

Contribution of components of Green Supply Chain Continuous Improvement in Green Supply Chain Performance measurement- A Pilot Empirical Study of the Indian Automobile Manufacturing Sector

Mohd. Asif Gandhi ¹

¹*Department of Mechanical Engineering, Anjumain-I-Islam's Kalsekar Technical Campus, School of Engineering and Technology, Mumbai University, India*

Abstract : *This paper is one of the several extensions of the research works done by [5]. Green Supply Chain Practices have been known to have an impact on Green Supply Chain Performance [6]. This paper tests empirically through a pilot study of the Indian Automobile Manufacturing Sector, the contribution of the eleven variables constituting the construct Green Supply Chain Continuous Improvement in Green Supply Chain Performance measurement. Also the paper establishes the reliability of the questionnaire instrument developed previously for measuring the construct Green Supply Chain Continuous Improvement and also for measuring the eleven variables that constitute the construct Green Supply Chain Continuous Improvement. Further the paper establishes the correlation among these eleven variables. Finally this paper conducts Confirmatory Factor Analysis (CFA) to arrive at a single factor (linear combination of eleven variables constituting the construct Green Supply Chain Continuous Improvement) to aid in measuring the construct Green Supply Chain Continuous Improvement. Finally the paper establishes the order of contribution of the eleven variables constituting the construct Green Supply Chain Continuous Improvement.*

Keywords: *Automobile, CFA, Green Supply Chain Performance, Green Supply Chain Practices, Green Supply Chain Continuous Improvement, Indian, Manufacturing Sector, Pilot Study.*

I. Introduction

Green Supply Chain Continuous Improvement has been identified as one of the ten Green Supply Chain Performance measures which are impacted by five Green Supply Chain Practices [5]. Accordingly, this paper statistically tests the response to the eleven variables constituting the construct Green Supply Chain Continuous Improvement as identified in [5]. Green Supply Chain Continuous Improvement in turn is a sub-construct of the main construct Green Supply Chain Performance. Since Green Supply Chain Continuous Improvement has been identified as being constituted of eleven variables, it is of interest to know how these eleven variables fare in the pilot empirical study of the Indian automobile manufacturing sector by means of a questionnaire instrument developed by [5]. It is also of interest to know the order of contribution of these eleven variables constituting the construct Green Supply Chain Continuous Improvement. The 50 automobile manufacturing plants that were surveyed during the pilot empirical study are among the ones listed in [2]. The survey methodology was used in line with the findings of [3].

II. The Research Questions Addressed By The Study

The six 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 eleven variables constituting the construct Green Supply Chain Continuous Improvement.

Research Question 2. To know the reliability of the questionnaire instrument for measuring the construct Green Supply Chain Continuous Improvement.

Research Question 3. To know the reliability of the questionnaire instrument for measuring the eleven variables constituting the construct Green Supply Chain Continuous Improvement.

Research Question 4. How are the eleven variables constituting the construct Green Supply Chain Continuous Improvement correlated?

Research Question 5. How many factors are retained by the eleven variables constituting the construct Green Supply Chain Continuous Improvement?

Research Question 6. What is the order of contribution of the eleven variables constituting the construct Green Supply Chain Continuous Improvement?

III. The Construct Green Supply Chain Continuous Improvement And Its Eleven Component Variables Used In The Study

There are eleven variables that constitute the construct Green Supply Chain Continuous Improvement. They are depicted in the Table 1 in their abbreviated form.

Table 1. The eleven variables constituting the construct Green Supply Chain Continuous Improvement

The eleven variables constituting the construct Green Supply Chain Continuous Improvement	GSCCI1	GSCCI2	GSCCI3	GSCCI4	GSCCI5	GSCCI6	GSCCI7	GSCCI8	GSCCI9	GSCCI10	GSCCI11
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IV. The Descriptive Statistics Of The Scaled Data On Green Supply Chain Continuous Improvement

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 following descriptive statistics of the eleven variables constituting the construct Green Supply Chain Continuous Improvement.

Table 2. Descriptive Statistics of the data scaled by the questionnaire on Green Supply Chain Continuous Improvement

Simple Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
GSCCI1	50	4.38000	1.15864	219.00000	1.00000	5.00000
GSCCI2	50	4.52000	0.93110	226.00000	2.00000	5.00000
GSCCI3	50	4.48000	0.99468	224.00000	2.00000	5.00000
GSCCI4	50	4.32000	1.20272	216.00000	1.00000	5.00000
GSCCI5	50	4.38000	1.10454	219.00000	2.00000	5.00000
GSCCI6	50	4.38000	1.15864	219.00000	1.00000	5.00000
GSCCI7	50	4.36000	1.06445	218.00000	2.00000	5.00000
GSCCI8	50	4.02000	1.05926	201.00000	1.00000	5.00000
GSCCI9	50	4.02000	1.05926	201.00000	1.00000	5.00000
GSCCI10	50	3.98000	1.03982	199.00000	1.00000	5.00000
GSCCI11	50	4.02000	1.05926	201.00000	1.00000	5.00000

V. The Reliability Of The Instrument For The Construct And Its Variables

The reliability of the questionnaire instrument developed by [5] for the construct Green Supply Chain Continuous Improvement is shown in the Table 3 as 0.989432 which is considered to be excellent [4].

Table 3. Reliability by Cronbach's Coefficient Alpha for the construct Green Supply Chain Continuous Improvement

Cronbach Coefficient Alpha	
Variables	Alpha
Raw	0.989219
Standardized	0.989432

The reliability of the questionnaire for the eleven variables that constitute the construct Green Supply Chain Continuous Improvement is shown in the Table 4. All the eleven variables in Table 4 have a reliability greater than 0.9 which is considered as excellent [4].

Table 4. Reliability of the individual eleven variables constituting the construct Green Supply Chain Continuous Improvement

Cronbach Coefficient Alpha with Deleted Variable				
Deleted Variable	Raw Variables		Standardized Variables	
	Correlation with Total	Alpha	Correlation with Total	Alpha
GSCCI1	0.978508	0.987235	0.977490	0.987516
GSCCI2	0.877705	0.989640	0.878211	0.989841
GSCCI3	0.924173	0.988562	0.925583	0.988737
GSCCI4	0.945884	0.988165	0.944413	0.988295
GSCCI5	0.981455	0.987142	0.980673	0.987440
GSCCI6	0.978508	0.987235	0.977490	0.987516
GSCCI7	0.892778	0.989234	0.892250	0.989515
GSCCI8	0.942541	0.988084	0.942647	0.988337

Cronbach Coefficient Alpha with Deleted Variable				
Deleted Variable	Raw Variables		Standardized Variables	
	Correlation with Total	Alpha	Correlation with Total	Alpha
GSCCI9	0.942541	0.988084	0.942647	0.988337
GSCCI10	0.942642	0.988096	0.942140	0.988348
GSCCI11	0.942541	0.988084	0.942647	0.988337

VI. The 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 Green Supply Chain Continuous Improvement is shown in Table 5. Since all the values of correlation coefficient are positive, and have a minimum value above 0.7 going up to a maximum value above 0.9, it indicates that all the eleven variables that make up the construct Green Supply Chain Continuous Improvement are oriented towards the goal of Green Supply Chain Continuous Improvement in a unidirectional manner in varying degrees ranging from acceptable to good to excellent [4]. This is also an indicator of existence of internal consistency reliability of the questionnaire instrument for the data collected.

Table 5. Pearson's Correlation coefficient amongst the eleven variables of Green Supply Chain Continuous Improvement

Pearson Correlation Coefficients, N = 50 Prob > r under H0: Rho=0											
	GSCCI1	GSCCI2	GSCCI3	GSCCI4	GSCCI5	GSCCI6	GSCCI7	GSCCI8	GSCCI9	GSCCI10	GSCCI11
GSCCI1	1.00000	0.87247 <.0001	0.93640 <.0001	0.96540 <.0001	0.98520 <.0001	1.00000 <.0001	0.87966 <.0001	0.90824 <.0001	0.90824 <.0001	0.90422 <.0001	0.90824 <.0001
GSCCI2	0.87247 <.0001	1.00000	0.95899 <.0001	0.83248 <.0001	0.89536 <.0001	0.87247 <.0001	0.87801 <.0001	0.77554 <.0001	0.77554 <.0001	0.76981 <.0001	0.77554 <.0001
GSCCI3	0.93640 <.0001	0.95899 <.0001	1.00000	0.85842 <.0001	0.92655 <.0001	0.93640 <.0001	0.83576 <.0001	0.84296 <.0001	0.84296 <.0001	0.83820 <.0001	0.84296 <.0001
GSCCI4	0.96540 <.0001	0.83248 <.0001	0.85842 <.0001	1.00000	0.96660 <.0001	0.96540 <.0001	0.92840 <.0001	0.85990 <.0001	0.85990 <.0001	0.88642 <.0001	0.85990 <.0001
GSCCI5	0.98520 <.0001	0.89536 <.0001	0.92655 <.0001	0.96660 <.0001	1.00000	0.98520 <.0001	0.94010 <.0001	0.90040 <.0001	0.90040 <.0001	0.89521 <.0001	0.90040 <.0001
GSCCI6	1.00000 <.0001	0.87247 <.0001	0.93640 <.0001	0.96540 <.0001	0.98520 <.0001	1.00000	0.87966 <.0001	0.90824 <.0001	0.90824 <.0001	0.90422 <.0001	0.90824 <.0001
GSCCI7	0.87966 <.0001	0.87801 <.0001	0.83576 <.0001	0.92840 <.0001	0.94010 <.0001	0.87966 <.0001	1.00000	0.78987 <.0001	0.78987 <.0001	0.81792 <.0001	0.78987 <.0001
GSCCI8	0.90824 <.0001	0.77554 <.0001	0.84296 <.0001	0.85990 <.0001	0.90040 <.0001	0.90824 <.0001	0.78987 <.0001	1.00000	1.00000 <.0001	0.98238 <.0001	1.00000 <.0001
GSCCI9	0.90824 <.0001	0.77554 <.0001	0.84296 <.0001	0.85990 <.0001	0.90040 <.0001	0.90824 <.0001	0.78987 <.0001	1.00000 <.0001	1.00000 <.0001	0.98238 <.0001	1.00000 <.0001
GSCCI10	0.90422 <.0001	0.76981 <.0001	0.83820 <.0001	0.88642 <.0001	0.89521 <.0001	0.90422 <.0001	0.81792 <.0001	0.98238 <.0001	0.98238 <.0001	1.00000	0.98238 <.0001
GSCCI11	0.90824 <.0001	0.77554 <.0001	0.84296 <.0001	0.85990 <.0001	0.90040 <.0001	0.90824 <.0001	0.78987 <.0001	1.00000 <.0001	1.00000 <.0001	0.98238 <.0001	1.00000

VII. Factor Analysis

Using a statistical analysis software called SAS 9.2, Confirmatory Factor Analysis (CFA) was conducted on the construct Green Supply Chain Continuous Improvement which consists of eleven variables. 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 obtained by using Principal Components Method as the initial factor method.

Eigenvalues of the Correlation Matrix: Total = 11 Average = 1				
	Eigenvalue	Difference	Proportion	Cumulative
1	9.95624014	9.37227239	0.9051	0.9051
2	0.58396774	0.33345665	0.0531	0.9582
3	0.25051110	0.09888029	0.0228	0.9810
4	0.15163081	0.11474656	0.0138	0.9948
5	0.03688425	0.01611828	0.0034	0.9981
6	0.02076597	0.02076597	0.0019	1.0000
7	0.00000000	0.00000000	0.0000	1.0000
8	0.00000000	0.00000000	0.0000	1.0000
9	0.00000000	0.00000000	0.0000	1.0000
10	0.00000000	0.00000000	0.0000	1.0000
11	0.00000000		0.0000	1.0000

An Eigen value indicates the relative importance of each factor in accounting for the particular set of variables being analysed. From Table 6 it is clear that the first factor can explain 9.95624014 variables. No other factor in the Table 6 can explain at least one variable. Hence the only the first factor will be retained by

MINEIGEN criterion as the only factors as shown by the factor pattern of Table 7. The variance explained by the only retained factor is 9.9562401.

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

Factor Pattern	
	Factor1
GSCCI1	0.98191
GSCCI2	0.89762
GSCCI3	0.93802
GSCCI4	0.95447
GSCCI5	0.98411
GSCCI6	0.98191
GSCCI7	0.90992
GSCCI8	0.95341
GSCCI9	0.95341
GSCCI10	0.95287
GSCCI11	0.95341

The final communality estimates for the eleven variables constituting the construct Green Supply Chain Procurement are shown in Table 8.

Table 8. The final communality estimates for Green Supply Chain Continuous Improvement

Final Communality Estimates: Total = 10.606434										
GSCCI1	GSCCI2	GSCCI3	GSCCI4	GSCCI5	GSCCI6	GSCCI7	GSCCI8	GSCCI9	GSCCI10	GSCCI11
0.96414434	0.80572103	0.87987601	0.91101960	0.96847642	0.96414434	0.82795133	0.90898431	0.90898431	0.90795411	0.90898431

Communality estimates are indicative of how much of each variable is accounted for by the underlying factors taken together. A high value of communality means that not much of the variable is left over after whatever the factors represent is taken into consideration. In short the communality estimates are indicative of the relative contribution of each of the variables in the construct. Accordingly Figure 1 shows in the descending order, the relative contribution of each of the eleven variables of the construct Green Supply Chain Continuous Improvement as follows: GSCCI5, GSCCI1, GSCCI6, GSCCI4, GSCCI8, GSCCI9, GSCCI11, GSCCI10, GSCCI3, GSCCI7, GSCCI11.



Figure 1. Contribution of the eleven components of Green Supply Chain Continuous Improvement in descending order.

VIII. Conclusion

The aim of this paper was to study the contribution of the eleven variables constituting the construct Green Supply Chain Continuous Improvement in Green Supply Chain Performance measurement. It was found that all the eleven variables in the study were positively and well correlated with each of the other variables meaning that all the eleven variables involved are oriented towards Green Supply Chain Continuous

Improvement. The reliability of the construct Green Supply Chain Continuous Improvement was 0.989432 which is considered excellent. Also the reliability of the eleven variables constituting the construct Green Supply Chain Continuous Improvement was above 0.9 which means that the questionnaire is reliable to measure each of the variables and also the construct Green Supply Chain Continuous Improvement as a whole. Also the results of Confirmatory Factor Analysis reveal that one factor accounting for 9.95624014 variables is retained. The variance explained by the retained factor is 9.9562401. The descending order of contribution of each of the eleven variables constituting Green Supply Chain Continuous Improvement in Green Supply Chain Performance measurement is as follows: GSCCI5, GSCCI1, GSCCI6, GSCCI4, GSCCI8, GSCCI9, GSCCI11, GSCCI10, GSCCI3, GSCCI7, GSCCI11.

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