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ANALYSIS OF SUPPLIER SELECTION CRITERIA IN TRADITIONAL AS WELL AS GREEN SUPPLY CHAIN MANAGEMENT IN INDIAN MSMEs

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Abstract

Supply chain has been traditionally viewed as a one-way integrated manufacturing process, wherein raw materials are converted into final products and then delivered to customers. Under this definition, the supply chain includes only those activities associated with manufacturing, from raw material acquisition to final product delivery. With increasing concerns towards environmental protection, enterprises have become more and more responsible for their products, wanting to reduce pollution and damage to environment. Green supply chain management (GSCM) considers a systematic and integrated approach for companies to maintain their sustainability and competitiveness in the market. Among various issues concerning GSCM, green supplier selection is an important issue in improving the environmental performance. This study attempts to find out traditional and green manufacturing factors, considered during supplier selection in the Indian Micro-Small and Medium Enterprises (MSMEs). Major activities of the traditional and green supply chain; namely cost, quality, service performance, environmental manufacturing management, risk, environmental performance assessment, delivery and innovation &learning are covered in the study. A factor analysis was done using Statistical Package for the Social Sciences (SPSS) to help managers understand the important traditional and environmental dimensions. Factor analysis was used to evaluate the relative importance of various environmental factors, while the data were analyzed using "mean" score. The study found that, from amongst all 8 main traditional and green supply chain performance measures, cost is found to be the most important criteria even today for the selection of suppliers in Indian MSME manufacturing industry, followed by quality, risk, service performance, delivery, environmental manufacturing management, innovation & learning and environment performance assessment. However, when we look at the sub factors, it is clearly seen that the industries these days are not only focusing on purchase cost, but at the same time also on the disposal cost of the

component, meaning that companies are looking for green related criteria in their selection process.

Index Terms— Supplier selection, Supplier selection methods, Supplier selection criterion, Traditional supply chain, Green supply chain management, MSMEs.

I. INTRODUCTION

The concept of supply chain management (SCM) is becoming more complex and competitive day by day; as it was earlier considered as the process of converting raw materials into a finished product and finally delivering it to the customer. Changes in the state of environment, subsequent public pressure and environmental logistics have all come to enforce the shift in manufacturing and business practices. In this context, it has become very important to analyze the entire life cycle effect of all processes and products. Moreover, the structure of traditional supply chain is to be extended further and is to be included with the product recovery mechanism as well. According to Deshmukh A. and Vasudevan H. (2014), the presence of this extension has created an additional level of complexity in the analysis and design of supply chain.

Environmental management or Green supply refers to the way in which innovations in supply chain management and industrial purchasing are considered in the context of the environment. Green supply chain management (GSCM) consists of the purchasing function's involvement in activities that include reduction, recycling, reuse and substitution of materials. Among the various issues in GSCM, green supplier selection is a crucial problem, which needs to be addressed in improving the environmental performance. This is because, a good supplier helps in the supply of material that comply with the regulations and further assists in green design, affecting the performance of the entire supply chain.

Carvalho H., et al., (2010), Rao P.,and Holt D., (2005) and Van Hoek R., and Erasmus I., (2000) observed that, GSCM is an important organizational philosophy, which plays a significant role in promoting efficiency and synergy between partners. It facilitates environmental performance, minimizes waste and saves cost in order to achieve corporate profit and to set market-share objectives through environmental risks and impacts reduction.

This study explains the practices and issues related to the implementation of traditional and green supplier selection criteria among various MSMEs based in India. Total eight criteria namely cost, quality, service performance, environmental manufacturing management, risk, environmental performance assessment, delivery and innovation & learning are considered along with 76 sub factors. The paper consists of five sections. After this introduction, in Section 2, the review of the relevant literature is given. It helps in establishing the link between traditional and green supply chain management. Section 3 contains the research methodology. The result and comparative analysis of various factors of traditional and green supply chain management by calculating "mean score "are presented in section 4. Finally, the conclusion is presented in section 5.

II. LITERATURE REVIEW

Research studies done so far on traditional supplier selection and evaluation have defined numerous evaluation criteria and selection frameworks for supplier selection. In the pursuit of exploring the criteria for traditional supplier selection, the path breaking work by Dickson (1966) has been one of the most cited studies. Weber C. A., et al., (1991), re-examined Dickson's work by reviewing various published articles between 1966 and 1990. Twenty three distinct criteria are identified in various supplier selection problems by Dickson G. W., (1966) and Weber C. A., et al., (1991). Among the 23 criteria identified for vendor selection, the product quality was ranked as the most important, while it was followed by on-time delivery, performance history of supplier and warranties & claimed policies, with cost holding sixth position and so on. In a later work, Cheraghi S. H., et al. (2004), continued to extend these key players' initial work to obtain the current perspective of supplier selection by analyzing articles published between 1990 and 2001. They (Cheraghi S. H., et al. 2004) also provided an update of Dickson's seminal work with 13 more criteria. Deshmukh A. and Chaudhari A., (2011), collected 49 articles on traditional supplier selection criteria from 1992 to 2007. Authors reviewed, ranked and compared them with the criteria given by Dickson G. W., and Weber C. A., et al. Chang B., et al. (2011) and used DEMATEL to find influential factors in selecting SCM suppliers and found that technology ability, stable delivery of goods, lead time and production capability criteria are more influential than the other evaluation criteria. They also suggested extending the scope of the study and exploring the addition of a green supply chain in future studies.

Purchasing function in relation to other functions has a greater role to play in environmental management performance of an organization. Lee A.H.I., et al., (2009a), proposed quality, technology capability, pollution control, environment management, green products and green competencies for green supplier selection in the high-tech industry. Awasthi A., et al. (2010), presented a fuzzy multi criteria approach for evaluating the environmental performance of suppliers and mentioned that the availability of clean materials, environmental efficiency, green image, environmental costs, green products, environmental & legislative management and green process management as the most commonly referred criteria in green supplier evaluation literature. Yeh W.C., and Chuang M.C., (2011) developed two multi-objective genetic algorithms for green partner selection, which involved four objectives such as cost, time, product quality and a green appraisal score.

Bhateja A.K., et al. (2011), conducted a study of various activities of the supply chain processes of various Indian manufacturing industries. Six major activities of the supply chain; namely green sourcing & procurement, green manufacturing, green warehousing, green distribution, green packaging and green transportation were covered. Sarode A.D. and Bhaskarwar V.S., (2011), identified, green product development, green procurement practices, availability of clean technology, green disposal, green transportation, economic labeling of products and reverse logistics as merely focused for supplier selection in Indian manufacturing sectors. Govindan K., et al. (2013), proposed a fuzzy multi criteria approach for measuring sustainability of a supplier and considered pollution production, resource consumption, eco-design and environmental management system as environmental criteria.

The major four activities of the green supply chain management; namely green purchasing, green manufacturing, green marketing and reverse logistics were covered in the study by Nimawat D. and Namdev V., (2012). Kumar S., et al. (2012), investigated the green supply chain management practices likely to be adopted by the manufacturing industry covering electrical and electronics products in India. The study concluded that the factors like green sourcing & procurement, green manufacturing, green warehousing, green distribution, green packaging and green transportation play an important role in supplier selection.

They offered green image, product recycling, green design, green supply chain management, pollution treatment cost and environment performance assessment criteria for green supplier selection.

III. RESEARCH METHODOLOGY

Based on the literature review and discussions with the industrial experts and academicians, a tentative list of the criteria for traditional and green supplier selection was formulated, and accordingly a questionnaire was designed and prepared. In the testing phase of the questionnaire, consultations with industry representatives and academicians included their views on the criteria selected and it was also to check whether all the relevant criteria were covered in the questionnaire. Based on their feedback, the criteria list was modified and put into a structured form, with each sub-criteria falling under their respective criteria/major criteria. At the end of the pre-testing stage, 76 sub-criteria under the heading of eight major criteria were finalized. Each criterion in the questionnaire was judged on a five point Likert Scale, where, 1 = very low, 2 = low, 3 = moderate, 4 = high and 5 = very high were clearly mentioned. Likert scale is a tried and tested scale and has been successfully used in many cases, including supplier selection. Reliability indicates the extent to which an experiment, test or any other measuring procedure yields the same results (Pallant J., 2001). The reliability assessment was conducted on Statistical Package for the Social Sciences (SPSS) software. The responses were obtained from a total of 278 industries that included manufacturing, chemical industries, pharmaceutical industries, automobile industries, plastic industries, electrical and electronics MSME industries. Directors, CEOs, Proprietors and General Managers of these enterprises were interviewed. This was made to obtain accurate information and data to help in the formulation of the important traditional and green evaluation measures. Pallant J., stated in her book that reliability can be measured in various ways. The most common method to measure reliability is by using Cronbach alpha, which was carried out using SPSS. The value ranges from 0 to 1, with higher values indicating greater reliability. Digalwar and Sangwan (2007) recommended a minimum value of 0.7. Cronbach alpha values are dependent on the number of items on the scale. If the number of items in the scale is less than 10, then Cronbach alpha values can be quite small. Here, the mean inter-item correlations were also calculated. Pallant J., (2001), recommended their optimum value to be above 0.3. Item analysis was conducted for each of the 76 parameters through a mean score method. These dimensions were represented and included in the questionnaire, for measuring the different facets of GSCM practices implementation in MSMEs.

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IV. DATA ANALYSIS AND DISCUSSION

Reliability Analysis

Reliability analysis in the study was carried out using a total of 84 criteria (with 8 major and 76 sub-criteria) on SPSS software. The Cronbach alpha values and the range of correlation coefficient give an idea about the scale chosen. It also helps to find whether the sub-criteria have been properly assigned to their respective criteria or not. The Cronbach alpha values were expected to be more than 0.7. Table 1 shows the reliability analysis of the major criteria selected in the study.

TABLE I. RELIABILITY ANALYSIS

Criteria	Total Items	Cronbach Alpha	Range of correlation coefficients
Cost	6	0.846	0.358-0.530
Quality	6	0.886	0.427-0.607
Service Performance	6	0.820	0.337-0.686
Environmental Manufacturing Management	6	0.796	0.397-0.652
Risk	2	0.659	0.530-0.618
Delivery	6	0.565	0.417-0.721
Environmental Performance Assessment	5	0.565	0.365-0.722
Innovation & Learning	3	0.742	0.616-0.752

KMO and Bartlett's Test of Sphericity

The next appropriateness for factor analysis was determined by examining the strength of relationships among the sub-criteria. This was conducted by three measures, the coefficients in the correlation matrix, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. If the loading coefficient is higher than 0.6, the reliability is considered to be high. Meanwhile, if the loading coefficient is lower than 0.3, the reliability is considered to be low (Urbach N. and Ahlemann F., 2010).The Bartlett's test of sphericity should be significant ($p < 0.05$) in the factor analysis to be considered appropriate. The KMO index ranges from 0 to 1 with 0.6 recommended as the minimum value (Pallant J., 2001). Digalwar and Sangwan (2007) recommended KMO value to be more than 0.5 as optimal. Cronbach alpha value and range of correlation coefficients is calculated using reliability analysis. Also, the correlation matrix in Table 1 shows that a majority of the correlations are greater than 0.3. It can be seen from the table that reliability analysis confirms that all the eight major criteria are suitable for applying factor analysis. This indicates that the sub-criteria have common factors (Digalwar and Sangwan, 2007). Table 2 below shows KMO and Bartlett's test of sphericity analysis of the major criteria selected in the study. Analysis of the KMO measure using SPSS in Table 2 shown below reveals that all the measures meet the required standard. The Bartlett's test indicates that all the criteria are significant ($p < 0.05$).

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TABLE II. KMO AND BARTLETT'S TEST OF SPHERICITY

Criteria	KMO	Bartlett's significance value (p)
Cost	0.896	0.000
Quality	0.923	0.000
Service Performance	0.831	0.000
Environmental Manufacturing Management	0.812	0.000
Risk	0.646	0.000
Delivery	0.662	0.000
Environmental Performance Assessment	0.701	0.000
Innovation & Learning	0.778	0.000

Factor Analysis

Factor analysis was conducted considering each of the criteria. The components were extracted in SPSS using principal component analysis with varimax rotation. Initially, factors with Eigen value more than or equal to one were extracted and the scree plot along with the un-rotated factor solution were analyzed. Those factors with a significant slope above the bend in the scree plot were extracted (Pallant J., 2001). A sample scree plot for cost criterion is shown below in Figure 1. The results of the factor analysis for cost, quality, service performance and environmental manufacturing management are shown in Table 3. Similarly for other criteria, factor analysis was performed and total number of factors extracted is as follows: in cost 6 factors, quality 6 factors, service performance 6 factors, environmental manufacturing management 6 factors, risk 2 factors, delivery 6 factors, environmental performance assessment 5 factors and in innovation & learning 3 factors.

TABLE III. SUMMARY OF FACTOR ANALYSIS FOR SUB-CRITERIA

Criteria	Eigen Value	% Variance	Factors Extracted
Cost	2.131 1.462 1.117 1.104 1.022 0.976	17.760 12.184 9.310 9.202 8.516 8.137	6
Quality	3.980 1.543 1.153 1.102 1.044 1.011	23.902 14.066 10.234 7.134 6.534 6.739	6
Service Performance	2.348 2.109 1.675 1.200 1.039 1.023	30.152 11.889 9.442 6.768 5.858 5.767	6
Environmental Manufacturing Management	3.467 1.577 1.341 1.136 1.109 1.007	32.111 11.336 9.635 8.169 7.972 6.987	6

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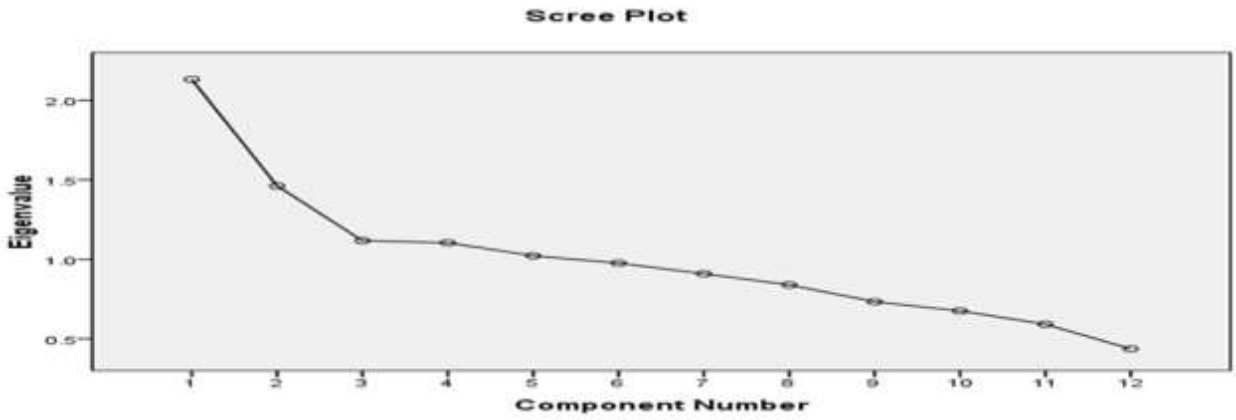

FIGURE I. SAMPLE SCREE PLOT FOR COST

Table IV to VI show the mean values (M) and standard deviation (S.D) of the main criteria and sub-criteria respectively as obtained from various respondents. The tables show the important criteria in the descending order of their means. Higher mean values indicate a more important criteria.

TABLE IV. PERFORMANCE OF MAIN FACTORS

Criteria	Mean	Std. Deviation
Cost	3.23	1.081
Quality	3.20	1.043
Risk	3.20	1.013
Service performance	3.15	1.015
Delivery	3.07	1.127
Environmental Manufacturing Management	3.06	1.149
Innovation and Learning	3.03	1.055
Environmental Performance Assessment	3.02	1.125

Among all eight main traditional and green supply chain factors, cost with its mean value 3.23 is found till today as the most important criteria for the MSME manufacturing industry in India and was ranked at number 1 in mean value, followed by quality and risk at 2nd position with same men value 3.20, and all the other criteria such as service performance, delivery, environmental manufacturing management, innovation & learning and environment performance assessment following the next positions. To summarize, figure 3 shows the importance of the major green supplier criteria in Indian industries.

Table 5 shown below for cost, which had 12 underlying dimensions was having a component disposal cost, which is a green suppliers selection criteria with its mean value 3.23 as the most important dimension and ranked it at 1st position, whereas purchase cost generally is referred as a traditional criteria for supplier selection was ranked at 2nd

position with mean value 3.15. Similarly other traditional criteria in cost such as tax and custom duties, operational expenses etc. were at 3rd and 4th positions. It shows that MSME companies are looking forward to adoption of green criteria in their selection process.

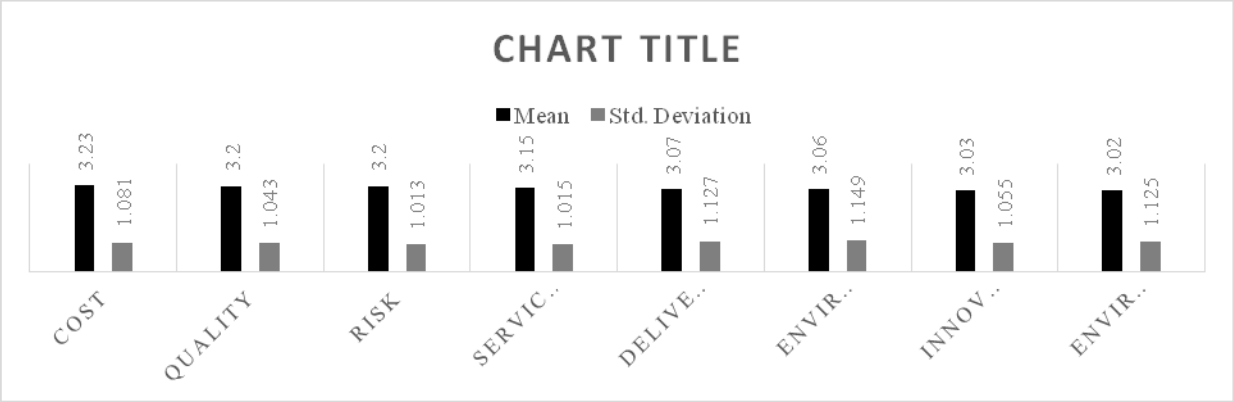

FIGURE II. IMPORTANCE OF THE MAJOR CRITERIA IN INDIAN MSMES

TABLE V. PERFORMANCE OF COST CRITERIA

Sub-criteria	Mean	Std. Deviation
Component disposal cost	3.23	1.074
Purchase cost	3.15	1.082
Tax and Custom duties	3.12	1.121
Operational expenses	3.10	1.063
Water and Air pollution treatment cost	3.09	1.114
Discount if the amount is paid before due date	3.09	1.105
Reduction of transportation cost	3.09	1.050
Recycling cost	3.06	1.148
Condition of payment	3.03	1.018
Fright cost	2.99	1.113
Acquisition of environmental raw material	2.99	1.009
Cost after sales	2.87	0.984

Table 6 shown below for quality, with 10 underlying dimensions and found quality management in the enterprise as the most important dimension, with men value 3.61 and ranked at 1st position followed by reliability of the component with mean value 3.46 and ranked at 2nd

position. Similarly other criteria such as, quality performance as per ISO 9000 or 14000, less rejection/rate of return, standards of incoming quality control as per green quality requirements, durability of the component, ergonomic quality, experience of the supplier in the same field, provide sample before ordering and product line complaint rate are shown in table with its mean value and found their importance in supplier selection process.

TABLE VI. PERFORMANCE OF QUALITY CRITERIA

Sub-criteria	Mean	Std. Deviation
Quality management in organization	3.61	0.964
Reliability of the component	3.46	1.113
Quality performance as per ISO 9000 or 14000	3.43	1.085
Less rejection/Rate of return	3.34	1.046
Standards of incoming quality control as per green quality requirements	3.30	1.112
Durability of the component	3.20	1.172
Ergonomic Quality	3.19	1.036
Experience of the supplier in the same field	3.17	1.052
Provide sample before ordering	3.10	1.094
Product line complaint rate	2.90	1.145

Service performance, which had 15 underlying dimensions was having ease of communication (3.58) as the most important dimension followed by supply capacity (3.46) with its 1st and 2nd position. Customer support, customer satisfaction, response to change, flexibility (payment, process, fright, price reduction), warranty periods, supply variety, buffer stock, geographical location, reaction to demand, technical support, sales competency, production facility and capacity and co-operation with customers for environmental procurement are the other important supplier selection criteria used under service performance in the descending order of their means. Environmental manufacturing management had 12 underlying dimensions such as green manufacturing, reverse logistics, green distribution, technology and R&D management, minimization of natural resources during manufacturing, green procurement, production schedule, environmental policy, ease for further dismantle, environmental planning, degree of co-operation with customer for environmental procurement and agile manufacturing capability. Results show that in environmental manufacturing management, mean value of green manufacturing is 3.35 and found it as the most important dimension, followed by reverse logistics and green distribution with same mean value as 3.31 at 2nd position. It shows that, because of government and public pressure companies are considering the concept of green in their manufacturing process and because of remanufacturing or disposal of the material, they have to look equally for reverse logistics and green distribution. Risk as a criterion had 3 underlying dimensions such as co-operation risk, green risk and production risk. Results of this study show that green risk is having high mean value (3.05) and it shows that MSME companies are thinking about release of hazardous and harmful substances in atmosphere followed by production risk (3.01). This is because MSME companies till today have been focusing more on their production processes so that customers would get good product quality as well as probability of late delivery is avoided at the same time they would not reduce their sell and brand reputation would accordingly improve.

Delivery had 10 underlying dimensions and found consistency in delivery (3.28) as the most important dimension followed by reliability delivery methods (3.26) meaning companies still believe in consistency of goods from the suppliers along with how reliable they are in delivering goods. Other criteria in delivery with its mean value in descending values are as follows: short delivery lead time (3.23), perfect order fulfillment (3.23), special request (3.22), on time delivery (3.21), error free type product type & quality (3.16), adoption of reusable packaging material (3.05), product received in good state (3.00), production volume changes (3.00). Environmental performance assessment, which had 8 underlying dimensions was having air emission and water waste management with its mean value 3.57 leading at 1st position followed by hazardous waste management and reduced use of energy consumption at 2nd and 3rd position. MSME companies are also considering increasing prices of energy, air emission and water waste management with natural resources and hazardous waste management having been considered as most decisive for supplier selection. Innovation and learning had 6 underlying dimensions such as process innovation, product innovation, training to managers and workers, information sharing across supply chain, supplier development initiatives and flexible work force. Results show that process innovation (3.16) is the most important dimension followed by product innovation (3.12). It shows innovation & learning is the important criteria in supplier selection, because it helps the MSME industries to reduce their costs and increase in market share, resulting in overall financial gain for enterprises.

V. CONCLUSION

Along with the challenging opportunities in manufacturing, there is an imperative need for making environment friendly products today. The environmental and social issues have also become important for managing any business. GSCM considers ecological causes as well as economic concerns as the objectives, while traditional supply chain management usually concentrated on economic aspect as a single objective. Green supply chain management (GSCM) is a relatively new issue with significant environmental ramifications for the majority of Indian industries. This study investigated the important performance measures for traditional and green supplier selection by "mean method". The study shows that from amongst all 8 main traditional and green supply chain performance measures, cost is the most important criteria for the MSME manufacturing industry in India, followed by the quality, risk, service performance, delivery, environmental manufacturing management, innovation & learning and environment performance assessment. But, when we look at the sub factors, it is clearly seen that MSME industries these days are not only focusing on purchase cost, but at the same time they are thinking of disposal cost of the component as it is ranked one with mean value. Similarly other green criteria such as green manufacturing, reverse logistics, green risk, air emission & water waste management, hazardous waste management, reduced the use of energy consumption and green risk are equally considered along with traditional criteria such as warranty periods, supply variety, buffer stock, geographical location, product received in good state, production volume changes, consistency in delivery, production risk and optimization of man power resources. From this study, it can be seen that the Indian MSME manufacturing companies are nowadays changing their focus from traditional to green supply chain in the supplier selection process.

Limitation of this study is that the results of the research have a very high dependence on experts' opinion. One possible solution to address this issue would be to increase the number of experts to widen the impact and hence the robustness of the analyses and results. Another limitation is difficulties in asking respondents about the effectiveness of their own companies' performance in relation to supplier selection process and supply chain management. Also, the respondents were assured that all the information gained from them would be used only for the research study and would remain absolutely confidential.

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APPENDIX

QUESTIONNAIRE FOR STATISTICAL ANALYSIS

Traditional & Green Manufacturing Performance Criteria and Related Variables

Please rate the degree or extent of practice for each variable on 1 to 5 scales.

(1-Very low, 2- Low, 3-Medium, 4- High, 5- Very High)

OR

(1-Completely Disagree, 2- Rarely Agree, 3- Partly Agree, 4- Rather Agree, 5- Completely Agree)

A typical ***example*** is shown below -

Sr. No.	**Criteria**	**Very Low ⟷ Very High**					**Rating**
1	Reduced use of paper contracts	1	2	3	4	5	*4*
2	Minimizing the use of packaging considered	1	2	3	4	5	*5*
Sr. No.	***Criteria***	***Ratings***					
1	**How important for you the following "Cost" criteria in supplier selection**	**Very Low ⟷ Very High**					**Rating**
1	Purchase cost	1	2	3	4	5	
2	Fright cost.	1	2	3	4	5	
3	Discount if the amount is paid before due date.	1	2	3	4	5	
4	Tax and custom duties	1	2	3	4	5	
5	Recycling cost	1	2	3	4	5	
6	Transportation cost	1	2	3	4	5	
7	Water and air pollution treatment cost	1	2	3	4	5	
8	Operational expenses	1	2	3	4	5	
9	Acquisition of environmental raw material	1	2	3	4	5	
10	Cost of component disposal	1	2	3	4	5	
11	Payment conditions	1	2	3	4	5	
12	After sales cost	1	2	3	4	5	