Analysis Of Barriers For Implementing Green Supply Chain Management In Small and Medium Sized Enterprises (SMEs) of India.

Nikunj K. Parmar

Abstract —Green Supply Chain Management (GSCM) is recent innovation for enhancing Supply Chain efficiency. The 'Green' component stresses upon the need of environment friendly Supply Chain by focusing on the reduction of waste. The requirement of GSCM in India has increased due to several factors including corporate responsibility, environmental & legislative reasons and competition. Nevertheless, many manufacturing firms in India have not adopted the GSCM yet. This study aims to find out the major barriers in implementing GSCM in Small and Medium scale Enterprises (SMEs) of India and rank them according to their effect. Barriers have been identified through literature review. A research questionnaire has been used to conduct primary data collection. Two Multi Criteria Decision Making tools, namely Interpretive Structural Modeling (ISM) and fuzzy Analytical Hierarchy Process (AHP), are used to rank different barriers. The results may help SMEs in establishing an economically and environmentally sound supply chain network.

Keywords —Barrier analysis, Fuzzy Analytical Hierarchy Process (AHP), Green Supply Chain Management, Interpretive Structural Modeling(ISM).

I. INTRODUCTION

ENVIRONMENTAL issues have become very important in present times due to their high level of visibility (Sanjeev Kumar et al.). To gain strategic advantages, it has become necessary to change traditional supply chain (Dileep More and Babu, 2008). Programs such as design for the environment, life cycle analysis, total quality environmental management, GSCM and ISO 14000 standards are popular for environmentally conscious practices (Olugu et al., 2011). Sustainable Supply Chain Management (SSCM) has been identified as an appropriate solution to balance environmental, social as well as economic benefits in supply chain (Luthra et al., 2014a, 2014b).

"Sustainable Development" was the key concept of the 1992 Earth Summit in Rio, as governments and international organizations committed themselves to take action to protect the environment as in integral part of long-term economic development (Ashish Kumar Bhateja et al., 2011).

Nikunj K. Parmar Pandit Deendayal Petroleum University, Gandhinagar, India

Organizational management is forced to incorporate the environmental management into corporate practices (Yang et al., 2010). Adding the green component to supply chain management involves addressing the influence and relationships of supply chain management to the natural environment (Ashish Kumar Bhateja et al., 2011).

Green Supply Chain Management (GSCM) has received more attention in the last few years in academia and industries (Arvind Jayant et al., 2014). Green Supply Chain Management (GSCM) basically aims to increase the amount of 'good' outputs, that are Product and Revenue generated and reduce the 'bad' inputs and outputs that are Raw material consumed, Energy utilized, Capital invested and Waste produced during the manufacturing process. The six major activities of GSCM are Green Sourcing & Procurement, Manufacturing, Warehousing, Distribution, Packaging and Transportation (Ashish Kumar Bhateja et al., 2011).

Small and Medium Sized Enterprises (SMEs) play a vital role in forming the economic foundation for the states of India. So, most Indian industries will have to develop supply chains from an environmental sustainability point of view by modifying traditional SCM to GSCM through initiation of green procurement strategies (Mudgal et al., 2010). During adoption of GSCM in traditional SCM, some hurdles can be anticipated due to the expected transition. These hurdles are called barriers and industries must equip themselves to remove them (Kannan Govindan et al., 2013). Although, no company would be able to eradicate all the possible barriers simultaneously some major barriers can be eradicated with GSCM. In present study, I have tried to find out the essential barriers by ranking them according to their effect on each other. 22 different barriers to GSCM have been identified through literature review. These barriers have been categorized into 5 different categories, namely Technology, Financial, Knowledge, Involvement & Support and Outsourcing. Two Multi Criteria Decision Making (MCDM) tools are used to rank the barriers as to get accurate result. These are, 1. Interpretive Structural Modeling (ISM) and 2. Fuzzy-Analytical Hierarchy Process (AHP).

ISM has been performed after listing down all the 22 major barriers from literature review. As an input, ISM takes the Structural Self Interaction Matrix (SSIM) of the barriers, which shows the contextual relationship among the variables. And as an output, ISM gives a hierarchical structure consisting

of the all 22 barriers in hierarchy according to their effect and importance. The hierarchy is made-up of several levels with arrows pointing upward. The barriers at the bottom are of most importance and leads to the other barriers which are in the higher levels. This gives an effective graphical representation of the level of importance of barriers.

Fuzzy AHP is the combination of Fuzzy logic and AHP. AHP is applied and the ranking is calculated after using the Fuzzy logic on the data collected. This method was carried out after gathering the data from the company officials of a Small and Medium Scale Enterprise. Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. AHP is a theory of measurement through pairwise comparisons and relies on the judgements of experts to derive priority scales. It is these scales that measure intangibles in relative terms. In result, this method gives the ranking of 22 barriers depending upon the response of a Supply Chain Management official.

II. LITERATURE REVIEW

There are a plenty of research papers available on the field on GSCM. But very few are on the topic of Barrier analysis in Indian firms. TABLE I shows 6 research papers which helped me the most in understanding GSCM and carrying out this research.

TABLE I
LITERATURES REVIEWED

No	Authors and paper titles	Description
1.	Arvind Jayant, Mohd Azhar, 2014. "Analysis of the barriers for implementing green supply chain management (GSCM) Practices: An Interpretive Structural Modeling (ISM) Approach"	Determine the relationship among the barriers in implementing GSCM in Indian industries using ISM and MICMAC analysis. 20 barriers have been found. 19 are linkage variables, 1 is driver variable. Lack of sustainability certification (ISO 14001), Cost of disposal of hazardous products have been identified as top level barriers and Lack of Government support as most dominant bottom level barrier.
2.	Ashish Kumar Bhateja, Rajesh Babbar, Sarbjit Singh, Anish Sachdeva, 2011. "Study of Green Supply Chain Management in the Indian Manufacturing Industries: A Literature Review cum an Analytical Approach for the measurement of performance"	To measure the Green component of performance. A GSCM Index having 17 Indicators & 33 Sub-Indicators. Many important findings and results i.e. Key Environmental Issues in Indian Manufacturing Sectors, Initiatives like Green sourcing & procurement, Green productions & mfg., Green warehousing & distribution, Green transportation, Collaboration with suppliers and/or customers on Green, Criteria for selection a vendor to support your Green, Barriers to adopting Green SCM practices.
3.	Helen Walkera, Lucio Di Sistob, Darian McBain, 2008. "Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors"	Identified the drivers and barriers to GSCM. They've considered Costs, management commitment, lack of buyer awareness, Lack of legitimacy in Internal barriers and Regulation, Poor supplier commitment, Industry specific barriers in External barriers.
4.	Kannan Govindan, MathiyazhaganKaliyan, DevikaKannan, A.N.Haq, 2013. "Barriers analysis for GSCM implementation in Indian industries using analytic hierarchy process."	Identifying the barriers in implementing GSCM in Indian industries based on procurement effectiveness. 47 initial barriers under five barrier categories namely Outsourcing, Technology, Knowledge, Finance and Involvement & Support were examined from literature and industrial discussion. Then they've used AHP and ranked all the barriers in their respective categories.
5.	Marjan Mohammadjafari, Reza Shokrizadeh, Majid Heidari, Saeed Parvaresh, 2014. "Study the Barriers of Green Supply Chain Management Implementation in Iranian Industries Using Analytic Hierarchy Process"	Essential barriers are identified through recourse to analytic hierarchy process (AHP). 20 barriers were identified under 5 categories and sent to 10 relevant experts who gave the pair wise comparison weight from Saaty's method of nine point scale values (1–9). This concluded that Iranian industries still struggle to prioritize environmental performance improvements over economic performance. However, they are interested in improving environmental performance.
6.	Sanjeev Kumar, Somnath Chattopadhyaya, Vinay Sharma. "Developing green supply chain system for Indian Enterprises"	To assess SCM in SMEs of India. Data collected through the Competitive Strategies and Best Practices Benchmarking Questionnaire from 119 SMEs. Measurement models of GSCM practices are compared by factor analysis. 14 factors were considered with 105 underlying statements in questionnaire. Cronbach's Alpha value was calculated.

TABLE II
22 BARRIERS IN 5 CATEGORIES WITH REFERENCE PAPER NUMBERS

Category	Barrier	Reference
Technology	T1. Lack of IT applications	[1]
	T2. Resistance to advance technology adoption	[1]
	T3. Lack of Technical expertise	[5]
	T4. Fear of failure	[5]
	T5. Lack of effective environmental measures	[5]
	T6. Complexity of design to reuse/recycle and reduce energy consumptions	[5]
Financial	F1. Cost Implication	[1], [8]
	F2. Non-availability of bank loans to encourage green product	[1], [8]
	F3. Cost of disposal of hazardous products	[1], [8]
Knowledge	K1. Lack of knowledge about green practice	[8]
	K2. Less awareness of customer about GSCM	[4]
	K3. Lack of environmental awareness to the supplier	[8]
	K4. Lack of awareness about reverse logistics adoption	[8]
Involvement & Support	InS1. Lack of corporate social responsibility	[8], [4]
	InS2. Poor organizational culture in adopting GSCM	[8]
	InS3. Lack of Top management commitment in adopting GSCM	[4]
	InS4. Market competition	[4]
	InS5. Lack of recycling and reuse efforts of organization	[1]
Outsourcing	O1. Lack of training courses about implementing GSC	[1]
	O2. Lack of government support to adopt GSCM	[1], [4]
	O3. Lack of sustainability certification (ISO 14001)	[1], [4]
	Pollution/Wastage in industries	[1], [4]

III. METHODOLOGY

A. Data Collection

The primary data was collected through the literature review. 22 different barriers were identified with 5 categories. This data was used in the Interpretive Structural Modeling to create a hierarchical structure of barriers. Then one questionnaire was sent to an official from the Supply Chain department of one Small and Medium Scale Enterprise to collect the response regarding the importance of barriers. This data was used to analyze the barriers with Fuzzy-AHP method.

B. Interpretive Structural Modeling (ISM)

Structural Self Interaction Matrix (SSIM), consisting the barriers, is created. Below mentioned notations are used to establish the relationship between the barriers.

> V- Barrier i will lead to barrier j
>
> A- Barrier j will lead to barrier i
>
> X- Barrier i and j will lead to each other
>
> O- Barrier i and j are unrelated

Create Reachability Matrix by writing '1' in the cell of which column barrier leads to the row barrier and '0' in the cell of which column barrier doesn't lead to the row barrier. Now prepare a "Reachability Set" for each of the row barrier. After preparing the Reachability Set, calculate the number of barriers in each set. Give the level number '1' to the barrier having the least number of barriers in set. Now remove the barrier number which has been given a level from each set. Again calculate the number of barriers in Reachability Set and give next level number to the barrier/s having least number of barriers in "Reachability Set". Some barriers will be given the same level in case of tie. The barriers are then arranged according to their levels from bottom to top and connected with the barriers in upper level. Fig. 2 shows the ISM constructed after the data analysis.

According to ISM, "Cost Implication" is the most affecting barrier to implementation of GSCM in Manufacturing firms of India.

C. Fuzzy-Analytical Hierarchy Process (Fuzzy AHP)

After getting a satisfying hierarchical structure, I and my mentor, Mr. T S Jaikishan, decided to continue the work further. After this, the data sheet was sent to the company official of Supply Chain Management department and response was recorded. This response is used to do further analysis by Fuzzy AHP. Response was taken in the form of 5 different notations, each having one significant value of Fuzzy triangle. Fuzzy triangular value is a set of three values indicating the Fuzzy Input matrix.
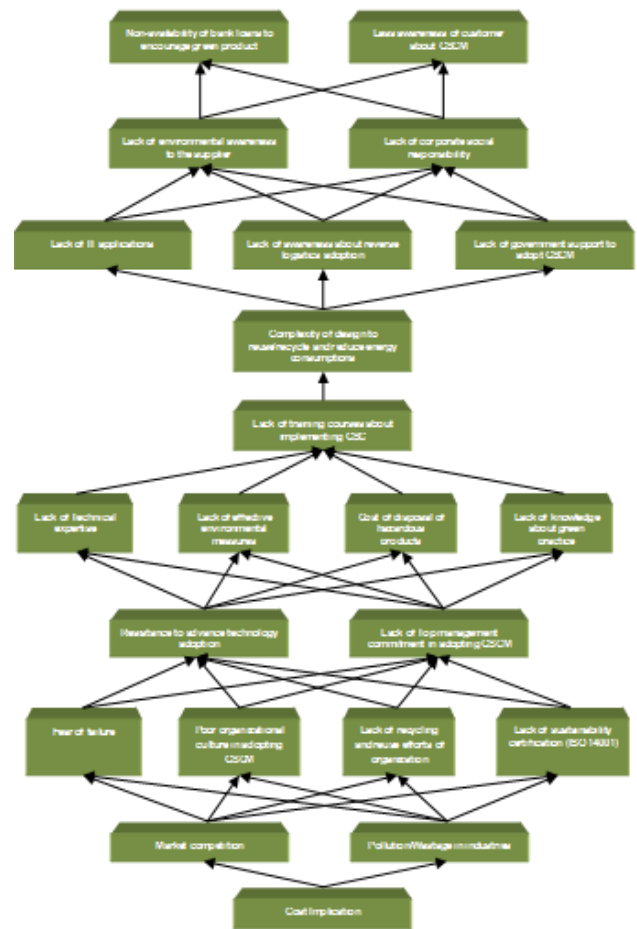

Fig. 2: Interpretive Structural Model

TABLE III
INPUT MATRIX

Description		Input matrix	Fuzzy Input Matrix
Very Low importance	(VL)	1	(0,1,3)
Low importance	(L)	2	(1,3,5)
Equal Importance	(E)	3	(3,5,7)
High Importance	(H)	4	(5,7,9)
Very High Importance	(VH)	5	(7,9,9)

TABLE IV
RESPONSE INPUT MATRIX OF CATEGORIES

Category Vs Category					
Cate.	Tech	Fin	Know	InS	Out
Tech	1	2	4	3	4
Fin	0.5	1	4	3	4
Know	0.25	0.25	1	2	2
InS	0.333333	0.333333	0.5	1	4
Out	0.25	0.25	0.5	0.25	1

TABLE V
RESPONSE INPUT MATRIX BETWEEN THE TECHNOLOGY BARRIERS

Technology Vs Technology						
Tech	T1	T2	T3	T4	T5	T6
T1	1	4	2	2	4	4
T2	0.25	1	4	2	5	4
T3	0.5	0.25	1	2	5	5
T4	0.5	0.5	0.5	1	5	5
T5	0.25	0.2	0.2	0.2	1	3
T6	0.25	0.25	0.2	0.2	0.333333	1

TABLE VI
RESPONSE INPUT MATRIX BETWEEN THE FINANCIAL BARRIERS

Financial Vs Financial			
Financial	F1	F2	F3
F1	1	4	5
F2	0.25	1	2
F3	0.2	0.5	1

TABLE VII
RESPONSE INPUT MATRIX BETWEEN THE KNOWLEDGE BARRIERS

Knowledge Vs Knowledge				
Knowledge	K1	K2	K3	K4
K1	1	5	4	3
K2	0.2	1	3	2
K3	0.25	0.333333	1	3
K4	0.333333	0.5	0.333333	1

TABLE VIII
RESPONSE INPUT MATRIX BETWEEN THE INVOLVEMENT & SUPPORT BARRIERS

Involvement & Support Vs Involvement & Support					
InS	InS1	InS2	InS3	InS4	InS5
InS1	1	2	2	2	2
InS2	0.5	1	3	2	3
InS3	0.5	0.333333	1	2	4
InS4	0.5	0.5	0.5	1	4
InS5	0.5	0.333333	0.25	0.25	1

TABLE IX
RESPONSE INPUT MATRIX BETWEEN THE OUTSOURCING BARRIERS

Outsourcing Vs Outsourcing				
Outs	O1	O2	O3	O4
O1	1	4	2	2
O2	0.25	1	2	2
O3	0.5	0.5	1	3
O4	0.5	0.5	0.333333	1

The TABLE IV to TABLE IX are the input matrices given by the company officials. The values in right upper triangular matrix are given the Fuzzy triangular value according to TABLE I. Then three matrices, 1. FUZZY A, 2. FUZZY B and 3. FUZZY C, are constructed for each matrix by splitting triangular values. These matrices are called Fuzzy Split Matrices. After this, the calculation is done.

If we take the values from first row of Fuzzy A as $a_{11}, a_{12}, a_{13}, \ldots, a_{1j}$, second row of Fuzzy A as $a_{21}, a_{22}, a_{23}, \ldots, a_{2j}$ and i^{th} row of Fuzzy A as $a_{i1}, a_{i2}, a_{i3}, \ldots, a_{ij}$.
Then the value in first cell of calculation matrix = $(a_{11}*a_{12}*a_{13}*\ldots*a_{1j})1/j$. This is how the values for Calculation matrix are calculated for each Fuzzy input matrix. Now a new matrix is formed by multiplying the calculation matrix value with the corresponding column sum value (TABLE X). The weights in this matrix are given by the formula : $((c-a)+(b-a))/3 + a$. The ranks are given from these weights. 1st rank is given to the category having the highest weight. Similarly we'll get the weights of barriers. But these weights will be the local weights of barrier. Now that we've got the weights of Categories, the overall weights of the Barriers are obtained by multiplying the local weights of Barriers with the weight of the corresponding category. These weights are known as BNP. Overall ranks are now given by BNP (Best NonFuzzy Performance) values. After doing these calculations, we get the final output as the ranks of different barriers and barrier categories. The ranks are given according to BNP values of different categories and barriers.

TABLE X
RANKING PROCEDURE OF CATEGORIES

Category Vs Category					
	a	b	c	Weight	Rank
Tech	0.3550961	0.483627	0.546036	0.461586	1
Fin	0.3798145	0.311646	0.286836	0.326099	2
Know	0.0786585	0.092058	0.088024	0.086247	4
InS	0.133131	0.080401	0.057508	0.090347	3
Out	0.0532999	0.032268	0.021596	0.035721	5

IV. RESULTS

In ISM structure, results show that "Cost Implication" is the most effective barrier from all the 22 barriers as it leads to the above leveled barriers.

Whereas in Fuzzy AHP method, the result includes the local and overall ranks of all the 5 categories and 22 barriers. Results are shown in below tables.

TABLE XI
RANKING OF TECHNOLOGY BARRIERS

Category	BNP	Rank
Tech	**0.46159**	**1**
T1	0.185397	2
T2	0.113847	3
T3	0.071785	4
T4	0.064528	5
T5	0.015936	13
T6	0.010093	16

TABLE XII
RANKING OF FINANCIAL BARRIERS

Category	BNP	Rank
Fin	**0.3261**	**2**
F1	0.252355	1
F2	0.046844	7
F3	0.0269	9

TABLE XIII
RANKING OF KNOWLEDGE BARRIERS

Category	BNP	Rank
InS	**0.09035**	**3**
InS1	0.027275	8
InS2	0.026026	10
InS3	0.016107	12
InS4	0.015884	14
InS5	0.005055	21

TABLE XIV
RANKING OF KNOWLEDGE BARRIERS

Category	BNP	Rank
Know	**0.08625**	**4**
K1	0.056602	6
K2	0.015359	15
K3	0.00871	17
K4	0.005577	20

TABLE XV
RANKING OF OUTSOURCING BARRIERS

Category	BNP	Rank
Outs	**0.03572**	**5**
O1	0.016692	11
O2	0.006541	19
O3	0.008173	18
O4	0.004314	22

Ranking of the barriers here shows the overall rank of that particular barrier. i.e. barrier F1 is having 1st rank among all

the 22 barriers. This shows that Cost Implication is most affecting barrier according to the Fuzzy AHP method.

V. CONCLUSION

Table XVI
BARRIERS ACCORDING TO THEIR RANKS

Rank	Barrier	Not-ation
1	Cost Implication	F1
2	Lack of IT applications	T1
3	Resistance to advance technology adoption	T2
4	Lack of Technical expertise	T3
5	Fear of failure	T4
6	Lack of knowledge about green practice	K1
7	Non-availability of bank loans to encourage green product	F2
8	Lack of corporate social responsibility	InS1
9	Cost of disposal of hazardous products	F3
10	Poor organizational culture in adopting GSCM	InS2
11	Lack of training courses about implementing GSC	O1
12	Lack of Top management commitment in adopting GSCM	InS3
13	Lack of effective environmental measures	T5
14	Market competition	InS4
15	Less awareness of customer about GSCM	K2
16	Complexity of design to reduce energy consumed	T6
17	Lack of environmental awareness to the supplier	K3
18	Lack of sustainability certification (ISO 14001)	O3
19	Lack of government support to adopt GSCM	O2
20	Lack of awareness about reverse logistics adoption	K4
21	Lack of recycling and reuse efforts of organization	InS5
22	Pollution/Wastage in industries	O4

TABLE XVI shows the barriers listed according to their overall ranks.

Results show that the categories of barriers affecting the most on the implementation of GSCM in Indian Small and Medium Sized Enterprises are "Technology" and "Financial" having rank 1 and 2 respectively. It reveals that Indian industries are unable to fulfill their economic needs and do not spend much for GSCM implementation. Hence, overcoming the barrier of "Cost Implication" is most important. The categories "Knowledge" and "Outsourcing" are the least affecting categories of barriers.

Comparing the results of both methods – ISM and Fuzzy AHP, most effective barrier is "Cost Implication" from all the 22 different barriers. However, many other barriers show somewhat different pattern in the output of both the methods. This maybe because of the difference in driving force of the method. i.e. ISM is based on the relationship between different barriers while the Fuzzy AHP considers the responses collected from the company official. These both input methods are different, hence the result may vary.

VI. FUTURE SCOPE

In this study, I have tried to rank all the barriers according to their effects and importance towards the implementation of GSCM.

During the collection of the responses from company official, I asked for further advice regarding the barriers. In reply to which he advised me to consider "Lack of Visibility" as a barrier. The major effect it causes is that it limits the proper flow of information and material resulting in poor coordination between certain departments. So for the future references, this additional barrier should be added to the list of the barriers along with the other barriers found from literature review. Students may apply the methods used in this study to identify the effect of this particular barrier on the GSCM of Small and Medium Sized Enterprises of India. MCDM tools have number of applications from which many can be applied to the research paper level as well as the academic level.

REFERENCES

[1] Arvind Jayant, Mohd Azhar (2014). "Analysis of the barriers for implementing green supply chain management (GSCM) Practices: An Interpretive Structural Modeling (ISM) Approach". *Procedia Engineering 97 (2014) 2157 – 2166*

[2] Ashish Kumar Bhateja, Rajesh Babbar, Sarbjit Singh, Anish Sachdeva (2011). "Study of Green Supply Chain Management in the Indian Manufacturing Industries: A Literature Review cum an Analytical Approach for the measurement of performance". *IJCEM International Journal of Computational Engineering & Management, Vol. 13, July 2011*

[3] Dileep More, A. and Babu, S. (2008) 'Prespectives, practices and future of supply chain flexibility', *International Journal of Business Excellence, Vol. 1, No. 3, pp.302–336.*

[4] Helen Walkera, Lucio Di Sistob, Darian McBain (2008). "Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors". *Journal of Purchasing & Supply Management 14 (2008) 69–85*

[5] Kannan Govindan, MathiyazhaganKaliyan, DevikaKannan, A.N.Haq (2013). "Barriers analysis for GSCM implementation in Indian industries using analytic hierarchy process". *2013 Elsevier B.V.*

[6] Luthra, S., Qadri, M. A., Garg, D., & Haleem, A. (2014a). "Identification of critical success factors to achieve high green supply chain management performances in Indian automobile industry." *International Journal of Logistics Systems and Management, 18(2), 170-199.*

[7] Luthra, S., Garg, D., & Haleem, A. (2014b). "Critical success factors of green supply chain management for achieving sustainability in Indian automobile industry". *Production Planning & Control, (ahead-of-print), 1-24.*

[8] Marjan Mohammdjafari, Reza Shokrizadeh, Majid Heidari, Saeed Parvaresh (2014). "Study the Barriers of Green Supply Chain Management Implementation in Iranian Industries Using Analytic Hierarchy Process". *The Open Access Journal of Resistive Economic (OAJRE)/Green Economics/ Volume 2, Number 12, 2014 Published Online July 20*

[9] Olugu EU, Wong KY, Shaharoun AM. (2011). "Development of key performance measures for the automobile green supply chain. Resources, Conservation and Recycling"*;55(6):567–79.*

[10] Sanjeev Kumar, Somnath Chattopadhyaya, Vinay Sharma. "Developing green supply chain system for Indian Enterprises". *Int. J. Business Excellence, Vol. X, No. Y, xxxx*

[11] Yang, C-L., Lin, S.P., Chan, Y-H. and Sheu, C. (2010) "Mediated effect of environmental management on manufacturing competitiveness: an empirical study". *Int. J. Production Economics, Vol. 123, No. 1, pp.210–220.*

Nikunj K. Parmar, is currently in his last semester of a 4 year B. Tech. program pursuing Industrial Engineering form Pandit deendayal Petroleum University, India. This particular research paper is his first research paper. His areas of interest revolve around Industrial Engineering including Supply Chain Management, Production Management, Operational Research, Industrial Management, etc. He is currently working on two projects in one of the Leading Manufacturer of Plastics Injection Moulding Machines & Blow Moulding Machines in India namely 1. Risk Assessment of the production, assembly and storage are; 2. Production time optimization using spaghetti tool in 4 different zones of the company.