Impact of Green Supply Chain Management Attributes on Supply Chain Performance: Measurement Instrument Validity and Reliability Verification

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Abstract

In the recent past, substantial amount of awareness has been created on sustainable practices and policies in the corporate sector and sustainable development as a goal in general. A geometric growth has been observed in the number of papers published on Green Supply Chain Management (GSCM) in the last few decades (Fahimnia, Sarkis, & Davarzani, 2015). Organizations can be assessed for sustainability by their ecological footprint. The Automotive sector with a substantial ecological footprint becomes a candidate for studies of the sustainable practices and policies employed by the sector. This paper studies the effect of sustainable policies and other Green Supply Chain Management Attributes in multinational automotive firms on the performance of their supply chains. The paper uses the open-source statistical tool R to do a pilot study as a preliminary step for analyzing the model and verifying validity and reliability of the measurement instrument using PLS SEM technique.

Keywords
Green Supply Chain Management, GSCM Attributes, Supply Chain Performance, Automotive Industry, Ecological Footprint

1. Introduction

Green Supply Chain Management (GSCM) refers to the green practices like use of pollution-free practices, minimum wastage of resources and so on in the conventional Supply Chain Management. The field of Green Supply Chain Management has been witnessing a good growth in recent period. Several authors have contributed to this field in recent periods (Fahimnia et al., 2015). The concept of 'Sustainable development' is now being considered to be an important goal of many entities including multinational organizations.

Sustainability of any entity can be measured by its Ecological footprint. Ecological footprint of an entity is the amount of natural resources it demands for functioning as against our planet's capacity to re-produce the resources. The automotive sector with a substantial ecological footprint becomes a candidate for study. The automobile sector in India produced around 23 million vehicles including two-wheelers and three-wheelers in the period 2014-2015,

with a growth of 8.68 percent over the previous year (Society of Indian Automobile Manufacturers, 2015). In India, Chennai, Pune and Gurgaon are a few major automotive industry hubs.

Emerging economies like India, Brazil and China with their resources provide somewhat similar basis for comparison of the industry sectors. Countries like China are stressing on environmental regulations which prompts their industries to adopt Green Supply Chain Management (GSCM) (Zhu & Sarkis, 2007). This paper studies the supply chain performance of the major multinational automotive players in India. A study was conducted among a few major multinational automotive firms in India as a preliminary step to the main study of the effect of GSCM Attributes on the Supply Chain Performance of the players.

2. Literature Review and Research Gap

Initially, the steps to keep industrial pollution under control were limited to the levying of taxes. Large scale deforestation and introduction of chemicals into the atmosphere, water and soil became a cause for concern in the 1960s and 1970s. The book "Silent Spring" written by Rachel Carson in 1962 triggered a movement in US towards increased recognition of these issues (Sarkis, Zhu, & Lai, 2011). The first steps towards sustainable development by the United Nations can be traced back to the United Nations Conference on the Human Environment held in Stockholm in 1972. The year 1983 saw the creation of World Commission on Environment and Development (WCED) (Rio+20 United Nations Conference on Sustainable Development, 2012). United Nations Environment Programme (UNEP) has been working towards environmental causes (United Nations Environment Programme, 2015). The Brundtland Commission in 1987 brought about a heightened awareness towards the cause of "Sustainable Development"(Commission, 1987). The United Nations Conference on Environment and Development (UNCED) was held in 1992 and Agenda21 was implemented which was followed by the formation of Commission on Sustainable Development (CSD) in 1993 (Rio+20 United Nations Conference on Sustainable Development, 2012).

The pollution caused by industries was a subject of study since the days of industrial revolution. Specialization of labour was introduced as a concept by Adam Smith and then selection of specific suppliers and distribution channels for organizations also became a practice. This led to the study of Supply Chains as we know them today. Early industries also focused on minimization of wastes. But it was generally a matter of economic efficiency, rather than having environmental benefits. Green Supply Chain Management (GSCM) includes such policies in the management of the supply chains as minimization of environmental pollution, minimization of wastage of resources, effective information-sharing between stakeholders and effective collaboration with different stakeholders. It also includes the reuse of residues back into the system that is sometimes referred to as Reverse Logistics. In 1969, the first works in these areas were published by Ayres and Kneese (1969); (Sarkis et al., 2011). These works also expressed concerns about the effect of the disposal of these wastes in the environment and the effect of Greenhouse gases emissions on the atmosphere. Some works were also published during the 1970s in these areas. Boustead and Hancock (1979) discuss on industrial ecology and life-cycle analysis in their work. A remanufacturing system model is developed with non-zero lead-time by Muckstadt and Isaac (1981); (Srivastava, 2007). Kelle and Silver (1989) use mathematical models for problem formulations (Srivastava, 2007). Environmental practices were studied as a source of economic benefits in the 1980s (Frosch & Gallopoulos, 1989; Sarkis et al., 2011). The study of the use of GSCM practices as a source of economic benefits for an organization was also developing (Bhote, 1989; Sarkis et al., 2011).

Papers have been published on the study of 'green' logistics (Sarkis et al., 2011; Szymankiewicz, 1993) and different functions in an organization with 'green' perspective (Drumwright, 1994; Pohlen & Theodore Farris, 1992; Sarkis et al., 2011). Papers discuss the Ecological Modernization Theories (EMT theories) as well (Sarkis et al., 2011; Spaargaren & Mol, 1992). Studies have also been made on some of the functions and operations in an organization integrated with an environmental perspective (Sarkis, 1995). Works have been done on green design (Srivastava, 2007; Zhang, Kuo, Lu, & Huang, 1997). Bras and McIntosh (1999) conduct a study on production

planning and control for remanufacturing (Srivastava, 2007). During the 2000s, the field matured a little and several case-studies with more advanced modelling tools were published (Sarkis et al., 2011; Seuring & Müller, 2008). Lately, the research has been in the direction of ultimately suggesting economic benefits of environmental governance (Tang, Lai, & Cheng, 2012).

Very few papers study supply chain performance and Green Supply Chain Management in the literature. This study will contribute to the literature through an empirical study to investigate the relationship between Green Supply Chain Management Attributes and Supply Chain Performance with an operational perspective for an emerging economy.

3. Hypotheses Development

Green Supply Chain Management (GSCM) as has been mentioned in the above discussion has been found to be a contributor to Supply Chain Performance. Greening is found to be a source of benefits for organizations including economic benefits as has been found by the above mentioned authors. Green practices help create a positive image of the organization's brand among its stakeholders and hence improve its performance. Green Supply Chain Management (GSCM) Attributes: Green Policy, Green Operations, Green Marketing, Green Collaboration with Supplier, Green Collaboration with Partner and Green Collaboration with Customer were found to influence Supply Chain Performance.

A Green Policy means a thrust at the strategic level to improve the performance of the supply chain. It guides the entire supply chain - the organization, its employees, suppliers and customers to adopt green practices and hence improve its performance.

H1: Green Policy Construct is found to directly impact Supply Chain Performance Construct.

Green Operations refers to the quality aspects, minimum wastage of resources and use of clean equipment, techniques and fuels during production and operations. The use of Green Operations with minimum wastage is found to improve performance of the supply chain.

H2: Green Operations Construct is found to directly impact Supply Chain Performance Construct.

Green Marketing involves promotion of information related to green practices. It also involves timely and complete disclosure of information to the stakeholders. It creates a positive image and goodwill for the organization among the stakeholders. It helps in transparency which again results in better image of the organization among the stakeholders. All these lead to better performance of the supply chain.

H3: Green Marketing Construct is found to directly impact Supply Chain Performance Construct.

Green Collaborations with the stakeholders in various environmental goals and sharing of environmental risks and impacts all result in improvements in the performance of the supply chain.

H4: Green Collaboration with Supplier Construct is found to directly impact Supply Chain Performance Construct.

H5: Green Collaboration with Partner Construct is found to directly impact Supply Chain Performance Construct.

H6: Green Collaboration with Customer Construct is found to directly impact Supply Chain Performance Construct.

Supply Chain Performance is found to result in supply chain surplus and several beneficial outcomes of which greater awareness and efforts towards environmentally beneficial activities is one among them. This results in reduction of emission of pollutants like Carbon-dioxide, Sulphur oxides, Nitrous oxides, etc. and also reduction of emission of waste water, solid waste and reduction of noise pollution.

H7: Supply Chain Performance Construct is found to directly impact Reduction of Pollutants Construct.

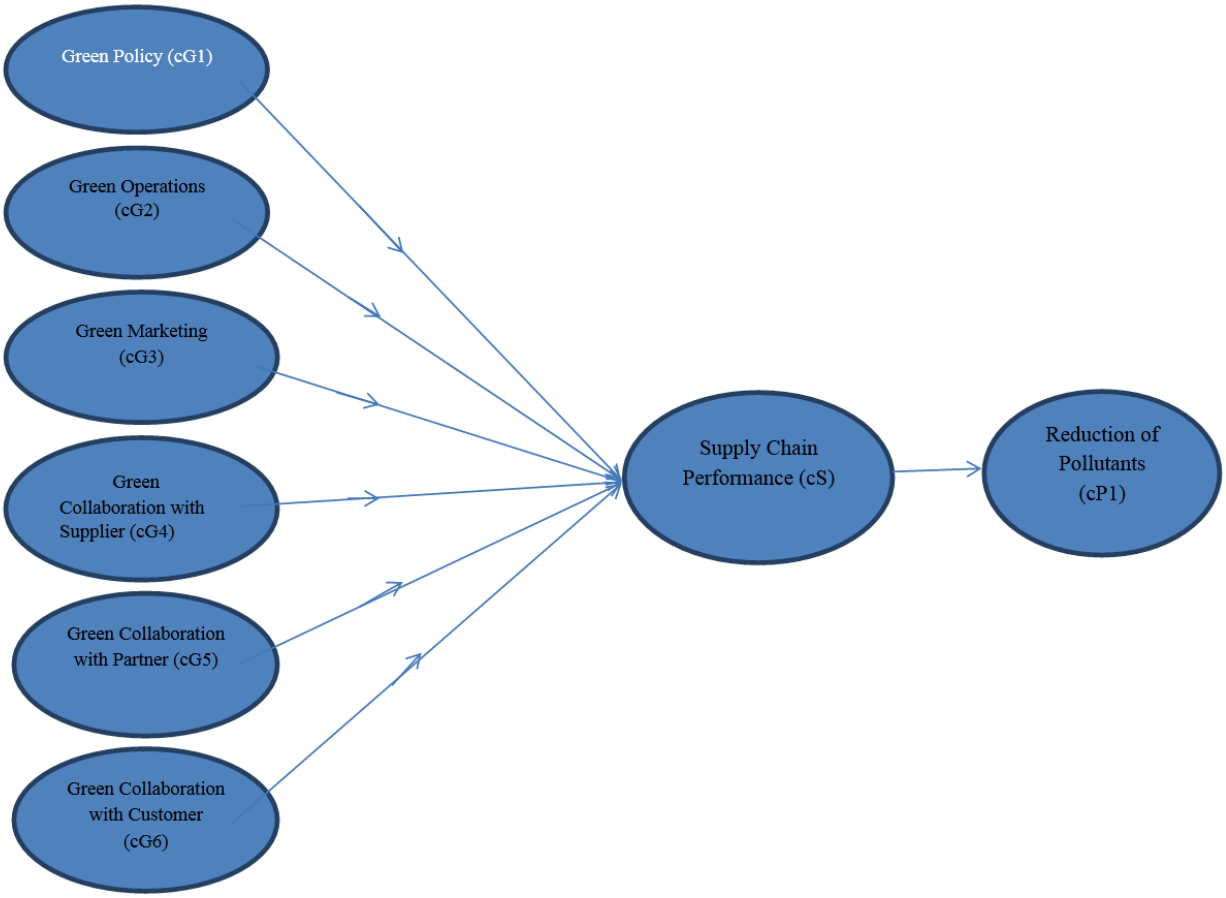

Fig1: Theoretical Model

4. Methodology

The theoretical model shown above is tested by collecting data from 50 executives from major multinational automotive players in India. The main study is descriptive in nature. Non-probability convenience sampling technique was used for the study. It was made sure that the samples collected were proportional to the size of the firms from which the samples were collected to make the samples representative of the population. The scales for GSCM attributes (cG1, cG2, cG3, cG4, cG5, cG6) and construct cP1 were gathered from a study by Yang, Lu, Xu, and Marlow (2013). The study was done for the Chinese container-shipping industry. With very few changes, the scales were adopted for our study since the scales were found suitable for the study based on extensive literature review. The scales for Supply Chain Performance were adopted from Gunasekaran, Patel, and McGaughey (2004). Likert scales were used for the study. The scales were tested for Validity and Reliability, so that they could be used for further studies. PLS SEM was used to test the relationships in the theoretical model in Fig.1. PLS SEM refers to the Structural Equations Modelling done using Partial Least Squares method. While the conventional Covariance-based SEM focusses on the fit between the actual and estimated covariance matrices, PLS SEM focusses on prediction of the Variances. PLS SEM also is good when there are fewer items loading on a construct. Moreover, research suggests that the results obtained using covariance-based SEM and PLS SEM are comparable. PLS SEM was found suitable for our study.

5. Data Analysis

The analysis part of our study was done in the open source software R. As mentioned earlier, PLS SEM was used for the analysis. When the data were analyzed using 'plspm' package in R, following results were obtained. Based on preliminary analysis, an item in 'cG3' construct which originally had 5 items and an item in 'cS' construct which originally had 8 items were removed from the questionnaire because their loadings on the respective constructs were found to be below 0.5. Then, the edited questionnaire was used for analysis and the results obtained were as follows:

Table1: PLS SEM results using R

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PARTIAL LEAST SQUARES PATH MODELING (PLS-PM)

---------------------------------------------------------
MODEL SPECIFICATION
1   Number of Cases      50
2   Latent Variables     8
3   Manifest Variables   31
4   Scale of Data        Standardized Data
5   Non-Metric PLS       FALSE
6   Weighting Scheme     centroid
7   Tolerance Crit       1e-06
8   Max Num Iters        100
9   Convergence Iters    4
10  Bootstrapping        FALSE
11  Bootstrap samples    NULL

---------------------------------------------------------
BLOCKS DEFINITION
    Block         Type   Size   Mode
1     cG1    Exogenous      3      A
2     cG2    Exogenous      4      A
3     cG3    Exogenous      4      A
4     cG4    Exogenous      3      A
5     cG5    Exogenous      3      A
6     cG6    Exogenous      3      A
7      cS   Endogenous      7      A
8     cP1   Endogenous      4      A

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BLOCKS UNIDIMENSIONALITY

	Mode	MVs	C.alpha	DG.rho	eig.1st	eig.2nd
cG1	A	3	0.704	0.835	1.89	0.633
cG2	A	4	0.762	0.848	2.33	0.623
cG3	A	4	0.804	0.873	2.53	0.678
cG4	A	3	0.762	0.863	2.03	0.538
cG5	A	3	0.769	0.867	2.06	0.614
cG6	A	3	0.777	0.870	2.07	0.496
cS	A	7	0.901	0.922	4.39	0.624
cP1	A	4	0.800	0.870	2.52	0.681

OUTER MODEL

		weight	loading	communality	redundancy
cG1					
1	G11	0.524	0.869	0.756	0.000
1	G12	0.409	0.798	0.636	0.000
1	G13	0.313	0.696	0.484	0.000
cG2					
2	G24	0.289	0.757	0.574	0.000
2	G25	0.440	0.829	0.687	0.000
2	G26	0.325	0.761	0.579	0.000
2	G27	0.245	0.689	0.475	0.000
cG3					
3	G38	0.324	0.852	0.725	0.000
3	G310	0.293	0.765	0.585	0.000
3	G311	0.273	0.684	0.468	0.000
3	G312	0.359	0.870	0.756	0.000
cG4					
4	G413	0.369	0.782	0.612	0.000
4	G414	0.454	0.851	0.723	0.000
4	G415	0.390	0.835	0.697	0.000
cG5					
5	G516	0.371	0.748	0.559	0.000
5	G517	0.375	0.861	0.741	0.000
5	G518	0.460	0.870	0.756	0.000
cG6					
6	G619	0.374	0.807	0.651	0.000
6	G620	0.426	0.843	0.711	0.000
6	G621	0.402	0.844	0.712	0.000
cS					
7	S1	0.190	0.820	0.672	0.465
7	S2	0.186	0.774	0.599	0.414
7	S3	0.171	0.753	0.567	0.393
7	S4	0.178	0.785	0.616	0.426
7	S5	0.173	0.773	0.598	0.414
7	S7	0.192	0.841	0.707	0.489
7	S8	0.171	0.795	0.633	0.438
cP1					
8	P11	0.351	0.831	0.690	0.432
8	P12	0.205	0.624	0.390	0.244
8	P13	0.350	0.819	0.671	0.420
8	P14	0.338	0.871	0.758	0.474

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CORRELATIONS BETWEEN LVs
         cG1     cG2     cG3     cG4      cG5      cG6     cS     cP1
cG1   1.0000  0.1554  0.2470  0.266  -0.0096   0.0831  0.379  0.389
cG2   0.1554  1.0000  0.6322  0.205   0.6371   0.0065  0.606  0.552
cG3   0.2470  0.6322  1.0000  0.248   0.4097   0.0254  0.629  0.504
cG4   0.2660  0.2046  0.2482  1.000   0.2159   0.2251  0.546  0.544
cG5  -0.0096  0.6371  0.4097  0.216   1.0000  -0.1036  0.528  0.489
cG6   0.0831  0.0065  0.0254  0.225  -0.1036   1.0000  0.227  0.119
cS    0.3793  0.6063  0.6292  0.546   0.5277   0.2273  1.000  0.791
cP1   0.3886  0.5516  0.5043  0.544   0.4892   0.1193  0.791  1.000

----------------------------------------------------------
SUMMARY INNER MODEL
           Type     R2  Block_Communality  Mean_Redundancy    AVE
cG1   Exogenous  0.000              0.625            0.000  0.625
cG2   Exogenous  0.000              0.578            0.000  0.578
cG3   Exogenous  0.000              0.634            0.000  0.634
cG4   Exogenous  0.000              0.677            0.000  0.677
cG5   Exogenous  0.000              0.686            0.000  0.686
cG6   Exogenous  0.000              0.691            0.000  0.691
cS   Endogenous  0.692              0.627            0.434  0.627
cP1  Endogenous  0.625              0.627            0.392  0.627
```

6. Inferences and Conclusion

Content validity of the instrument was assessed by experts in Supply Chain Management area. The Cronbach's alphas (internal consistency) are found to be above 0.7 for all the constructs indicating good reliability. The Dillon-Goldstein rhos (composite reliability) are also found to be above 0.8 indicating good reliability. The indicator loadings on the constructs are all above the conservative mark of 0.7 except for two loadings which are above 0.6 which comes in the range of 0.4 to 0.7 which is reasonably acceptable. The AVE (Average Variance Extracted) values of all the constructs are also above 0.5 indicating good Convergent Validity. Also, the AVE values for all the constructs are greater than the square of the respective correlations with the other constructs indicating good discriminant validity.

Thus the scales are tested for Validity and Reliability in our study. Our study is on the effect of GSCM attributes on Supply Chain Performance and hence Reduction of Pollutants. The results of our study indicate that a full-scale research could be conducted to study the above mentioned variables, which is to be carried out by the authors. Such a study could have several benefits. First it would establish GSCM practices as a source of operational and economic benefits for an organization and also for cleaner environment. It will also be a study among fewer number of studies conducted with an emerging economies' perspective.

7. Limitations and Direction for Further Studies

The study has been conducted based on the perceptions of respondents which is also a good way to study the variables even though it could be called a subjective approach to study the variables. A study based on variables with hard data could be called more objective. The data in our case has been collected by personal administration of the questionnaire. In case, electronic administration of questionnaire or some other means is introduced, there could be some bias due to common methods bias. There could also be some bias due to respondent's lack of knowledge while responding to the questionnaire.

As indicated earlier, this study forms a good base for a full-scale study on the above variables. Studies could also be in the direction of assessing GSCM Attributes on financial performance of the organization and also on the brand value and goodwill of the organization with the public. The scales could be tested for studies across industries and different countries.

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