Supplier Selection in Power Plant: A Case Study

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ABSTRACT:
This research paper is an attempt to select the best supplier with proficiency in adopting sustainable practices for ABC Thermal Power Plant using Factor Analysis technique by SPSS software with keeping in mind the long term relationship goals and establishing co-dependencies with integrated Supplier Relationship Management (SRM). With the help of personal interview, telephonic interview and questionnaire, data is collected from vendors and ABC Thermal Power Plant and analyzed. On the basis of researcher's observation all seventeen factors are prioritized and different Weightage has been allotted to them. Statistical Analysis is also done using SPSS software. The seventeen factors used are – "Exposure to SRM". "Hindrance due to lack of supply (HDS)", "Waste Management", "Sustainable Practices", "Low Pricing", "High Pricing with Additional Benefits", "Reverse Logistics", "Storage Capabilities", "ISO Certification". "Geographical Proximity", "Supply Chain Decision Making (SCDM)", "Financial Stabilities", "Commitment to Carbon Footprint reduction", "Green Transportation Channel (GTC)", "Information Sharing", "Integrated Decision Making" and "Associated Services". Composite Supplier Selection Index (CSSI) and cut-off value has been calculated as- (3.71). The research findings suggest that vendor 2 is most suitable with score of (4.39).

Keywords- FACTOR ANALYSIS, SRM, SPSS, THERMAL POWER PLANT

I.   INTRODUCTION-

Supplies are always in great demand when it comes to industrial operations .The quality of raw material their price accompanied by sustainability and environmental effects are a major concern for industrial operators these days. Supplier Relationship Management is the subject which is focused to develop two-way mutually beneficial relationships with strategic supply partners to deliver greater level of innovation and competitive advantage. In world arena due to increasing awareness of environmental sustainability among stake holders, local communities, employees as well as government huge pressure is surmounting on the organizations to adopt sustainability effectively by the government stringent rules and regulations so the decision regarding effective supplier relationship management plays a key role to improve organizational performance and competitive advantage keeping in view of sustainable supply chain management. As in case of thermal power plants various suppliers are required as-for Coal, Ash handling, Engineering and construction works, Maintenance, and Recruitment agency. From which Coal suppliers are of primary concern as coal is the key element. The supplier selection process deploys a great amount of a firm's financial income. In return, firms also look forward to large profit from contracting with high price. The above mentioned challenges create suppliers selection and managing relationship with them a tough nut to crack for operations and management sciences disciplines. Supplier Relationship Management (SRM) is the systematic approach to evaluating vendors that supply goods, materials and services to an organization, determining each supplier's contribution to success and developing strategies to improve their performance. SRM is a recognition that these are accurately and usefully thought of as comprising a relationship, one which can and should be managed in a coordinated fashion across functional and business unit touch-points and throughout the relationship life-cycle. It helps to determine the value each supplier provides and which ones are most critical to business continuity and performance. Factor Analysis is the procedure

primarily used for data reduction and summation. It analyzes interrelation among large set of variables and attempt to explain them in common underlying dimensions. Factor Analysis is a statistical method used to describe variability among observed, correlated variables in term of a potentially lower number of unobserved variables called factors. It helps to deal with data sets where there are large numbers of observed variables that are thought to reflect smaller number of underlying/latent variables.

Assumptions-
1. Linear relationship between all variables.
2. Homogenous sample is taken.
3. Multiple variables that can be measured at continuous scale.
4. Assumes independence of observation.
5. Large sample size requires.
6. No significant Outliners.
This paper besides providing a review of literature on SRM and Factor Analysis includes Factor Analysis of supplier selection in Thermal Power Plant.

II. LITERATURE REVIEW-
An SRM system strategically aims for collaboration with suppliers, So that a company can develop a new product competitively and produce goods efficiently. Accordingly, topics such as shaping the purchasing strategy, supplier selection, collaboration, and supplier management have widely studied. Purchasing strategies can be classified into two types. One is the competitive approach, which assumes that based on completion between suppliers; buyers can obtain goods for the minimum price. The other is the cooperative approach, where the suppliers and the buyer form a strategic relationship and cooperate with one another to achieve a long-term goal (Chandra and Kumar, 2000). A good supplier selection process is very important for efficient purchasing and manufacturing. The decision making process of evaluating and selecting a supplier is complicated for two reasons. First, suppliers can be evaluated by more than one criterion. Second, each supplier has a different specialty and thus a different criterion. Additionally, there are two problems encountered in supplier selection (Ustun and Demirtas, 2008). One is the single sourcing problem: the goal is to satisfy the buyer's needs with one supplier. In this case, the manager would decide who is best among them. The other problem is a multiple sourcing in which it is not possible to satisfy the buyer's needs with one supplier and in turn, allocate

suppliers to them (Ghodsypour and O'Brien, 1998). With this in mind two issue of the supplier selection approach are paramount:
1. The identification of which criteria should be considered in the assessment of suppliers (Dickson, 1966; Weber et al., 1991).
2. The application of techniques for the evaluation of suppliers in the decision making process so that they can properly selected (Schniederjans and Garvin, 1997).

Factor Analysis is a multivariate statistical technique applied to a single set of variables when the investigator is interested in determining which variables in the set form logical subsets that are relatively independent of one another (Pearson, 2013). In other words factor analysis is particularly useful to identify the factors underlying the variables by means of clubbing related variables in the same factor (Verma and Abdel Salam, 2019). In this paper main focus is given of Factor Analysis for selection of supplier. Factor Analysis is based on the assumption that all variables correlate to some degree. The variable should be measured at least at the ordinal level. Sample size should be large [3 and 4]. There are two main approaches for factor analysis: Exploratory factor analysis (EFA) and Confirmatory factor analysis (CFA). Exploratory factor analysis is used for checking of dimensionality and often used in the early stages of research to gather information about the interrelationships among a set of variables (Pituch and Stevens, 2016). On the other hand, the confirmatory factor analysis is a more complex and sophisticated set of technique used in the research procedures to test specific hypotheses or theories concerning the structure underlying a set of variables (Black, Anderson, Babin and Tatham, 2006). In Thermal Power Plant, suppliers can be measured by the large number of parameters. The application of Factor analysis provides valuable inputs to the decision makers and policy makers to focus on few factors. People working in Thermal Power plant have concerns regarding their suppliers- geographical proximity, reverse logistics usage, Sustainable practices, supply chain decision making, commitment on reduction of carbon footprint, information sharing, ISO certification, financial stability of their suppliers, storage capabilities, degree of exposure to supplier relationship management, green transportation channel usage, waste management, pricing whether low or high and providing additional benefits with it and associated services provided by the suppliers.

Instead focusing on one or two factors, the researcher can make strategy to optimize these components for the growth of their business.

S. No.	Year	Title	Authors	Findings
1	2021	Factor Analysis as a Tool for Survey Analysis	Noora Shrestha	Factor Analysis is a promising tool to extract significant Factors
2	2019	Testing statistical assumptions in research	Verma and Abdel Salam	Clubbing of variable by Factor Analysis
3	2016	Applied multivariate statistics for applied sciences	Pituch and Stevens	Applications of SPSS
4	2010	SPSS survival manual: A step by step guide to data analysis	Pallant J	Factor analysis in SPSS
5	2009	An integrated approach to SRM	Jongkyung park and Kitae shin	SRM effectiveness Increases with Integration and collaboration
6	2009	A Weighted additive fuzzy multi objective model for the supplier selection problem under price breaks in supply chain	Ghodsypour and O'Brien	SRM and supplier Selection relationship
7	2008	An integrated multi-objective decision making process for supplier selection	Ustun and Demirtas	Allocation for supplier selection

TABLE 1- Findings from Different Research Papers on Factor Analysis.

III. METHODOLOGY-

Methodology is a system of methods used in a particular area of study and activity. Two techniques and software have been used to perform Factor analysis and obtaining the results. An interview technique is a conversation where questions are asked and answers are given verbally to transform the information from interviewee to interviewer, although information transfer can happen in both directions. Interviews involve the use of a set of predetermined questions and of highly standardized techniques of recording. The Unstructured interviews are characterized by a flexibility of approach to questioning. The language of the interviewer can be adapted to the ability or educational level of the person interviewed and as such misinterpretations concerning question can be avoided. It served as a great advantage of the interview process. A questionnaire is a research instrument consisting of series of questions and other prompts for a purpose of gathering information from respondents. In this method a questionnaire is sent (usually by mail or email) to the person concerned with a request to answer the questions and return the questionnaire. A questionnaire is mailed to respondents who are expected to read and understand the questions and write down the reply in the space meant for the purpose in the questionnaire itself. Statistical analysis is done using SPSS software as shown in Table-3. The "Statistical Package for Social Science" (SPSS) is a package of programs for manipulating, analyzing, and presenting data; the package is widely used in the social and behavioral sciences. For this research purpose we have preferred Single factor analysis as it gives the proper view of the data and have higher efficiency and effectiveness over other methods.

Checking reliability of collected data is must before processing on the further calculation. We have calculated this value of Cronbach's Alpha using SPSS software. Value of Alpha should be more than 0.50 less than that represent the irrelevancy the data recorded and the steps should be taken to ensure better reliability, no calculation or further procedure should be than with that data as that data is not good enough to defend the result it brought. Value of

Cronbach's Alpha for this research is 0.589, which   signifies the reliability of data.

Reliability Statistics

Cronbach's Alpha	N of Items
.589	17

TABLE-2 depicts the Cronbach's Alpha value calculated by SPSS.

The methodology examines various factors which have to be considered on selection of a supplier for Thermal Power Plant. Factors are considered with the help of Industry Experts.

S No.	Factors Considered
1	Exposure
2	Hindrance due to supply (HDS)
3	Sustainable practices
4	Low Pricing
5	High Pricing with Additional benefit
6	Reverse Logistics
7	Storage Capabilities
8	ISO Certification
9	Geographical Proximity
10	Supply Chain Decision Making (SCDM)
11	Financial Stability of supplier
12	Commitment to reduces Carbon Footprint
13	Green Transportation Channel (GTC)
14	Information Sharing (IS)
15	Integrated Decision Making (IDM)
16	Waste Management (WM)
17	Associated Services (AS)

Table 3- Factors considering for Factor Analysis

TABLE 4- Statistical Analysis of Considered Factors

	N	Minimum	Maximum	Sum	Mean	Weightage	CSSI
Exposure	85	3.000	5.000	267.000	3.14118	.03	.09
HDS	85	1.000	5.000	295.000	3.47059	.05	.17
Waste Management	85	2.000	5.000	321.000	3.77647	.07	.26
Sustainable Practices	85	2.000	5.000	342.000	4.02353	.08	.32
Low Pricing	85	2.000	5.000	274.000	3.22353	.03	.09
HP and AB	85	1.000	5.000	241.000	2.83529	.03	.08
Reverse Logistics	85	2.000	5.000	285.000	3.35294	.04	.13
Storage Capabilities	85	2.000	5.000	348.000	4.09412	.09	.37
ISO Certification	85	1.000	5.000	298.000	3.50588	.05	.18
Geographical Proximity	85	1.000	5.000	302.000	3.55294	.05	.18
SCDM	85	2.000	5.000	354.000	4.16471	.10	.42
Financial Stability	85	1.000	5.000	280.000	3.29412	.04	.13
Carbon Footprint	85	1.000	5.000	345.000	4.05882	.09	.36
GTC	85	1.000	5.000	285.000	3.35294	.05	.17
Information Sharing	85	2.000	5.000	348.000	4.09412	.10	.41
IDM	85	1.000	5.000	266.000	3.12941	.03	.09
Associated Services	85	1.000	5.000	315.000	3.70588	.07	.26
Valid N (list wise)	85					1.00	3.71

IV.   DATA COLLECTION AND ANALYSIS

In order to collect data to perform the Factor Analysis, regular visits were made to various departments of ABC Thermal Power Plant (production department, quality management, marketing department, purchasing department etc) and many key meetings were held with the head of these departments to understand the present status of the firm based on considered factors. An Interviewing technique is used when meetings were held with the different departmental heads to obtain relevant information regarding different aspects of ABC Thermal Power Plant. Then a questionnaire is prepared based on these meetings which include seventeen factors. These factors are "Exposure to SRM". "Hindrance due to lack of supply (HDS)", "Waste Management", "Sustainable Practices", "Low Pricing", "High Pricing with Additional Benefits", "Reverse Logistics", "Storage Capabilities", "ISO Certification". "Geographical Proximity", "Supply Chain Decision Making (SCDM)", "Financial Stabilities", "Commitment to Carbon Footprint reduction", "Green Transportation Channel (GTC)", "Information Sharing", "Integrated Decision Making" and "Associated Services". Departmental heads were asked to fill the questionnaire to capture their views on supplier selection criteria on a linkert scale which shows "Strongly Agree, Agree, Somewhat Agree, Disagree and Strongly Disagree" and marks were allotted in range from 1 to 5 as nature of the question. Questionnaire contains 26 questions under 17 factors. After that data of ten vendors from ABC Thermal Power Plant were also collected to analyze and found out the best one among them. Then data is analyzed to draw conclusions.

Mean of the attributes- Sum of all the values obtained from questionnaire

Number of questions responded by the respondents

V. RESULTS AND DISCUSSIONS

The result of the factor analysis is shown in Table 4. The table shows all the factors included, mean of these factors, Weightage is given with the help of industrial experts on notion of the value of mean of that factor recorded on data of questionnaire, higher the value of mean higher the Weightage would be given to that particular factor, Weightage given to each factor is- Exposure to SRM is given as (0.03), HDS is given as (0.05), Waste Management is given as (0.07), Sustainable Practices is given as (0.08), Low Pricing is given as (0.03), High Pricing with Additional Benefits is given as (0.03), Reverse Logistics is given as (0.04), Storage Capabilities is given as (0.09), ISO Certification is given as (0.05), Geographical Proximity is given as (0.05), Supply Chain Decision Making is given as (0.10), Financial Stability is given as (0.04), Carbon Footprint is given as (0.09), Green Transportation Channel is given as (0.05), Information Sharing is given as (0.10), Integrated Decision Making is given as (0.03) and

Associated Services is given as (0.07). Weightage has been allotted to factors to attain a summation of all Weightage as (1). From the data of questionnaire mean of the entire factor separately are multiplied to the Weightage to extract Composite Supplier Selection Index (CSSI), then we add all values of factors present in CSSI to extract Cut-off value, which is (3.71) for our research. After the giving suitable Weightage to the factors for attaining long term sustainable relationship with the suppliers we move towards another set of data which is acquired by ABC Thermal Power Plant of their 10 vendors. That data is also stored in those seventeen factors so that statistical analysis can be carried out efficiently and effectively. Then we multiply their respective values of the factors with the Weightage of that factor, after this we get particular assigned cell values of factors of all 10 vendors respectively. We required the summation of all the factorial values of each vendor and compare with our cut-off value. After the comparison Vendors are ranked according to their respective values Vendor having highest value is selected. In this set of data Vendor 2nd gets the highest value as shown in TABLE-5=

TABLE 5- Composite Suppliers Selection Index

Factors	vendor 1	vendor 2	vendor 3	vendor 4	vendor 5	vendor 6	vendor 7	vendor 8	vendor 9	vendor 10
Exposure	0.09	0.09	0.09	0.12	0.09	0.12	0.12	0.09	0.09	0.15
HDS	0.25	0.25	0.20	0.25	0.20	0.25	0.20	0.15	0.10	0.20
Waste Management	0.28	0.28	0.21	0.21	0.21	0.21	0.35	0.28	0.35	0.21
Sustainable Practices	0.32	0.32	0.40	0.16	0.24	0.16	0.16	0.24	0.32	0.16
Low Pricing	0.06	0.09	0.06	0.12	0.15	0.12	0.12	0.09	0.09	0.09
HP and AB	0.09	0.12	0.09	0.09	0.12	0.09	0.09	0.15	0.15	0.15
Reverse Logistics	0.16	0.16	0.16	0.20	0.16	0.16	0.16	0.20	0.12	0.12
Storage Capabilities	0.27	0.45	0.36	0.36	0.45	0.45	0.45	0.45	0.27	0.36
ISO certification	0.20	0.25	0.25	0.15	0.15	0.15	0.20	0.20	0.15	0.15
Geographical Proximity	0.20	0.20	0.25	0.25	0.15	0.20	0.25	0.25	0.20	0.20
SCDM	0.50	0.40	0.30	0.50	0.20	0.30	0.30	0.40	0.30	0.30
Financial Stability	0.16	0.20	0.16	0.16	0.12	0.12	0.12	0.12	0.20	0.16
Carbon	0.36	0.45	0.36	0.27	0.36	0.27	0.27	0.36	0.27	0.27

Footprint										
GTC	0.25	0.20	0.20	0.15	0.20	0.20	0.15	0.15	0.15	0.25
Information Sharing	0.40	0.50	0.50	0.20	0.40	0.40	0.30	0.40	0.30	0.40
IDM	0.12	0.15	0.12	0.03	0.15	0.15	0.12	0.06	0.06	0.12
Associated Services	0.28	0.28	0.21	0.35	0.28	0.21	0.28	0.14	0.14	0.21
SUMMATION -	3.99	4.39	3.92	3.57	3.63	3.56	3.64	3.73	3.26	3.50
RANK	**2**	1	3	7	6	8	5	4	10	9

VI. CONCLUSION-

In the Indian context India is the world's third largest producer and third largest consumer of electricity. The national electric grid in India has an installed capacity of 374.2GW.Electric energy consumption in agriculture was recorded as being the highest (17.89%) worldwide. The per capita electricity consumption is low compared to most other countries despite India having a low electricity tariff.

• Share of Fossil energy is- 79.8%
• Share of Renewable energy is- 20.2%

Energy share of fossil are considerably higher hence selection of supplier should became more important. In our study we gave higher Weightage to the environment friendly factors (Carbon Footprint, Sustainable Practices, Green Transportation Channel and Waste Management) among all 10 vendor 2nd vendor is the best. Awareness towards environment cause, proper following of government rules and regulation for reducing carbon foot print, better training of employees, technological up-gradation and improved Supply Chain Communication with Information sharing are some remedies which can increase supplier's selection probabilities.

(a) Implications for future research-

Supplier's relationship Management is phenomena which is equally important for large as well as small scale. It's very versatile and growing mechanism. Further analysis can be drawn among the factors by using –KMO (Kaiser Meyer and Olkin) sampling adequacy, and various Factor Extraction methods can be applied to draw different results like- Principle Axis Factoring, Eigen value or by Scree Plot or Principal Component Analysis. We only need to remember that we must draw minimum number expressing maximum variance. We can also apply factor rotation to make it simpler to handle and remove cross loading of factors. It is also divided into two types- 1. Orthogonal (two factors are separated by right angle), which means factors are not correlated but it is less natural but easy to handle. It has two types- Varimax and Quartimax. 2. Oblique here two or more factors can correlate which makes it much more complicated to handle. It also has two types- Oblimin and Promax. Validity and Reliability test can also be performed. As far as Factor Analysis and SRM are concerned it possesses a wide scope. This research paper brings different factors for the selection of supplier which can also be implied for Distributor, Partners or for identification of better fit for Participant of Supply Chain of Thermal Power Plants.

(b) Implication in Industry-

According to the Central Electricity Authority, 269 thermal power plants in India consume 87.8% of total amount of water consumed by Industrial sector. This research work help's in identifying suppliers for thermal power plants and other organization to collaborate for longer duration or periods with ensuring Sustainable Practices in Integrative Supplier Relationship Management (SRM). It is easy to understand and less time taking to increase the efficiency and effectiveness of the organization. It can also be used as a referential paper for further studies in the domain of SRM, Factor Analysis and Supplier Selection Criteria. Supplies have a lasting impact over the finished goods, we can say that a finished is only as good as its supply; hence selecting a decent supplier is necessary. Various different organizations have their own unique set of demands from suppliers this research paper possess seventeen variables and their Weightage which can be useful in making choices of requirement from a supplier. It also possesses a Cut-off by which existing

suppliers can be evaluated accordingly. This process can we done and can be carried out quickly with most suited answers as it deals with whole factors involved individually so any Organization can apply it as per their requiring factors to conclusively select the best possible solution with good enough reasoning. It is not limited for supplier selection only; it is highly versatile and can be used to identify the better among available options. Whether it is for Distributor, Retailer, Partner or Part of Supply Chain, they can be identified and can be selected, and this research paper includes major driving factor in selection of supplier in Thermal Power Plant. Any supplier want to enter in this industry can consider these factors as bench mark and on can ensure a healthy chance to enter in the industry by working on those factors.

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