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A Factorial Study of Corporate Performance of Nigerian Refineries in Regard to their Raison d'etre

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Abstract

Realizing that the Nigerian refineries are dysfunctional and therefore are unable to meet its raison d'etre. A survey was undertaken as to identifying and ascertaining the inter correlations among a gamut of variables, that influence the operation of the Nigerian refineries.

Accordingly, a statistical approach involving a combine use of Kendall's coefficient of concordance which ranks variables in merit order sequentiality and Principal Component Analysing (PCA) that tries to perceive similarity in dissimilarity by achieving parsimony through factor reduction was deployed as statistical tools.

Our results show that a null hypothesis claiming that the rankers of the gamut of factors by forty (40) judges is discordant was rejected at a p-value of 0.05. Thus suggesting that the computed index of consistent ranking (coefficient of concordance W = 0.56909) is a middling.

Besides, the PCA deployed was successful in achieving parsimony by clustering a plethora of sixty one (61) variables into mere nineteen (19) collections or enfoldments. To-boot, an outstanding sturdy cluster wielding remarkable positive factor loadings which was creatively labelled Ominium Gatherum came up trumps as most significant and its quite needful as policy instrument.

Thus, if NNPC is to square away (neaten up) the dysfunctionality and have to nudge their operation towards a decent future, this paper importunes that the ominium gatherum, in the first instance needs to be factored into their aggregate planning.

Key words: Ominium gatherum, Principal Component analysis, Coefficient of Concordance, Refinery, Subsidy.

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1.0 INTRODUCTION

Nigeria operates four refineries that contribute to a gross output of about 222.5 bpd of crude out of the 445 bpd of installed capacity. The current output is considered grossly inadequate to meet the total demand of about 35 million litres per day of PMS. Consequently, the nation is pushed to the precipice of energy crises that has manifested in frequent acute shortage of petroleum products, a situation that is in itself rather embarrassing, being the seventh oil producer in the world.

There are oodles of factors that contribute to this kind of anomaly. Among others, they include inadequate manpower planning, operational dysfunction, paucity of innovative initiatives, recycling of retired staff on contract basis, exportation of crude oil and subsequent buying back of the refined products, as well as approval and payment of subsidy by government. There are more offending reasons why the refinery is malfunctioning, but space forbids their inclusion.

This research is considered paramount at this point in time because it is blushing to hear that a nation that is ranked seventh in the world oil output is being seen by the outside world as a banana republic that exports crude oil and then goes to buy back the bye products to satisfy its domestic needs. Moreover, it is important that exhaustible resource should be judiciously used in such a manner that the proceeds from the utilization would be ploughed back for the establishment of heavy industries that will in turn becomes sources of income generation that will be relied upon when the natural resource would have depleted.

As it were, now, petroleum appears to be an albatross on the neck of government because by mismanaging the resources, it has become a burden that hinders our progress. For instance, economic activities are hampered by fuel scarcity and where you find it to buy it is at a prohibited cost. This situation has lingered and is still lingering. An oeuvre of studies has examined a farrago of problems associated with the conversion of crude oil into end products and found that they are multi-facetted. However, aggiornamento in this field reveals that the balance of literature is glaringly deficient on the combined use of Kendall coefficient of Concordance and a brand of Factor Analysis, Principal Component Analysis (PCA), as analytic in researching the problem.

The current study breaches this frontier of knowledge by applying the combination of these two models as to have a bird's-eye-view, not worm's view of the problem. Accordingly, the combined model is seemly and adequate as against others that seem to be like viewing the problem from a low position.

Vast literature related to oil upstream, midstream and downstream sectors abound. Specifically, efforts to address the problem of refinery operation has been carried out by many researchers. Petroleum refining is undoubtedly, one of the most complex chemical industries. [1] Studied the complex nature of refineries comprising many different and complicated processes with various possible configurations and structures. Several attempts had been made on how to improve refinery output. In Nigerian, the effect of petroleum shortages occasioned by poor performance of the Nigerian refineries was studied by [2]. In this research, a projection for petroleum products and energy demand was highlighted and necessary steps must be taken to meet the projection as a way forward. Significant effort has been made by these authors [3, 7] on the application of Linear Programing and Mixed Integer Linear programming models to investigate refinery planning and optimization.

Relatedly, a Mixed Linear Programing approach as it applies to refinery optimization was carried out by [14]. More recently, [4] had studied the inherent risks associated with Nigerian Marginal oilfields and provide useful insight on how to mitigate risks to unlock economic potential of the marginal oil field. Modelling of refinery production, planning and scheduling to enhance operational efficiency is credited to [5]. Furthermore, [6] addressed the problem of refinery planning under uncertainty using applied stochastic optimization. [7] applied mathematical programming in optimizing operations in petroleum refineries while [8] take a cursory study on how best our refineries can be deregulated to achieved optimal performance of the industry.

Safety of operators and equipment is of great essence in refinery operation as it enhances production output and reduce as reasonable practical, the effect of hazard to operators. One of the latest research on this is credited to [9] who carried out detailed safety evaluation and analysis of Naphtha Hydro – Treating Unit (Nhu) of the Kaduna Refining and Petrochemical Company to ascertain the safety level of the unit's operation. The study concluded by suggesting proactive control measures to be implemented to reduce safety and occupational health hazard. Maintenance of refinery is a key success factor for optimal output as seen in [10]. The investigation focused on how best refineries can be maintained to reduce the down time due to pressure on the equipment. The result revealed that Reliability Centered Maintenance (RCM) is popular among other methods in achieving continue improvement in reliability of equipment. Refineries equipment are always over stretch do to continuous operation. [11] study on how best refineries can overcome the problem of equipment stretch and conclude that debottlenecking can enhance the efficiency and effectiveness of the refinery. Similar study was carried out by [12]. It analyze the criteria used in the industry for measuring the performance of petroleum refineries and recommend management

intervention model. The paper [13] studied the uncertainty of refinery using Hybrid of Stochastic Programming Approaches with Economic and Operational Risk Management. Nigerian refineries has become cost centre [12, 15] and effort is needed to correct this anomalies. Several research were carried out to evaluate the specious administration of subsidy regime of the Federal Government credited to [8, 16, and 18].

The aim of this study is to conduct a survey of a diversity of factors that impact on the performance of oil refining functions in Nigeria. And having identified these factors to further examine the interplay among them so that through such knowledge and understanding of the dynamics, policy variables can be articulated to guide the operators of the refinery on the optimal plan to follow in order to achieve effectiveness and efficiency in their operations. This has become imperative because resources have to be well managed and utilized for the growth and development of the Nigerian economy. Natural resources like the crude oil deposit is an endowment from nature and its exhaustible. Therefore, optimal utilization is needed so that proceeds from such sector can be reinvested for future utilization when the resources is depleted

2.0 Methodology

2.1 Research design

The game plan adopted in this research setting involves a general survey of attitudes of refinery workers towards crude refining. The population is the total workforce in Nigeria refineries. However a stratified sampling comprising Kaduna Refining and Petrochemical Company (KRPC), Warri Refining and Petrochemical Company (WRPC), and part of the academia represented by Federal University of Petroleum Resources, Effurun (FUPRE) were taken as our sampling unit.

Scale items couch from past studies on refinery were used to craft questionnaire which were administered to knowledgeable people in the organisation taken as sampling units. The sixty one (61) scale items or variables are contained in the questionnaire. Altogether, 150 sets of questionnaire were administered but only 118 were retrieved. Respondent's scores were collated as data matrix and fed into StatistiXL software that provided an output of the following:

(1) Scree Plot
(2) Eigen Value and Eigen vectors

(3) Factor Loadings
(4) Descriptive Statistics

These outputs guided the subsequent interpretation that were rendered.

Previous to this, the scale items were referred to 40 judges who rank them in the descending order of importance. The consistency in ranking is represented by coefficient of concordance, W. And chi square (χ^2) statistic was used to appraise how consistence the judges were in ranking the scale items.

The detail of the coefficient of concordance is sketched hereunder.

a. Let N = number of scale items to be ranked and let k = the number of judges assigning ranks.
b. Cast the observed rank into K X N matrix
c. For each entity obtain R_j, which is the total scores of each of the scale item
d. Obtain the mean of the various R_j's
e. Obtain the deviation of every R_j from the calculated mean of (d)
f. Obtain the square of the deviation of each of the scale items
g. The Kendall Coefficient of Concordance (W), which measures the degree of agreement between the judges is obtained from the formula as stated below

$$W = 12\,S/K^2\,(N^3 - N) \qquad (1)$$

Where $S = \sum(R_j - \sum R_j/N)^2$ = Rank variance

See (Legendre, 2005) for detailed information on the application of the Coefficient of Concordance.

2.1 Test of Hypothesis

Here, we put forward the following hypothesis:

H_o: The rankings of the 40 judges are discordant

H_1: The judges are using the same standard in ranking.

Since N is essentially large, we apply χ^2 – test to ascertain the significant level of W calculated.

Clearly, χ^2 = k (N-1) W

2.3 Abridge theory studding the application of the Principal Component Analysis (PCA)

Let X_{ij} and Y_{ij} represent a pair of variables in the data matrix.

Define column mean as

$$\overline{X_{.j}} = \sum_{i=j}^{N} \frac{X_{ij}}{n_j}$$

And

$$\overline{Y_{.j}} = \sum_{i=j}^{N} \frac{Y_{ij}}{n_j}$$

Then $x = X_{ij} - \overline{X_{.j}}$ and

$y = Y_{ij} - \overline{Y_{.j}}$

Hence, the Correlation coefficient, r_{ij} is defined as

$$r_{ij} = \frac{\sum xy}{\sqrt{(\sum x^2).(\sum y^2)}}$$

When r_{ij} is computed for every pair from the whole lot of ${}^{n}C_2 = \frac{n!}{(n-2)!2!}$, we then collate same into a correlation matrix which forms the first input to Factor Analysis.

StatistiXL software is then used to generate output such as:

i. Descriptive Statistics
ii. Communalities
iii. Factor Loading
iv. Eigen values and Eigen vectors

3.0 RESULT

FACTORS	1	2	3	4	5	…	57	58	59	60	61
SUM OF RANKS	102	1447	1489	709	1498	…	1731	993	1436	2131	481

$\mathbf{R_j - [\frac{\sum Rj}{N}]}$	$\mathbf{(R_j - [\frac{\sum Rj}{N}])^2}$
-1196.36	1431279.642
148.639	22093.55232
190.639	36343.22832
-589.361	347346.3883
…	…
432.639	187176.5043
-305.361	93245.34032
137.639	18944.49432
832.639	693287.7043
-817.361	668079.0043
Total	**17218503.35**

$\sum R_j =$ 79200

$[\frac{\sum R_j}{N}] =$ 79200/61 = 1298.361

$S = \sum(R_j - \frac{R_j}{N})^2$ = 17218503.35

W = 17218503.35/ (1/12)*40^2 (61^3- 61)

= 17218503.35/30256000

= 0.569093

χ^2 = K (N-1) W

= 40 (61-1)0.569093

= 1365.8252

χ^2_{cal} = 1365.8252

(N – 1) = degree of freedom

Ho: The rankings of the 40 judges are discordant

H1: The judges are using the same standard in ranking

At 0.05 significant level, $\chi^2 = 79.08$, at 0.1 significant level, $\chi^2 = 74.4$

χ_{cal} = 1365.8252 > 79.08 and 74.4,

At 0.05 and 0.1 significant level, the critical values are 79.08 and 74.4 respectively which are each lower than the chi square value. This inclines to fail the null hypothesis. Hence accept H_1 hypothesis. This shows that the judges were in agreement in the ranking of the scale items.

3.1 RESULT INTERPRETATIONS

The coefficient of concordance was computed as w = 0.569 which is considered a middling in order words it is in the border line of average value. The chi square (χ^2) test at 0.05 and 0.1 significant level, the critical values are 79.08 and 74.4 respectively. This inclined us to fail to accept the null hypothesis that the judges ranking is discordant, our conclusion therefore, the judges use the same criteria to do the ranking. Consequently, appendix 1 list the scale items in merit order sequentiality.

The correlation matrix as obtained with StatistiXL is shown in table 2. Fig III. Shows that at Eigen value of one (1), nineteen (19) factors were extracted, and this shows that there is significant parsimony of scale factors from 61 to 19. We shall proceed now to discuss the 19 variable clusters

As can be seen from table 1 that follows, the variables cluster there comprises a collection of miscellaneous scale items which we have seemly creatively labelled omnium-gatherum.

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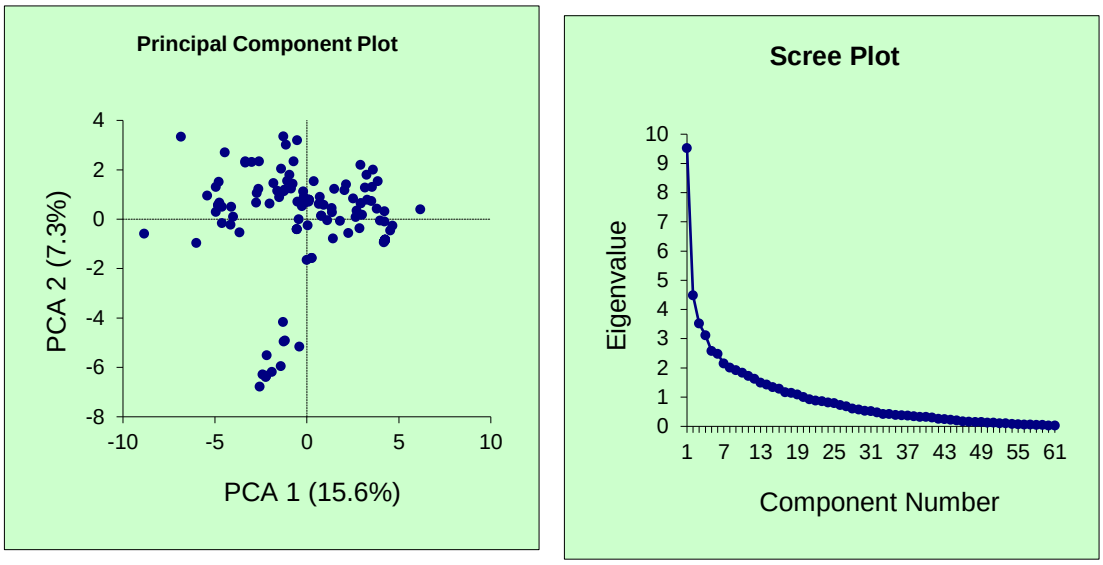

Fig. III: Showing PCA Plot and Scree Plot

PC1: OMIUM GATHERUM		
Components Loadings (correlations b/w initial variables and principal components.		
SCALE ITEM NO	**SCALE ITEM**	**COMPONENT LOADINGS**
4	Business Sustainability	0.574
7	Paucity of Investors	0.433
13	Currency fluctuation	0.695
14	Interest Rates	0.433
15	Political Vicissitudes	0.572
17	Properties Acquisition	0.556
20	Gas Flaring	0.509
23	Equipment Reliability	0.631
25	Safety Risk	0.624
28	Technology Limitation	0.603
31	Refinery Planning	0.507
33	Cost of adequate techniques	0.524
34	Infrastructure deficit	0.618
38	Turn Around Maintenance	0.494
41	Operational Risk	0.424
42	Standard Operating Procedure	0.639

43	Cognate Training	0.439
44	Manpower imbalance	0.584
46	Management Commitment	0.449
51	Leadership Style	0.482
53	Manpower Resource Recruitment	0.563
57	Population Encroachment	0.488

Table 1: **Omnium-Gatherum**

The factor loadings are predominantly middling and some moderate loadings. The magnitude of loadings indicates how important the scale item is within the cluster. As we can readily descend from the column vectors of loadings, they are all positive showing that omnium-gatherum cluster is a sturdy factor because none of them is negative. We shall take some sample of these variables to discuss their significance. For instance scale item 13 wields a factor loadings of 0.695 which is the first in the column has the highest value. The import is that the exchange rate between the dollar and naira as far as refinery operation costing is concern is very paramount and indeed it is so. Most of the materials using in refining crude are imported and little local content are involved. There is the need therefore for the management to undertake innovative research to discover how alternate local raw materials can be use in refining.

The next item is Standard Operating Procedure (SOP) with scale item number 42 which have a factor loading of 0.639. And this scale item implies that the standard operating procedure in system operation is to ensure safety of the people/machine. Our interpretation is that WRPC and KRPC are seemly in this aspect. Next in order of importance is equipment reliability with scale item no 23. A good number of equipment appears to be good but a major problem has been scale item no.15, political vicissitude, in order words, item 51 whose factor loading is 0.482, the leadership style appears to be deficient in grandeur and purposefulness**.** The leadership style is wreathen in corruption and ineptitude.

Safely risk have a scale item no. 25 and the corresponding factor loading of 0.624 is considered substantial. We cannot agree more in this claim, because refinery hardly have fire incident except for the scam of two years ago which did not result to any serious safety risk. The PCA model employed has singled item 34, infrastructure deficit, as the next important to safety risk. It seems that accumulated depreciation including obsolescence in technology is affecting the operations of the refinery and as such Turn-Around Maintenance (TAM), which is item 38 appears not to be too important by virtue of the low rating 0.494. Indeed TAM cannot be of much primacy when there is obvious technological obsolescence and this lead to unreliability of equipment. The implication is that the refinery is affected by age. Other important factors are manpower imbalance, and manpower resource recruitment with scale items 44 and 53 respectively with corresponding factor loading of 0.584 and 0.563. What is significant is that although the organization may have the right number of people but they are not matching competence. Other variables include interest rate, paucity of investors, and business sustainability. The rest include properties acquisition, gas flaring, refinery planning, operation risk, cognate training and population encroachment. All these are important variables to be included in the first phase of planning for repositioning the entire gamut of omnium-gatherum constitute elements of policy variable in case the organisation would organise for operational rebirth.

At this juncture, we take up another cluster which is organizations goodwill: Partnering alliance, gratification, maintenance, petroleum process technology and reputation as depicted in table 2 below.

PC2: ORGANIZATION'S GOODWILL		
11	Partnering Alliance	-0.448
16	Gratification	0.690
26	Maintenance	0.522
30	Petroleum Process Technology	0.418
56	Reputation	0.536

Table2: Organization's Goodwill

The respondent's evaluation of organisations goodwill is well captioned in the fivefold cluster creatively labelled as organisation's good will. It is a bipolar factor with four scale items wielding positive signs, where one of the scale item 11, creatively labelled as patterning alliance having a factor loading of -0.448 having a negative sign. The import of

this negativism is that the refinery management is not patterning or networking with similar refineries outside Nigeria. With a view to copying positive development as being practiced in order places. Gratification is in scale item 16, has the highest factor loading. In order words, the respondents could not agree more that unwholesome practices appears to be prevalent in the organisation. Scale item 26, wields a factor loading of 0.522 is a mediocre. It signifies that average attention is given to maintenance in the organization. But scale item 30, refinery process technology wields more factor loadings, this signifies that the processing methodology adopted by NNPC is not the state-of-art technology. Finally, the reputation of the organisation is considered adequate by virtue of factor loading of 0.536 for scale item 26.

The next cluster creatively labelled economic condition is another bipolar factor. With the exception of scale item no. 47, motivation, have a negative factor loading of -0.522, the rest four factors are moderately loaded. We know that payment in NNPC is very much higher than those in the civil service but by negative loading, the impression is that motivation is low. This can not necessarily by monetary, it may be recognition and some other ways. This factor has to be looked into. Our interpretation will be that part of lack of motivation might be that the work is not productive and challenging even though workers get good remuneration.

The scale item, soaring price has factor loading of 0.428. The factor loading indicates that the issue is fairly important, however, the soaring price arises on the account of the fact that Nigeria export crude and buys back refined products and that exposes Nigeria to market forces which tend to influence the high cost of the products in the domestic market. Competition, Sanctions and explosion risks all have similar factor loadings representing economic condition.

However, further downstream, we have oligopolistic practices by few oil marketers which sometimes create artificial scarcity in order to create soaring prices. This oligopoly is both practice by independent and major marketers alike. Funding, that is, the no. 1 scale item wield a factor loading of 0.485 falls within the regime of middling. Our interpretation of this scale item based on the factor loading is that the organization moderately funded by government but response appear to be undecided about income and the expenditure pattern in the organization. Again, sanction and explosion risk are also of moderately significant in the organization. Sanctions and explosion risk wield factor loadings of 0.475 and 0.466 respectively. Sanction such as prohibition of gas flaring is still not effectively enforced while explosion risk appears to be an uncommon issue.

Another important cluster is creatively labelled Nuggets of know-how is another bipolar factor because the matrix of the factor loadings are having negative and positive signs. The scale items nos. 6 and 49, changes in demand and skills respectively wield factor loadings of -0.415 and –0.481. The Nigerian consumers are in need of more products but there is no corresponding increase in supply. Marketers who are importing the products are not meeting the demand hence, the negative value. More importantly, the refinery appears not to have the right know how and the working plants to meet up with increase demand and that appears to be the main reason decision to export crude and buys back the refined products. Equally, the refineries do handle certain projects and we know that risks skulls in stillness just like surprise await in the ambush. The middling factor loading in this scale item suggests that project management risks are classified as average importance. Maintenance methodology, this scale item no. 29 has moderate loadings suggesting that maintenance attention is given fair concern. Skills, serial no. 49, have negative factor loadings of -0.489. The implication is that the skill to refine crude oil is lacked.

The next cluster is creatively labelled corporate overdrive. It is a lanky factor because all the variables have negative factor loadings. The implication is that extra effort is not being made in the area of process safety, job satisfaction, and manpower availability in order to achieve corporate goals.

Talking about supply chain management which encompasses three factors, market volatility, crude loading/unloading, and adequate manpower resource availability are negatively loaded as middling, suggesting that they are shadows of themselves. It further suggest that the products are unsteadily available in the market while adequate manpower availability is a farce. Besides, loading and unloading of crude for export and unloading of refined product where they are imported do involved unavoidably delays. All these scale items supply chain of products distribution in Nigeria.

Villainousness of vandalism: this represents a bipolar dual factor. The first reflects insecurity and terrorism. As a matter of fact, villains, for whatever reasons disrupt pipelines, bearing crude oil and gas for their own selfish motives. The factor loading on this issue wields a value of -0.450 suggesting that the issue is middling by PCA evaluation. The negative values shows that, within the context of the cluster, the variable is destructive, and it is neither in the interest of the organization nor that of Nigerian. The issue need to be addressed. On the other hand, legal risk is associated with havoc caused by the activities of villains. The effect of these villainous acts affect the communities in which they operate. The NNPC is held

accountable for payment of compensation. The issue is thus a serious environmental pollution matter.

Seemly corporate culture: In this motley, effective monitoring and supervisory role is considered, NNPC needs to liaise with National Environmental and Enforcement Agency (NESREA) including other agencies, National Oil Detection and Response Agency (NOSDRA), National Security and Defence Corps (NSDC), the Armed Forces, Police in order to curb the menace of the vandals.

Miscellany PC 12 – PC 19

This breed is a lanky factor because they all wield negative values. The import is that there appears not to be adequate networking of existing facilities, infrastructure and other facilities. These resource need to be optimally utilized. Again, the refinery operations need to be automated. Since this idea is yet be implemented, it is, loaded as negative factor.

Finally, we examine pipeline vitalization. We have stated from the foregoing, the negative dimension which the actors – villains - perpetrate. But that's a longer matter for another time.

CONCLUSION

At the onset, we set out the objective of this study to identify the gamut of factors that impact on the operation of the NNPC especially the WRPC. The study further tries to appraise the inter correlation among these variable. To this end, our results show that the variables identified are multifaceted and substantial correlation exist among them. These correlation have been found significant in the area of policy articulation for dealing with the research problem.

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APPENDIX 1

S/No	ORDER OF SEQUENTILITY	S/No	ORDER OF SEQUENTILITY
1	Funding Risk	32	Changes in demand for products
2	Cognate Training	33	Job satisfaction
3	Technical Knowhow	34	Standard Operating Procedure
4	Pipelines Vandalism	35	Environmental Regulations
5	Equipment/tools inspection	36	Soaring Price
6	Poor Management commitment	37	Cognate Training
7	Gratification	38	Sanction
8	Equipment Reliability	39	Competition Risk
9	Political Vicissitudes	40	Market volatility
10	Refinery Complete Automation	41	Industry Policies
11	Business Sustainability	42	Turn Around Maintenance
12	Safety Risk	43	Project Management Risk
13	Adequate Manpower Plan	44	Petroleum Process Technology
14	Manpower Resource Availability	45	Population Encroachment
15	Effective Supervision	46	Cost of adequate Techniques
16	Explosion Risk	47	Process Safety
17	Maintenance	48	Choice of Outsourcing
18	Paucity of investors	49	Refinery Planning
19	Insecurity/ Terrorism	50	Demand fluctuation
20	Interest Rate	51	Maintenance Methodology
21	Team work	52	Manpower Recruitment
22	Loading / Unloading	53	Partnering Alliance
23	Operations Risk	54	Skills
24	Infrastructure deficit	55	Relevant Linkages
25	Gas flaring	56	Manpower Planning
26	Currency fluctuation	57	Effective Communication
27	Return on investment	58	Leadership Style
28	Motivation	59	Reputation
29	Obsolete equipment	60	Legal Risk
30	Properties Acquisition	61	Fine
31	Technology Limitation		

Table 3: Showing the merit order sequentiality of the sixty One scale items