EVALUATION OF GREEN SUPPLY CHAIN MANAGEMENT PRACTICES IN SMALL-SCALE FORGING INDUSTRIES

***Malleshappa T. Bhagawati, **Dr Milind Rohokale**

**Research Scholar, ** Research Supervisor,*

Department of Mechanical Engineering,

OPJS University, Churu, Rajasthan

ABSTRACT

Forging has traditionally been considered the backbone of the manufacturing industry. It is an important contribution to those sectors that support the nation's economic growth, such as: Automotive, industrial machinery, energy, construction and mining machinery, railways, and general engineering. The forging industry of the future will be energy efficient and will protect the environment. In the next century, the forging plant will be a zero environmental responsibility, making it an esteemed and responsible neighbor in its community. There is a need to improve the energy efficiency of the forging processes, thus reducing their environmental impact in a cost-effective manner.

Green supply chain management (GSCM) was emerging in recent years. This idea covers all stages of manufacturing from the first to the last stage of the life cycle, that is, from the design of the product to its recycling. The Green Supply Chain (GSC) is an important element of a green management strategy for the entire company. A Green supply chain will help the organizations to comply with the new guidelines for achieving the triple bottom line objectives (economic, social, and environmental)

The aim of this study is to examine the present green level of the forging industry in Pune and its surroundings. The focus of this investigation includes a review of the literature, in-depth interviews, and a questionnaire survey. This study assesses the environmental assessment of the small-scale forging industries to find the key factors of sustainable supply chain management and its relationship with organizational performance.

***Keywords**: -Green supply chain management, small-scale industry, Environmental assessment*

INTRODUCTION

Forging is traditionally considered the backbone of the manufacturing industry. It is a major input to the sectors which support the economic growth of the nation, such as Automobile, Industrial Machinery, Power, Construction & Mining Equipment, Railways, and General Engineering. The Indian forging industry is recognized worldwide for its technical capabilities. With an installed capacity of around 38.5 lakh MT, the Indian forging industry has the capability to forge a variety of raw materials such as carbon steel, alloy steel, stainless steel, super alloys, titanium, aluminum, and so forth, as per the requirements of the user industry.

Forging clusters in the western region include Pune, Mumbai, Rajkot, and Vadodara, with a total of 147 forged units.

Performance Highlights (Source:- Association of Indian Forging Industry(AIFI[1])

	Installed capacity(In Lakh MT.)	**Total Production (In Lakh MT.)**	**Total Production(In Rs Cr)**
Financial Year 2014-15	37.6	22.5	27,835
Financial Year 2015-16	38.1	22.8	28,289
Financial Year 2016-17	38.5	23.9	31,189

Forging Process-wise Total Installed Capacity: Open Die Forging(17%) Hot Closed die forging(63%) Cold Closed Die forging(07%) Ring Rolling(06%) & Other types (07%)

Pune in the state of Maharashtra is having one of the largest forging clusters in India. Most of the automobile industries are in Pune which include cars, trucks, tempos, tractors, two-wheelers, three-wheelers, and excavators. Major Automobile Companies in Pune and its surroundings include Tata Motors, Firodia group, Kinetic Motors, Mercedes, General Motors, Volkswagen, etc. These automobile industries need forged products such as Gears, Cams, Crown wheels, axles, Connecting rods, hubs, etc. All these forged products are manufactured by the forging units located in nearby Pune. The industries such as Food processing, Chemical, Ordinance, Sugar, and engineering Industries also need the forged products that are manufactured in the cluster. Nearly one-fourth of the country's forging units are located in Pune. 60-70% of the forged units are in the large-scale sector, while the remaining 30-40% of the forging units are in the small and medium sector.

There are around 50 forging units and about20 Heat-Treatment units located in Pune and its surroundings. Both these units are in Micro, Small, and medium-scale industries. These MSMEs provide employment opportunities for around 22000 people directly or indirectly.
It is estimated that the annual turnover of the forging MSMEs enterprises in Pune is approximately 500-600 Cr. Rupees. While the annual turnover of heat-treatment MSMEs is approximately 80-100 Cr. Rupees. The unit's production level is between 500-3500 tons per year (tpa). Due to the slowdown of the Indian auto market and the decline of exports caused by the economic recession in the United States and Europe, the recent production levels have shown a downward trend.[1]

Profile of Forging & Heat Treatment MSME's in Pune(Source:- Association of Indian Forging Industry(AIFI[1])

Category of the units	Numb er. of units	Size of Units			Production level of Units(TPA)			Total annual production(T)	
		Micro	Small	Medium	500-1000	1000-2000	2000-3500	2010-2011	2011-2012
Forging	50	5	35	10	10	25	15	120,000	80,000
Heat Treatment	20	--	13	07	05	15	-	40,000	28,000
Total	70	5	48	17	15	40	15	160,000	108,000

Today, the forging industry faces some specific challenges in terms of environmental sustainability and economy. Forging companies located in and around Pune need to pay greater attention to sustainable supply chain management. According to Gilbert (2001),[2] Green Supply Chain Management is the integration of environmental thinking in the management of the supply chain. Green Supply Chain Management adds a green component to Supply Chain Management (Srivatsava, 2007)[3] Zhu & Sarkis, 2007[4]defined the concept of GSCM in such a way that it covers all phases of the product's life cycle, from the design stage to the production and distribution phases, to the use of the products by the end-users, its elimination at the end of the product's life cycle

LITERATURE REVIEW

While recognizing the importance of applying the principle of GSCM to India's forging industry, particularly in the western region, the literature on GSCM was reviewed to find papers covering such studies. This section briefly describes the research features reported in these papers. Ashishkumar Bhateja et al.[5] (2011) explained different activities of Indian manufacturing organizations' supply chain processes. The authors found the green components which are involved in their supply chain processes from raw material purchasing to final product shipment. Pandya Amit and Mavani pratik[6] (2012) investigated the green supply Chain Management practices which are yet to be adopted in the pharmaceutical industry. They studied the relationship between green supply chain management practices and the environment. Further, they also studied Financial and Operational performance. Toke et al [7](2012) formulated an appropriate strategy during the implementation of GSCM practices in Indian organizations.

Sharad Chaturvedi and Deepak Talesara(2017)[8] studied the GSCM practices adopted by the textile industry. They concluded that there is a link between the status of the GSCM process and the ISO14001 certification obtained by the organization (Ru-Lin Lin et al, (2011)[9] used fuzzy set theory and decision-making trial and evaluation laboratory (DEMATEL) methods to discuss the criteria affecting the performance of the automotive industry. This hybrid approach evaluates its performance and finds key criteria that improve the green performance of manufacturers. Their research results show that the increase in the cost of purchasing environmentally friendly materials is the most

influential and important standard, and pollution control measures are the most effective standards. S. Janaki, R Jayachitra(2014).[10] From the above literature survey, it can be seen that India's forging industry needs to conduct research on environmental performance.

METHODOLOGY

This study involves the following methodology

a) Identification of the problem
b) Literature Review
c) Designing the Questionnaire for the survey
d) Conducting Interview for Forging Personnel
e) Collection of data
f) Analysis of the data by statistical package for social sciences (SPPS)
g) Determination of the present green level of forging companies

After going through the literature review, the questionnaire for the survey work was designed. Then permission was sought from the management of the small-scale forging companies for conducting an interview with forging personnel. The data was collected from the forging company personnel. The collected data was tested by using statistical methods. The association between Green Supply Chain Management (GSCM) and its environmental performance was obtained

The conceptual model for the components of Green Supply Chain Management (GSCM)(LR, GP, ED, GL, and RL) Environmental Performance and Supply Chain Performance is shown in below fig 1

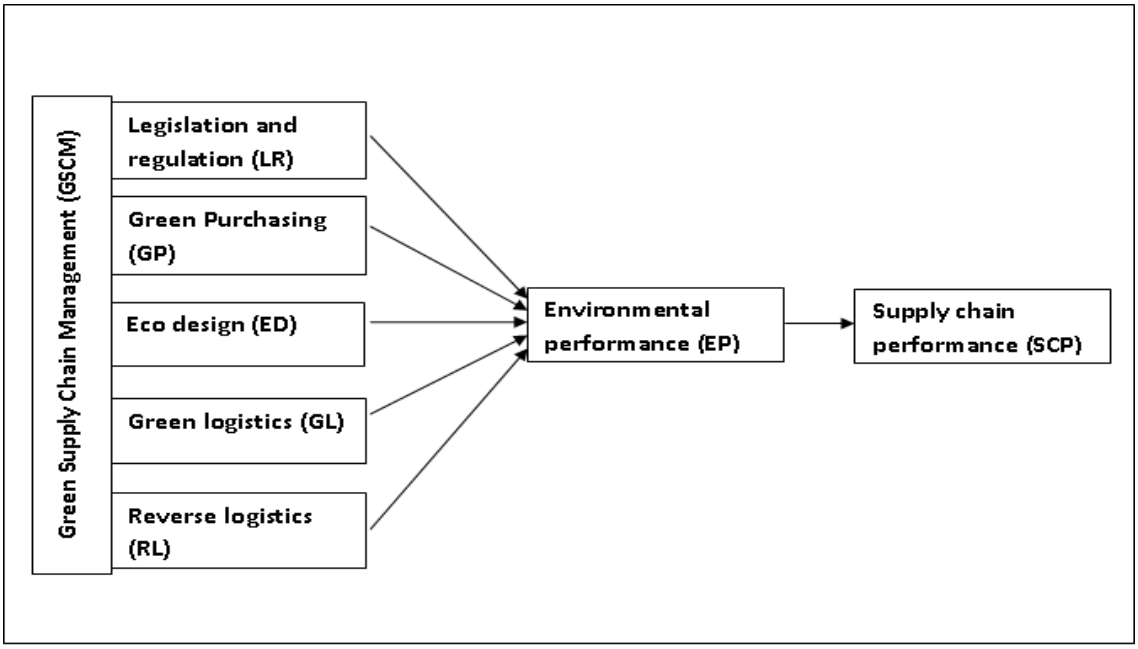

Fig1. Conceptual model for components of green supply chain management (GSCM) (LR, GP, ED,GL and RL), environmental performance and supply chain performance.

Hypothesis Setting

The hypotheses are formulated based on the objectives of the study.

H1: - Medium-scale enterprises are more likely to adopt Green Purchasing (GP) practices than small-scale enterprises.

H2: There is a significant difference between the mean ranks of dimensions of GSCM (LR, GP, ED, GL and RL).

H3: Legislation and Regulation (LR) is positively related to Environmental Performance (EP).

H4: Green Purchasing (GP) practices are positively related to Environmental Performance (EP).

H5: Green Logistics (GL) is positively related to Environmental Performance (EP).

H6: Reverse Logistics (RL) is positively related to Environmental Performance (EP).

H7: Eco-friendly design (ED) of collaboration in SMEs is positively related to Environmental Performance (EP).

H8: There is an interrelationship between various dimensions of GSCM (LR, GP, ED, GL, and RL), Environmental performance (EP), and Supply chain performance (SCP).

In the given sample data set, the P-value (Probability value) is the smallest level for which the null hypothesis is rejected (and the alternative hypothesis is accepted).

If the P-value $\leq \alpha$ then reject H0; otherwise accept H0. In general, α is taken to be 5% (0.05).

If the P value lies between 0.01 to 0.05 (i.e. $0.01 < P \text{ value} \leq 0.05$) then reject H0 at 5 % level of significance.

If the P-value ≤ 0.01 then reject H0 at 1 % level of significance.

If the P-value >0.05 then accept H0 at 5% level of significance.

In the entire study, the statistical significance has been labeled using asterisk (star) symbols; for ex: *P-value<0.05, **P-value<0.01, ***P-value<0.001. The non-significant P-values are labeled as NS (Statistically non-significant).

Structural Equation Modeling (SEM)

Structural Equation Modeling (SEM) is one of the multivariate statistical modeling tools which are widely used to investigate the independent determinants of the outcome variables of interest. Its estimation techniques, modeling capacities, and spectrum of application are expanding rapidly day by day. Structural Equation Modeling is a general term that describes large number of statistical models used to evaluate the validity of substantive theories, with empirical data. Statistically, it represents an extension of the Generalized Linear Modeling (GLM) procedure, such as the ANOVA and Multiple Regression Analysis. It is also used to study the relationships among latent constructs indicated by multiple measures. It is also applicable to experimental and non-experimental data, as well as cross-sectional and longitudinal data. In general SEM analysis goes through the steps of model specification, data collection, model estimation, model evaluation, and possible model modification.

RESULTS AND DISCUSSIONS

From Fig 2 and Table 1, the variables used for structural equation model are given below

Observed or Endogenous variables	Unobserved or Exogeneous variables
Legislation and Regulation (LR)	e1: Error term for Legislation and Regulation (LR
Green Purchasing (GP)	e2: Error term for Green Purchasing (GP)
Eco-friendly design (ED)	e3 : Error term for Eco-friendly design (ED)
Green logistics (GL)	e4: Error term for Green logistics (GL)
Reverse logistics (RL)	e5: Error term for Reverse logistics (RL)
Environmental Performance (EP)	e6: Error term for Environmental Performance (EP)
Supply chain performance (SCP)	e7: Error term for Supply chain performance (SCP)
	Green supply chain management (GSCM)

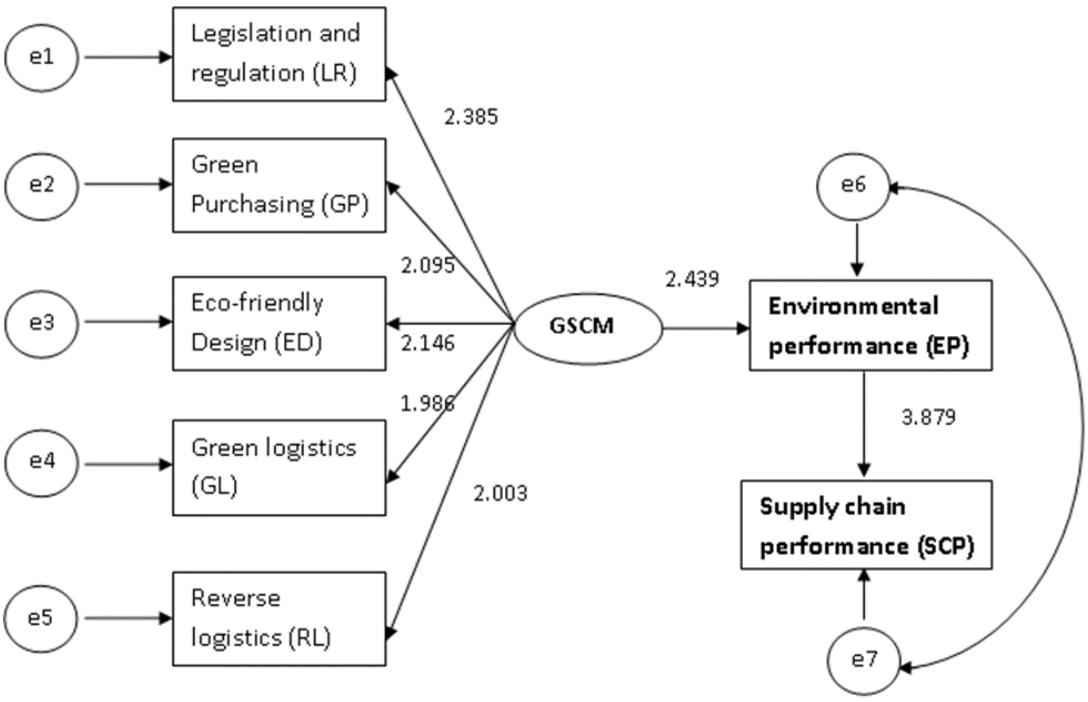

Fig2. Structural Equation Modeling on the impact of GSCM on EP and SCP

The distribution of statistical indices through Structural Equation Model (SEM) Analysis.

Variables			**Un-standardised co-efficient**	**S.E**	**Standardised coefficient**	**T-value**	**P-value**
	Direction of impact						
Legislation and regulation (LR)	←	GSCM	2.385	0.076	0.814	15.865	0.001***
Green Purchasing (GP)	←	GSCM	2.095	0.082	0.716	14.826	0.001***
Eco design (ED)	←	GSCM	2.146	0.077	0.795	15.123	0.001***
Green logistics (GL)		GSCM	1.986	0.085	0.703	14.463	0.001***
Reverse logistics (RL)	←	GSCM	2.003	0.089	0.709	14.736	0.001***
Environmental performance (EP)	←	GSCM	2.439	0.088	0.711	15.846	0.001***
Supply chain performance (SCP)	←	EP	3.879	0.074	0.899	18.911	0.001***

Note: ***denotes significance P-value<0.001 (Highly significant).

Variable details

Number of variables in the model: 15

Number of observed variables: 7

Number of unobserved variables: 8

Number of exogenous variables: 8

Number of endogenous variables: 7

In this study, a SEM model was tested and developed by exploring the relationship between GSCM, EP and SCP. The absolute fit of the dataset for the model test confirms that the model is stable. From the model, it is found that LR, GP, ED, and RL play an important role during the implementation of GSCM with the improvement in EP and SCP.

From Fig 2 and Table 1, the below interpretation has been made.

For legislation and regulations (LR) ; the standard co-efficient of GSCM is 2.385 which indicates that there will be little or partial effect of LR on GSCM, and the other variables are constant(fixed or adjusted)). The positive sign indicates positive effect. There will be increase of LR score by 2.385

which means that LR increases by 2.385 for each increase in GSCM score. The value of co-efficient is significant at 5% level.

For green purchasing (GP) , the un-standardized co-efficient of GSCM is 2.095, For eco-friendly design (ED) , the un-standardized co-efficient of GSCM is 2.146. For green logistics (GL), the un-standardized co-efficient of GSCM is1.986. For Reverse logistics (RL) , the un-standardized co-efficient of GSCM is 2.003, For environmental performance (EP), the un-standardized co-efficient of GSCM is 2.439, and finally , for supply chain performance(SCP), the un-standardized co-efficient of GSCM is 3.879.

From the structural equation model (SEM) analysis, it is seen that the unstandardized coefficient of environmental performance is maximum and indicates some partial effect of EP on SCP. And other variables are constant (fixed or adjusted). The positive sign indicates that it has positive effect and SCP would increase by 3.879 for each increase in EP score.

From Table 2, it is found that the calculated P value is 0.209, which is greater than 0.05, this indicates a perfectly fit model. Goodness of fit (GFI) value and adjusted goodness of fit (AGFI) value are greater than 0.09, and this represents a good fit to the sample data.

Structural equation model (SEM) fit summary.

Variable	Value	Suggested values
Chi-square	42.913	-
P value	0.209	>0.05
GFI	0.957	>0.90
AGFI	0.933	>0.90
CFI	0.969	>0.90
RMR	0.044	<0.08
RMSEA	0.033	<0.08

The calculated Comparative fit index (CFI) value is 0.969, which means that it is perfectly fitted, and that Root mean square residual (RMR) and Root mean square error of approximation (RMSEA) value, is less than 0.08 also indicating the perfect fit.[11,12, 13, 14, 15]

Decision Based on Statistical Analysis: We Reject Null Hypothesis (H0) and Accept Alternative Hypothesis (H1) at 5% Level of Significance (LOS).

CONCLUSION

Among the various dimensions of GSCM, the most influencing dimension is LR, which is then followed by ED, GP, RL, and GL. Green logistics has the minimum influence on GSCM. From this study, one can say that green supply chain management influences environmental performance which in turn has its impact on supply chain performance. The results from this study are helpful for manufacturing organizations for identifying an effective approach towards successful green supply chain management practices in SMEs.

The GSCM practices are mostly dominated by positively influencing some of the production system performances, particularly with the environmental compliances. The relationship between supply chain performance and the environmental performance in manufacturing sectors of SMEs was being evaluated from this study. The study further concludes that an environmental performance in manufacturing industries (SMEs) in Pune region positively influences the supply chain performances.

The Environmental Evaluation of Forging Industries which are in small scale sector in Pune and its surroundings was examined by means of a questionnaire survey. An attempt is being made to collect data from the forging industries in and nearby Pune. Then the statistical analysis was done from the data collected. This helps us to understand the present green level practices of the forging industries. From the analysis it is understood that there exists a closer relationship between Green supply chain management and its level of environmental performance. It is observed that the forging industries in Pune have little interest in the concept of green. Although the understanding and awareness of the environmental impact is positive, there are still many other obstacles in the forging industry. The government and forging industry should take some measures to change the prevalence of the current condition.

REFERENCES

1. Association of Indian Forging Industry (AIFI) www. indianforging.org

2.Gilbert, S (2001), "Greening Supply chain: Enhancing competitiveness through green productivity" Report of the top forum on enhancing competitiveness through green productivity held in Republic of China, 25-27 May 2000. ISBN 92-833-2290-8.

3. Srivastav, S. (2007) , " Green supply chain management: A state of the art literature review", International Journal of Management Review, Vol.9 No.1 , pp.53-80

4. Zhu, Q and Sarkis,J(2007), " The moderating effects of institutional pressures on emergent green supply chain practices and performances", International Journal of Production Research, Vol.45 No.18-19 4333-4355

5.Ashishkumar Bhateja, Rajesh Babbar, Sarbajith Singh and Anish Sachdev(2011), " Study of Green Supply Chain Management in Indian Manufacturing Industries: A literature Review cum an Analytical approach for the measurement of Performance",IJCEM International Journal of Computational Engineering & Management , Vol 13, pp 84-99

6.Pandya Amit R, Mavani Pratik M (2012), "An empirical study of green supply chain management drivers, practices and performances; with reference to The Pharmaceutical Industry of Ankaleshwar"(Gujrat) IJEMS, Vol3(3), pp 339-355

7.Toke L K, Gupta R C, Milind Dandekar(2012), " An Empirical study of Green supply chain management in Indian Perspective", International journal of Applied Sciences and Engineering Research Vol 1 No2.

8.Sharad Chaturvedi and Deepak Talesara (2017), "A Study of Green Supply Chain Management practices adopted by the Textile Industry of Pali district (Rajasthan)" International Journal of Economics & Management Sciences. Vol 6, Issue6 ISSN :2162-6359

9.Ru-Jen Lina, Rong-Huei Chen, Thi- Hang Nguyen(2011) , Green Supply Chain Management performance in automobile manufacturing industry under uncertainty", Procedia- Social and Behavioral Sciences,25, pp.233-245

10. S. Janaki, & R Jayachitra (2014), "Evaluation of Green Act in Small Scale Foundry Fragment, International Journal of Research in Engineering & Technology. ISSN 2321-7308

11.Hervani A A, Helms M M(2005) "Performance measurement for green supply chain management", Benchmarking International Journal 12(4): 330-353

12. Cronbach L J (1951) Coefficient alpha and the internal structure of tests. Psychometrika 16(3): 297-334.

13. Nunally JC (1978) Psychometric theory, 2nd edn Mc-Graw Hill , NewYork.

14. Gopal MH (1970) An introduction to research procedures in social sciences, Asia Publishing House Bombay.

15. Kothari CR(2004) Research Methodology Methods and Techniques, 2nd edn. New Age International publisher, New Delhi.