight to each component, a weight assigned from research study, components and factors give 'holistic approach' for evaluating each bid.

A common database can be maintained at national level to record CAI score of each bidder and awarded bidders can get PPI score after execution of each contract. This record can be used by all operators to access bidder's competency for particular type of project work, their performance record etc. from this central database. Cumulative scoring system if adopted for all bidders, contractors and operators can assess work. So great performances will be rewarded with good score and poor performances will be penalised with bad score or even negative score thus reducing cumulative score. This is the 'holistic approach' study wants to propose.

This framework approach is aligning with 'Modern Contract Theory'. Old contract theory is Social Contract theory which is a sort of hypothetical or actual agreement between society and its state, but non-participant like non-human animals and non-rational humans who are not

included in contract. But CAI framework overcomes this disadvantage by including many dimensions like HSE, environmental, Social responsibility, ethical values and sustainability which are non-human participants..

Modern Contract theory has addressed two potential issues: 'informational problems' and 'incomplete contracts'. The Modern Contract theory, guides us in structuring arrangements between employers and employees, shareholders and chief executives, and companies and their suppliers. Modern Contract theory is about giving each party the right incentives or motivations to work effectively together. This holistic framework includes these issues in the quantitative framework as CAI & PPI encompass broad factors in evaluating contract in terms of factors including bidder's various competencies, top management involvement, owner companies' past experience, PPI score of projects executed which is based on factors like Human resource development, benefits to stakeholders, benefits to performing companies, ethical values, social responsibility and commitment to future development in terms of research & innovations etc. proposing a win-win contract framework for all.

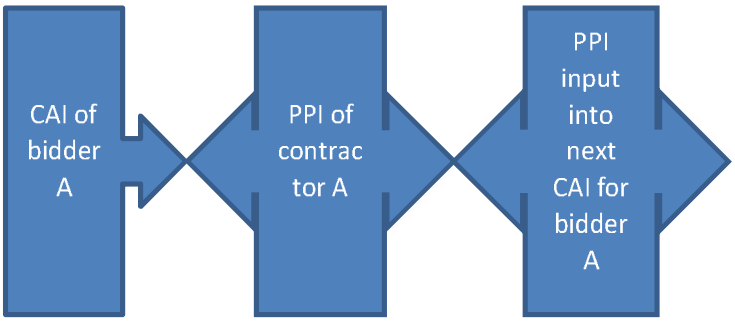

Fig 4.6 CAI PPI chain reaction

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