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

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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 [5].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 Procurement 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 Procurement and also for measuring the eleven variables that constitute the construct Green Supply Chain Procurement. Further the paper establishes the correlation among these eleven variables. Finally this paper conducts Confirmatory Factor Analysis (CFA) to arrive at three factors (linear combination of eleven variables constituting the construct Green Supply Chain Procurement) to aid in measuring the construct Green Supply Chain Procurement. Finally the paper establishes the order of contribution of the eleven variables constituting the construct Green Supply Chain Procurement.*

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

I.   Introduction

Green Supply Chain Procurement 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 identifies the variables constituting the construct Green Supply Chain Procurement [5]. Green Supply Chain Procurement in turn is a sub-construct of the main construct Green Supply Chain Performance. Since Green Supply Chain Procurement 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 [5]. It is also of interest to know the order of contribution of these eleven variables constituting the construct Green Supply Chain Procurement. 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.   Research Questions

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 Procurement.

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

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

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

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

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

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

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

Table 1. The five variables constituting the construct Green Supply Chain Planning

The eleven variables constituting the construct Green Supply Chain Procurement	GSCPROC1	GSCPROC2	GSCPROC3	GSCPROC4	GSCPROC5	GSCPROC6	GSCPROC7	GSCPROC8	GSCPROC9	GSCPROC10	GSCPROC11

IV. The Descriptive Statistics Of The Scaled Data On Green Supply Chain Procurement

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 Procurement.

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

Simple Statistics						
Variable	N	Mean	Std Dev	Sum	Minimum	Maximum
GSCPROC1	50	4.04000	1.00934	202.00000	2.00000	5.00000
GSCPROC2	50	3.98000	1.03982	199.00000	1.00000	5.00000
GSCPROC3	50	4.58000	0.70247	229.00000	2.00000	5.00000
GSCPROC4	50	4.36000	1.15635	218.00000	1.00000	5.00000
GSCPROC5	50	4.34000	1.17125	217.00000	1.00000	5.00000
GSCPROC6	50	4.44000	0.50143	222.00000	4.00000	5.00000
GSCPROC7	50	3.68000	1.16829	184.00000	1.00000	5.00000
GSCPROC8	50	4.02000	1.05926	201.00000	1.00000	5.00000
GSCPROC9	50	3.98000	1.03982	199.00000	1.00000	5.00000
GSCPROC10	50	3.68000	1.16829	184.00000	1.00000	5.00000
GSCPROC11	50	4.64000	0.87505	232.00000	1.00000	5.00000

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

The reliability of the questionnaire instrument developed by [5] for the construct Green Supply Chain Procurement is shown in the Table 3 as 0.954046 which is considered to be excellent [4].

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

Cronbach Coefficient Alpha	
Variables	Alpha
Raw	0.960878
Standardized	0.954046

The reliability of the questionnaire for the eleven variables that constitute the construct Green Supply Chain Procurement 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 Procurement

Cronbach Coefficient Alpha with Deleted Variable				
Deleted Variable	Raw Variables		Standardized Variables	
	Correlation with Total	Alpha	Correlation with Total	Alpha
GSCPROC1	0.973225	0.951758	0.958534	0.943507
GSCPROC2	0.979401	0.951388	0.968435	0.943142
GSCPROC3	0.700877	0.961093	0.711901	0.952361
GSCPROC4	0.887962	0.954624	0.868610	0.946788
GSCPROC5	0.881637	0.954910	0.865232	0.946910
GSCPROC6	0.132287	0.971380	0.138479	0.971233
GSCPROC7	0.855295	0.955919	0.852291	0.947377
GSCPROC8	0.983641	0.951151	0.967221	0.943186
GSCPROC9	0.979401	0.951388	0.968435	0.943142
GSCPROC10	0.855295	0.955919	0.852291	0.947377
GSCPROC11	0.570357	0.964204	0.587822	0.956644

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 Procurement is shown in the Table 5. Since all the values of correlation coefficient are above 0.9, it indicates that all the eleven variables that make up the construct Green Supply Chain Procurement are oriented towards the goal of Green Supply Chain Procurement in a unidirectional manner.

Table 5. Pearson's Correlation coefficient

	GSCPR OC1	GSCPR OC2	GSCPR OC3	GSCPR OC4	GSCPR OC5	GSCPR OC6	GSCPR OC7	GSCPR OC8	GSCPR OC9	GSCPR OC10	GSCPR OC11
	Pearson Correlation Coefficients, N = 50										
	Prob > |r| under H0: Rho=0										
GSCPR OC1	1.00000	0.97303 <.0001	0.65740 <.0001	0.89665 <.0001	0.88593 <.0001	0.12581 0.3840	0.91103 <.0001	0.99181 <.0001	0.97303 <.0001	0.91103 <.0001	0.47876 0.0004
GSCPR OC2	0.97303 <.0001	1.00000	0.68675 <.0001	0.90568 <.0001	0.89382 <.0001	0.13465 0.3512	0.88500 <.0001	0.98238 <.0001	1.00000 <.0001	0.88500 <.0001	0.53022 <.0001
GSCPR OC3	0.65740 <.0001	0.68675 <.0001	1.00000	0.76778 <.0001	0.77240 <.0001	0.18772 0.1917	0.40484 0.0035	0.64233 <.0001	0.68675 <.0001	0.40484 0.0035	0.74501 <.0001
GSCPR OC4	0.89665 <.0001	0.90568 <.0001	0.76778 <.0001	1.00000	0.99270 <.0001	-0.17317 0.2291	0.66106 <.0001	0.91038 <.0001	0.90568 <.0001	0.66106 <.0001	0.61475 <.0001
GSCPR OC5	0.88593 <.0001	0.89382 <.0001	0.77240 <.0001	0.99270 <.0001	1.00000	-0.15568 0.2803	0.64788 <.0001	0.89912 <.0001	0.89382 <.0001	0.64788 <.0001	0.63958 <.0001
GSCPR OC6	0.12581 0.3840	0.13465 0.3512	0.18772 0.1917	-0.17317 0.2291	-0.15568 0.2803	1.00000	0.34977 0.0128	0.09836 0.4968	0.13465 0.3512	0.34977 0.0128	0.18233 0.2051
GSCPR OC7	0.91103 <.0001	0.88500 <.0001	0.40484 0.0035	0.66106 <.0001	0.64788 <.0001	0.34977 0.0128	1.00000	0.91229 <.0001	0.88500 <.0001	1.00000 <.0001	0.36412 0.0093
GSCPR OC8	0.99181 <.0001	0.98238 <.0001	0.64233 <.0001	0.91038 <.0001	0.89912 <.0001	0.09836 0.4968	0.91229 <.0001	1.00000	0.98238 <.0001	0.91229 <.0001	0.53634 <.0001
GSCPR OC9	0.97303 <.0001	1.00000 <.0001	0.68675 <.0001	0.90568 <.0001	0.89382 <.0001	0.13465 0.3512	0.88500 <.0001	0.98238 <.0001	1.00000	0.88500 <.0001	0.53022 <.0001
GSCPR OC10	0.91103 <.0001	0.88500 <.0001	0.40484 0.0035	0.66106 <.0001	0.64788 <.0001	0.34977 0.0128	1.00000 <.0001	0.91229 <.0001	0.88500 <.0001	1.00000	0.36412 0.0093
GSCPR OC11	0.47876 0.0004	0.53022 <.0001	0.74501 <.0001	0.61475 <.0001	0.63958 <.0001	0.18233 0.2051	0.36412 0.0093	0.53634 <.0001	0.53022 <.0001	0.36412 0.0093	1.00000

VII. Factor Analysis

Using statistical analysis software called SAS 9.2, Confirmatory Factor Analysis (CFA) was conducted on the construct Green Supply Chain Procurement which consists of eleven variables. Principal Component's 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	8.08467938	6.65352185	0.7350	0.7350
2	1.43115753	0.34056061	0.1301	0.8651
3	1.09059692	0.79602590	0.0991	0.9642
4	0.29457102	0.24346818	0.0268	0.9910
5	0.05110285	0.00856355	0.0046	0.9956
6	0.04253929	0.03718629	0.0039	0.9995
7	0.00535301	0.00535301	0.0005	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 indicate 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 8.08467938 variables. The second factor can explain 1.43115753 variables. The third factor can explain 1.09059692 variables. Hence all the three factors are desirable factors. No other factor in the Table 6 can explain at least one variable. Hence the first factor, the second factor and the third 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 three factors is 8.0846794, 1.4311575 and 1.0905969.

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

Factor Pattern			
	Factor1	Factor2	Factor3
GSC_Pro1	0.98049	0.07321	-0.14114
GSC_Pro2	0.98576	0.04131	-0.08640
GSC_Pro3	0.74216	-0.31111	0.50163
GSC_Pro4	0.92658	-0.35668	-0.07472
GSC_Pro5	0.92081	-0.36267	-0.04024
GSC_Pro6	0.14792	0.77990	0.58777
GSC_Pro7	0.87573	0.43373	-0.16849
GSC_Pro8	0.98868	0.04450	-0.13370
GSC_Pro9	0.98576	0.04131	-0.08640
GSC_Pro10	0.87573	0.43373	-0.16849
GSC_Pro11	0.62405	-0.28348	0.61383

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 Pollution Prevention

Final Communality Estimates: Total = 10.606434										
GSCPR OC1	GSCPR OC2	GSCPR OC3	GSCPR OC4	GSCPR OC5	GSCPR OC6	GSCPR OC7	GSCPR OC8	GSCPR OC9	GSCPRO C10	GSCPRO C11
0.986632 60	0.980898 27	0.899224 63	0.991358 58	0.981047 66	0.975605 33	0.983410 81	0.997352 17	0.980898 27	0.983410 81	0.846594 71

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 1shows in the descending order, the relative contribution of each of the eleven variables of the construct Green Supply Chain Procurement as follows: GSCPROC8, GSCPROC4, GSCPROC1, GSCPROC7, GSCPROC10, GSCPROC5, GSCPROC2, GSCPROC9, GSCPROC6, GSCPROC3, GSCPROC11.
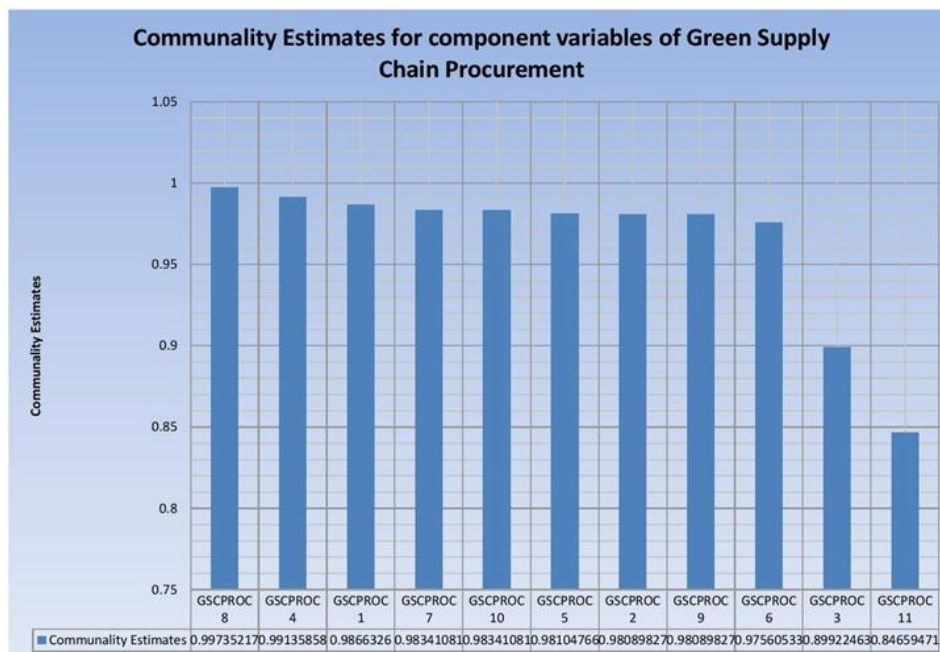
Figure 1. Contribution of the eleven components of Green Supply Chain Procurement in descending order.

VIII. Conclusion

The aim of this paper was to study the contribution of the eleven variables constituting the construct Green Supply Chain Procurement as a component measure of Green Supply Chain Performance. It was found that all the eleven variables in the study were strongly correlated with each of the other variables meaning that all the eleven variables involved are strongly oriented towards Green Supply Chain Procurement. The reliability of the construct Green Supply Chain Procurement was 0.954046 which is considered excellent. Also the

reliability of the eleven variables constituting the construct Green Supply Chain Procurement was above 0.9 which means that the questionnaire is reliable to measure each of the variables and also the construct Green Supply Chain Procurement as a whole. Also the results of Confirmatory Factor Analysis reveal that three factor accounting for 8.08467938 variables, 1.43115753 variables and 4.2237678 variables and 1.09059692 variables are retained.

Acknowledgements

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