

# Contribution of Design for Environment as a Green Supply Chain Practice – A Pilot Empirical Study of the Indian Automobile Manufacturing Sector

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## ABSTRACT

*This paper tests empirically through a pilot study of the Indian Automobile Manufacturing Sector, the contribution of the variables constituting the construct Design for the Environment (DfE) in Green Supply Chain Practices. Also the paper establishes the reliability of the questionnaire instrument developed previously for measuring the construct Design for the Environment and also for measuring the eight variables that constitute the construct Design for the Environment. Further the paper establishes the inter-item correlation among these eight variables. Finally this paper conducts Confirmatory Factor Analysis (CFA) to arrive at two factors (linear combination of variables constituting the construct Design for the Environment) to aid in measuring the construct Design for the Environment. Five research questions that were framed pertaining to this research were answered.*

**Keywords:** Automobile, CFA, Design for the Environment, Green Supply Chain Practice, Indian, Manufacturing Sector, Pilot Study.

## 1. INTRODUCTION TO DESIGN FOR THE ENVIRONMENT AND GREEN SUPPLY CHAIN PRACTICES

Design for the Environment has been identified as one of the five green supply chain practices having an influence over ten green supply chain performance measures [10]. Accordingly, this paper identifies the variables constituting the construct Design for the Environment. Design for the Environment in turn is a sub-construct of the main construct Green Supply Chain Practices. Since Design for the Environment has been identified as being constituted of eight variables, it is of interest to know how these eight variables fare in the pilot empirical study of the Indian automobile manufacturing sector by means of a questionnaire instrument [10]. The 50 Indian automobile manufacturing plants that were surveyed during the pilot empirical study are all listed in [2]. The survey methodology was used in line with the findings of [3].

## 2. THE RESEARCH QUESTIONS

The five research questions addressed by this paper are as follows:

Research Question 1. To have a feel of the responses of the Indian Automobile Manufacturing Sector pertaining to the eight variables constituting the construct Design for the Environment.

Research Question 2. To know the reliability of the questionnaire instrument for measuring the construct Design for the Environment.

Research Question 3. To know the reliability of the questionnaire instrument for measuring the eight variables constituting the construct Design for the Environment.

Research Question 4. How are the eight variables constituting the construct Design for the Environment correlated?

Research Question 5. How many factors are retained by the eight variables constituting the construct Design for the Environment ?

## 3. THE CONSTRUCT DESIGN FOR THE ENVIRONMENT AND ITS VARIABLES USED IN THE STUDY

There are eight variables that constitute the construct Design for the Environment. They are depicted in Table 1 in their abbreviated form.

**Table 2.** The eight variables constituting the construct Design for the Environment

The eight variables constituting the construct Design for the Environment	DFE1	DFE 2	DFE 3	DFE 4	DFE 5	DFE 6	DFE 7	DFE 8
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**4. THE DESCRIPTIVE STATISTICS ON THE DATA PERTAINING TO DESIGN FOR THE ENVIRONMENT THAT WAS SCALED**

A five point balanced Likert scale was used to scale the data from respondents on whom a questionnaire was administered. The respondents were employees of Indian automobile manufacturing firms and /or their plants as mentioned in [2]. The data collected revealed the descriptive statistics of the eight variables constituting the construct Design for the Environment as shown in the Table 2.

**Table 3.** Descriptive Statistics of the items (or variables) of Design for the Environment scaled by the questionnaire

Descriptive Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
DFE1	50	4.58000	0.85928	229.00000	1.00000	5.00000
DFE2	50	4.72000	0.67128	236.00000	1.00000	5.00000
DFE3	50	4.70000	0.67763	235.00000	1.00000	5.00000
DFE4	50	4.62000	0.69664	231.00000	1.00000	5.00000
DFE5	50	3.44000	1.35767	172.00000	1.00000	5.00000
DFE6	50	3.78000	1.03589	189.00000	1.00000	5.00000
DFE7	50	3.54000	1.29694	177.00000	1.00000	5.00000
DFE8	50	3.88000	0.96129	194.00000	1.00000	5.00000

**5. THE RELIABILITY OF THE INSTRUMENT FOR THE CONSTRUCT DESIGN FOR THE ENVIRONMENT THAT WAS SCALED**

The reliability of the questionnaire instrument developed by [8] for the construct Design for the Environment that was used is shown in the Table 3 as 0.898978 which is considered to be an indicator of good internal consistency reliability [4].

**Table 3.** Reliability by Cronbach's Coefficient Alpha for the construct Design for the Environment

Cronbach's Coefficient Alpha	
Variables	Alpha
Raw	0.886993
Standardized	0.898978

The reliability of the questionnaire for the eight variables that constitute the construct Design for the Environment is shown in the Table 4. All the eight variables shown in Table 4 have a reliability greater than 0.8 and less than 0.9 which is statistically considered to be an indicator of good internal consistency reliability [4].

**Table 4.** Reliability of the eight individual variables constituting the construct Design for the Environment

CRONBACH'S COEFFICIENT ALPHA WITH DELETED VARIABLE				
DELETED VARIABLE	RAW VARIABLES		STANDARDIZED VARIABLES	
	CORRELATION WITH TOTAL	ALPHA	CORRELATION WITH TOTAL	ALPHA
DfE1	0.588188	0.879457	0.680974	0.886387
DfE2	0.531790	0.885008	0.648998	0.889321
DfE3	0.561326	0.882996	0.674562	0.886977
DfE4	0.626353	0.878299	0.725311	0.882270
DfE5	0.683875	0.876553	0.586836	0.894941
DfE6	0.878668	0.848958	0.772595	0.877817
DfE7	0.746929	0.866066	0.673395	0.887085
DfE8	0.795037	0.859235	0.705970	0.884073

**6. PEARSON'S CORRELATION COEFFICIENT AMONG THE VARIABLES USED IN THE STUDY**

The Pearson's Correlation coefficient between different pairs of variables that constitute the construct Design for the Environment is shown in the Table 5. Since all the values of inter-item correlation coefficients are positive, it indicates that all the eight variables have unidirectionality with the construct Design for the Environment. All the inter-item correlations range from a minimum of above 0.6 to a maximum of above 0.9. Also there is a strong support for the fifteen variables constituting the construct Reverse Logistics [1], [5], [6], [7], [8], [9], [11] and [12]. This indicates that all the fifteen variables that make up the construct Reverse Logistics are oriented towards the goal of the construct Reverse Logistics in a unidirectional manner in varying degrees. This is again an indicator of excellent internal consistency reliability.

**Table 5.** Pearson's Correlation coefficient among the eight variables constituting the construct Design for the Environment

Pearson Correlation Coefficients, N = 50 Prob >  r  under H0: Rho=0								
	DfE1	DfE2	DfE3	DfE4	DfE5	DfE6	DfE7	DfE8
DfE1	1.00000	0.78262 <.0001	0.76056 <.0001	0.85300 <.0001	0.69663 0.00040	0.62141 0.0023	0.62742 0.0020	0.63422 <.0001
DfE2	0.78262 <.0001	1.00000	0.97806 <.0001	0.90250 <.0001	0.69315 <.0001	0.66179 <.0001	0.67722 <.0001	0.62638 <.0001
DfE3	0.76056 <.0001	0.97806 <.0001	1.00000	0.87760 <.0001	0.62422 <.0001	0.61109 <.0001	0.61132 <.0001	0.68222 0.0062
DfE4	0.85300 <.0001	0.90250 <.0001	0.87760 <.0001	1.00000	0.63723 <.0001	0.66255 <.0001	0.65763 0.0008	0.69622 <.0001
DfE5	0.69663 0.00040	0.69315 <.0001	0.62422 <.0001	0.63723 <.0001	1.00000	0.95541 <.0001	0.77794 <.0001	0.93259 <.0001
DfE6	0.62141 0.0023	0.66179 <.0001	0.61109 <.0001	0.66255 <.0001	0.95541 <.0001	1.00000	0.88014 <.0001	0.91569 <.0001
DfE7	0.62742 <.0001	0.67722 <.0001	0.61132 <.0001	0.65763 0.0008	0.77794 <.0001	0.88014 <.0001	1.00000	0.70781 <.0001
DfE8	0.63422 <.0001	0.62638 0.0207	0.68222 0.0062	0.69622 <.0001	0.93259 <.0001	0.91569 <.0001	0.70781 <.0001	1.00000

**7. CONFIRMATORY FACTOR ANALYSIS FOR THE CONSTRUCT DESIGN FOR THE ENVIRONMENT**

Using a statistical analysis software, SAS 9.2, Confirmatory Factor Analysis (CFA) was conducted on the construct Design for the Environment which consists of eight variables DFE1, DFE2, DFE3, DFE4, DFE5, DFE6, DFE7 and DFE8. Principal Components method was used as the initial factor method. Accordingly the Eigenvalues were obtained as shown in the Table 6.

**Table 6.** Eigen values of obtained by using Principal Components Method as the initial factor method

Eigenvalues of the Correlation Matrix: Total = 15 Average = 1				
	Eigenvalue	Difference	Proportion	Cumulative
1	1	4.69909019	2.17891529	0.5874
2	2	2.52017490	1.98375724	0.3150
3	3	0.53641766	0.33613826	0.0671
4	4	0.20027940	0.16258712	0.0250
5	5	0.03769228	0.03134672	0.0047
6	6	0.00634556	0.00634556	0.0008
7	7	0.00000000	0.00000000	0.0000
8	8	0.00000000		0.0000

From Table 6 it is clear that the first factor can explain 4.69909019 variables, the second factor can explain 2.52017490 variables. No other factor in Table 6 can explain at least one variable. Hence both the factors will be retained by MINEIGEN criterion as shown by the factor pattern of Table 7. The variance explained by the first factor is 4.6990902; the variance explained by the second factor is 2.5201749.

**Table7.** Factor pattern obtained for the two factors retained by MINEIGEN criterion

Factor Pattern		
	Factor1	Factor2
<b>DfE1</b>	0.76567	-0.46433
<b>DfE2</b>	0.73964	-0.63039
<b>DfE3</b>	0.75994	-0.58349
<b>DfE4</b>	0.80063	-0.53649
<b>DfE5</b>	0.68578	0.70419
<b>DfE6</b>	0.83263	0.54204
<b>DfE7</b>	0.75804	0.46910
<b>DfE8</b>	0.78043	0.51880

The final communality estimates for the eight variables constituting the construct Design for the Environment are shown in Table 8.

**Table 8.** The final communality estimates for Reverse Logistics

Final Communality Estimates: Total = 7.219265							
DfE1	DfE2	DfE3	DfE4	DfE5	DfE6	DfE7	DfE8
0.80184904	0.94444840	0.91796640	0.92883434	0.96618199	0.98708605	0.79467032	0.87822856

### **8. CONFIRMATORY FACTOR ANALYSIS FOR THE CONSTRUCT DESIGN FOR THE ENVIRONMENT**

The aim of this paper was to study the contribution of the eight variables constituting the construct Design for the Environment as a component of Green Supply Chain Practices. It was found that all the eight variables in the study were reasonably positively correlated with each of the other variables meaning that all the eight variables are strongly oriented towards Design for the Environment. The reliability of the construct Design for the Environment was found to be 0.898978 which is considered good. Also the reliability of the eight variables constituting the construct Design for the Environment was established and found to be between 0.8 and 0.9 which is statistically an indicator of good internal consistency reliability. So all the eight variables are retained as there is also a strong support from existing literature in their favour. This means that the questionnaire is reliable enough to measure each of the eight variables and also the construct Design for the Environment as a whole. Also the results of Confirmatory Factor Analysis reveal that two factors can explain 4.6990902 variables and 2.5201749 variables respectively. Accordingly both the variables are retained as the minimum requirement is that a factor should be able to explain more than one variable. The variance explained by the first factor is 4.6990902; the variance explained by the second factor is 2.5201749.

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