Contribution of Life Cycle Assessment as a Green Supply Chain Practice

A Pilot Empirical Study of the Indian Automobile Manufacturing Sector

[1]**Mohd. Asif Gandhi**
Assistant Professor
Department of Mechanical Engineering
Anjuman-I-Islam's Kalsekar Technical Campus, School of Engineering and Technology
Affiliated to University of Mumbai, New Panvel, India

***Abstract*—This paper tests empirically through a pilot study of the Indian Automobile Manufacturing Sector, the contribution of the variables constituting the construct Life Cycle Assessment in Green Supply Chain Practices. Also the paper establishes the reliability of the questionnaire instrument developed previously for measuring the construct Life Cycle Assessment and also for measuring the three variables that constitute the construct Life Cycle Assessment. Further the paper establishes the correlation among these three variables. Finally this paper conducts Confirmatory Factor Analysis (CFA) to arrive at one factor (linear combination of variables constituting the construct Life Cycle Assessment) to aid in measuring the construct Life Cycle Assessment. Five research questions that were framed pertaining to this research were answered.**

***Index Terms*— Automobile, CFA, Green Supply Chain Practice, Indian, Life Cycle Assessment, Manufacturing Sector, Pilot Study.**

I. INTRODUCTION TO LIFE CYCLE ASSESSMENT AND GREEN SUPPLY CHAIN PRACTICES

Life Cycle Assessment has been identified as one of the five green supply chain practices having an influence over ten green supply chain performance measures [5]. Accordingly, this paper identifies the variables constituting the construct Life Cycle Assessment. Life Cycle Assessment in turn is a sub-construct of the main construct Green Supply Chain Practices. Since Life Cycle Assessment has been identified as being constituted of three variables, it is of interest to know how these three variables fare in the pilot empirical study of the Indian automobile manufacturing sector by means of a questionnaire instrument [5]. The 50 Indian automobile manufacturing plants that were surveyed during the pilot empirical study are all listed in [1]. The survey methodology was used in line with the findings of [2].

II. THE RESEARCH QUESTIONS

The five research questions identified are as follows:

Research Question 1. To have a feel of the responses of the Indian Automobile Manufacturing Sector pertaining to the three variables constituting the construct Life Cycle Assessment.

Research Question 2. To know the reliability of the questionnaire instrument for measuring the construct Life Cycle Assessment.

Research Question 3. To know the reliability of the questionnaire instrument for measuring the three variables constituting the construct Life Cycle Assessment.

Research Question 4. How are the three variables constituting the construct Life Cycle Assessment are correlated?

Research Question 5. How many factors are retained by the three variables constituting the construct Life Cycle Assessment ?

III. THE CONSTRUCT LIFE CYCLE ASSESSMENT AND ITS VARIABLES USED IN THE STUDY

There are three variables that constitute the construct Life Cycle Assessment. They are depicted in the Table 1 in their abbreviated form.

Table 1. The three variables constituting the construct Life Cycle Assessment

The three variables constituting the construct Life Cycle Assessment	LCA1	LCA2	LCA3

IV. DESCRIPTIVE STATISTICS OF THE DATA ON LIFE CYCLE ASSESSMENT 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 [1]. The data collected revealed the descriptive statistics of the five variables constituting the construct Life Cycle Assessment as shown in the Table 2.

Table 2. Descriptive Statistics of the items (or variables) of Life Cycle Assessment scaled by the questionnaire

Simple Statistics						
Variable	**N**	**Mean**	**Std Dev**	**Sum**	**Minimum**	**Maximum**
LCA1	50	3.42000	1.41551	171.00000	1.00000	5.00000
LCA2	50	4.54000	0.99406	227.00000	1.00000	5.00000
LCA3	50	4.26000	1.33722	213.00000	1.00000	5.00000

V. THE RELIABILITY OF THE INSTRUMENT FOR THE CONSTRUCT LIFE CYCLE ASSESSMENT

The reliability of the questionnaire instrument developed by [5] for the construct Life Cycle Assessment is shown in the Table 3 as 0.649368 which is considered to be an indicator of questionable internal consistency reliability [3]. But since existing literature strongly supports these three variables, these three variables namely LC1, LC2 and LC3 are retained in the interest of the research [4].

Table 3. Reliability by Cronbach's Coefficient Alpha for the construct Life Cycle Assessment

Cronbach's Coefficient Alpha	
Variables	Alpha
Raw	0.614101
Standardized	0.649368

The reliability of the questionnaire for the three variables that constitute the construct Life Cycle Assessment is shown in the Table 4. Out of the three variables in Table 4 the variable LCA1 has a reliability of 0.887675 which is considered to be a good internal consistency reliability measure; the variables LCA2 has a reliability of 0.362610 which is considered to be a poor internal consistency reliability measure; and the variable LCA3 has a reliability of 0.223172 which is considered to be a poor internal consistency reliability measure [3]. Though the variables LCA2 and LCA3 are statistically poor measures of reliability, they are retained because there is a strong support of existing literature in their favour [4].

Table 4. Reliability of the individual three constituting the construct Life Cycle Assessment

Cronbach Coefficient Alpha with Deleted Variable				
Deleted Variable	Raw Variables		Standardized Variables	
	Correlation with Total	Alpha	Correlation with Total	Alpha
LCA1	0.190224	0.866333	0.183015	0.887675
LCA2	0.578560	0.362130	0.590945	0.362610
LCA3	0.605118	0.211323	0.679479	0.223172

VI. 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 Life Cycle Assessment is shown in the Table 5. Since all the values of correlation coefficient are positive, it indicates that all the three variables have unidirectionality with the construct LCA. LCA1-LCA2 correlation is low (0.12560); LCA1-LCA3 correlation is also low (0.22146); and LCA2-LCA3 correlation is reasonably high (0.79804). This indicates that all the three variables that make up the construct Life Cycle Assessment are oriented towards the goal of the construct Life Cycle Assessment in a unidirectional manner. This is again an indicator of internal consistency reliability.

Table 5. Pearson's Correlation coefficient among the five variables constituting the construct Life Cycle Assessment

Pearson Correlation Coefficients, N = 50 Prob > |r| under H0: Rho=0			
	LCA1	LCA2	LCA3
LCA1	1.00000	0.12560 0.3848	0.22146 0.1222
LCA2	0.12560 0.3848	1.00000	0.79804 <.0001
LCA3	0.22146 0.1222	0.79804 <.0001	1.00000

VII. CONFIRMATORY FACTOR ANALYSIS OF THE CONSTRUCT LIFE CYCLE ASSESSMENT

Using a statistical analysis software, SAS 9.2, Confirmatory Factor Analysis (CFA) was conducted on the construct Life Cycle Assessment which consists of three variables LCA1, LCA2 and LCA3. 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 = 5 Average = 1				
	Eigenvalue	Difference	Proportion	Cumulative
1	1.86766647	0.93130332	0.6226	0.6226
2	0.93636315	0.74039278	0.3121	0.9347
3	0.19597037		0.0653	1.0000

From Table 6 it is clear that the first factor can explain 1.86766647 variables. Hence it is a desirable factor. No other factor in the Table 6 can explain at least one variable. Hence the first factor will be retained by MINEIGEN criterion as shown by the factor pattern of Table 7. The variance explained by the factor is 1.8676665.

Table7. Factor pattern obtained for the single factor retained by MINEIGEN criterion

Factor Pattern	
	Factor1
LCA1	0.37301
LCA2	0.91886
LCA3	0.94033

The final communality estimates for the three variables constituting the construct Life Cycle Assessment are shown in Table 8.

Table 8. The final communality estimates for Life Cycle Assessment

Final Communality Estimates: Total = 1.867666		
LCA1	LCA2	LCA3
0.13913939	0.84430930	0.88421778

VIII. CONCLUSION

The aim of this paper was to study the contribution of the three variables constituting the construct Life Cycle Assessment as a component of Green Supply Chain Practices. It was found that all the three variables in the study were reasonably positively correlated with each of the other variables meaning that the variables are strongly oriented towards Life Cycle Assessment. The reliability of the construct Life Cycle Assessment was 0.887675 which is considered good. Also the reliability of the three variables constituting the construct Life Cycle Assessment was established. LCA1 had a reliability of 0.887675 which is a good indicator of internal consistency reliability. LCA2 has a reliability of 0.362610 which is statistically an indicator of unacceptable internal consistency reliability but it is still retained because existing literature strongly supports it. LCA3 has a reliability of 0.223172 which is statistically an indicator of unacceptable reliability but it is retained as it is strongly supported by existing literature. This means that the questionnaire is reliable enough to measure each of the three variables and also the construct Life Cycle Assessment as a whole. Also the results of Confirmatory Factor Analysis reveal that one factor accounting for 1.86766647 variables is retained.

IX. ACKNOWLEDGMENT

I express my heartfelt thanks to Dr. Abdul Razak Honnutagi for permitting me to go ahead with my research work from NITIE, Mumbai though our institute was at its formative stage. Also I acknowledge the patience and support of my wife Yasmin Mohd. Asif Gandhi for bearing with me during my long research hours for years. I express my heartfelt thanks to my parents Mr. Indravadan Chimanlal Gandhi and Mrs. Sarmista Indravadan Gandhi for encouraging me and motivating me to complete my research work. I dedicate all my success to them.

REFERENCES

[1] Gandhi, M.A. "A Review of the Indian Automobile Manufacturing Sector", IOSR Journal of Business and Management, vol 19, issue 3, Ver II, pp. 9-15, 2017.
[2] Gandhi, M.A. and Sharma, S. "A Review of Research Methodologies Linking Green Supply Chain Practices and Green Supply Chain Performance", International Journal of Supply Chain Management, vol 3, issue 4, 2014.
[3] George D, Mallery M. "Using SPSS for Windows step by step: a simple guide and reference", 2003.
[4] httpnbis.orgnbisresourceslife_cycle_assessment_thinkingguide_life_cycle_assessment_bcorp.pdf
[5] Sharma, S., and Gandhi, M.A. "Exploring correlations in components of green supply chain practices and green supply chain performance", Competitiveness Review, vol 26, issue 3, pp. 332-368, 2016.