Productivity Enhancement Through Green Supply Chain Initiatives- An Investigative Study

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Abstract

This study will examine the impact of economic, environmental, social, and technical factors in reverse logistics, as well as present a summary of significant drivers and barriers that have the potential to stimulate or deter enterprises from implementing reverse logistics methods. In the last half century, MSME sector has grown as a tremendously lively and competitive segment of the Indian economy. However, most research does not focus on this sector. To bridge this gap, this study identifies and evaluates the critical factors of Reverse logistics in the Indian MSME's. From a systematic literature review a list of critical factors in Reverse logistics were identified and a questionnaire was developed to conduct a survey in 36 Indian MSME's to assess their efficiency in Reverse logistics. Data Envelopment Analysis (DEA) methodology was applied to the data collected to identify the important Reverse logistics enablers and barriers. This methodology can also be used to assess the efficiency of the reverse logistics model, as well as to increase efficiency by altering critical factors. Key performance Areas such as Performance management system, Latest technologies, Volume of products, financial investment are the key performance inputs to be given more importance for the inefficient companies to become efficient. Awareness of Reverse logistics, Complexity of operation and third-party logistics are the output variables to be concentrated for the inefficient companies to match the benchmark companies. It can be further extended to other states and countries so as to make cumulative study among the region.

Keywords
Reverse logistics, Data Envelopment Analysis, Green supply chain, Sustainability and MSMEs.

1. Introduction
Due to increasing global competition, climate change, and government regulations, sustainability has become a top priority in most manufacturing companies worldwide (Vivek Gopi and Saleeshya PG 2022). The concept of incorporating environmentally friendly practises into the traditional supply chain is known as sustainable or green supply chain. The different aspects of Green Supply Chain Management(GSCM) are green purchasing, green manufacturing, green transportation, green distribution, green marketing and reverse logistics (Hervani et al. 2005). One of the major challenges faced in GSCM is the profitability in reverse logistics which involves End-of-life product collection, inspection and categorization, recovery procedure, lack of control over the volume, quality, and timing of returns are some concerns that needed to be addressed. The objective of this paper is to explore the current status of reverse logistics practises among different sectors through a survey-based study and to identify the critical factors (enablers and barriers) involved in implementing reverse logistics and finally doing the performance evaluation using the Data Envelopment Analysis (DEA) and benchmark the best practises of reverse logistics. This paper examines the role of economics, regulation, and corporate citizenship in reverse logistics and provides an outline of significant enablers and barriers that have the potential to incentivize or discourage firms from using reverse logistics practises.

2. Literature Review
GSCM refers to the integration of environmental thinking into supply chain management from raw material extraction to product design, manufacturing processes, delivery of final products to consumers, and end-of-life management (Srivastava 2007). The three pillars of sustainability of any system are Environmental, Economic and Social aspects which are called Triple Bottom Line (TBL). The two enablers Technology and Ethics are the foundation of sustainability (Molamohamadi and Ismail 2013) (Vinay Venugopal and Saleeshya PG 2019). In the academic community, GSCM has proven itself as a significant field and a distinct subject of sustainability. Since the last twenty years, GSCM research has exploded, but more understanding is still needed for future study. There are a number of prior research papers on GSCM (Soda et al. 2016). Some papers focus on the methodology of GSCM while the others concentrate on specific aspects and practices like green design, green manufacturing,

green purchasing, green transportation, green packaging, reverse logistics (Govindan et al. 2015b) (Soda et al. 2016) (Islam et al. 2018). In evaluating GSCM literature, few authors attempt to address broader aspects of the field as well as the confluence between green supply chain and sustainable supply chain (Fahimnia et al. 2015) (Srivastava 2007) (Malviya and Kant 2015). Among the green initiatives, green logistics garnered the least attention. While transportation systems have the biggest environmental impact, there is a lack of green logistics study on the topic. The lethality and risk of gas emissions from transportation has never surprised enterprises. It has been confirmed that the transportation industry alone is responsible for 15% of greenhouse gas emissions and 23% of CO_2 emissions, with a 45 percent rise in CO_2 emissions globally since 1990. It was then predicted that a further 40% increase would occur until 2030, jeopardising the health of all living things on the planet. As a result, firms might benefit financially in a variety of ways (Saada R 2021).

Reverse logistics is the management of a product's journey from the end user to the maker. Reverse logistics is a process in which goods are returned from customers to vendors or producers. Reverse logistics is required for activities such as returns and recycling after a client receives a product (Rogers 2001). Reverse logistics begins with the end user and works its way backwards through the supply chain to the distributor or from the distributor to the manufacturer. Product disposal via reverse logistics, such as recycling, refurbishment, or resale. Companies typically engage in reverse logistics because they feel that make profits by implementing it or they are socially forced to practise it. Reverse logistics implementation carry both direct and indirect gains. (Ravi 2005). Direct gains are the raw materials which can be used for new products and value added recovery option for some products which can be recycled and reduces the cost of manufacturing. Indirect gains are Green image for the organization and improved supplier and customer relations. Customers are rightfully authorized to return products in many countries, and regulation mandates that corporations be responsible for recovery as well. And, on occasion, businesses will participate in recovery programmes in order to maintain or develop a clean and green image (Reddy 2011).

MCDM methods are used in numerous sectors to address significant issues (Elomda et al., 2013; Ali et al., 2020a, 2020b). MCDM techniques have developed into a significant area of operative study during the past few decades (Figueira et al. 2004; Babar et al. 2020). Decision-makers in the modern day are now able to create efficient methods and decisions in the face of uncertainty thanks to MCDM methodologies (Nadaban et al.2016) (Ali et al. 2019a, 2019b). In the last three decades, Data Envelopment Analysis (DEA) has evolved into a sophisticated statistical, logical tool for measuring and evaluating productivity. DEA has been efficiently applied to a variety of enterprises engaged in a series of things in a variety of conditions all around the world. (Zhu 2011) DEA is a "data-oriented" method of assessing the performance of a group of fellow entities known as Decision-Making Units (DMUs), which translate numerous inputs into multiple outputs. A DMU is defined in a general and flexible manner. In recent years, a wide range of DEA applications for assessing the performance of various types of organisations engaging in many different activities in many different circumstances in many different nations have been seen. DMUs of various types have been practised in these DEA usages to evaluate the performance of units such as clinics, military operations, schools, cities and business firms as well as the performance of nations, areas, and other entities (Stefko Robert et al. 2018). DEA was created to deal with inputs and outputs (Norman and Stoker 1991). The efficiency of each DMU is evaluated in DEA utilising input-output data from several systems called DMUs (Decision Making Units). Specifically, it is a relative judgement based on the presented data rather than an absolute evaluation. Variable Returns to Scale (VRS model) is appropriate when all of the businesses aren't operating at full capacity. "The application of the CRS specification when not all enterprises are functioning at the optimal size, leads in measurements of TE that are confounded by scale efficiencies,". The usage of the VRS procedure allows TE to be calculated without these SE effects." The assumption in the CRS model can be relaxed (Banker et al. 1984) (Coelli et al. 2005).

3. Methodology

Detailed literature study:
Initially a detailed literature study was done to understand in depth about green supply chain management and its practices. The importance of GSCM and how it plays a major role in contributing to the sustainability was understood. The major gaps in GSCM practises was understood. The research question was: how to evaluate the effectiveness of implementation of GSCM in an industrial supply chain? The concepts involved in GSCM like green design, green manufacturing, green, transportation, green packaging and reverse logistics were reviewed.

Preliminary industry study:
After going through numerous literatures, we visited a pump manufacturing industry and studied the companies practises and the how the components are manufactured, assembled and delivered to the customers. We noted down our observations and found that reverse logistics process can be improved in the company. After checking

with managers and the industry professionals we understood that there are some uncertain factors when it comes to implementing reverse logistics.

Develop questionnaire and conduct survey:
After conducting the case study, it is important to conduct a survey to validate and diversify the scope of our study. Detailed literature study spotted light on various enablers and barriers in reverse logistics. A questionnaire was designed to find the significant enablers and barriers in context of Indian Micro, Small and Medium scale enterprises.

Do the performance evaluation:
After conducting the survey, it is essential to study the results obtained from the survey. It is done using a suitable model. Data Envelopment Analysis(DEA) is used to do the performance evaluation of the selected companies and benchmark the best practises.

3.1 Problem formulation
The DEA model can be classified into two: input-oriented model, output-oriented model. (Saleeshya P.G. and A. Subash Babu 2012). The phrase 'input-oriented' refers to a unit that can be made more efficient by reducing the proportions of its inputs while maintaining the proportions of its outputs. The phrase 'output-oriented' refers to a unit that can be made more efficient by raising the proportions of its output while maintaining the proportions of its input constant. We are utilising a DEA-input focused model in this work, which allows us to extract more input for a given output. The following model, as presented by Charnes et al. (1985, 1978) is employed in the current study's formulation. Different organisations have been designated as DMUs in this paper. These DMUs have many inputs (x_i) and outputs in common (y_r). Each DMU must deploy its resources in the most efficient way possible in order to achieve optimum efficiency. The best values of the weights provided to various inputs (v1, v2...) and outputs (u1, u2...) must be determined for this. The values for these weights will be determined by the model's answer. The goal of this approach is to increase the input by maintaining the output at a constant level, hence increasing the system's overall efficiency. The problem formulation in primal form is given below.

$$\text{Max} \sum_{r=1}^{m} u_r y_{rk} + c_k = 1$$

$$\text{Subject to} \sum_{r=1}^{s} v_i x_{ij} - \sum_{i=1}^{m} u_r y_{rj} - c_k \geq 0$$

$$\sum_{r=1}^{m} v_i x_i = 1$$

$$u_r v_i \geq 0$$

r=1, 2...., s

i =1, 2..., m

where,
s is the number of outputs
m is the number of inputs
u_r is the weight given to the rth output
v_i is the weight given to the ith input
y_r is the rth output
x_i is the ith input.
n is the number of companies
c_k is the measure of returns to scale

The Table.1 summarizes the inputs and outputs used for each aspect of sustainability considered in this study. It can be observed that there are 13 inputs and 10 outputs in total. In Table 2. the weights given to the Likert scale is tabulated.

Table 1. Classification of inputs and outputs based on aspects Sustainability

	Inputs	Outputs
Economic	Volume of products	Operational cost
	Financial burden of taxes	Cost saving and profit generation
	In-house facilities	
	Financial Investment	
	Inconsistent quality and quantity	
Environmental	Waste generation	Reduce of pollution and CO_2
	Company polices	Raw material dependence

Social	Motivational laws	
	Top level management support	Market value
		Awareness of Reverse logistics
		Competitive advantage
		Society
Technical	Lack of latest technologies	Complexity in Third party logistics
	Difficulty in supply chain members	Complexity of operations
	Limited forecasting and planning	
	Performance management systems	

Panagiotis Zervopoulos et al. (2011) proposed the following model for the weight scale utilised in this study. A weight of 0.1 was applied to the inputs and output criteria that were not applicable to the company.

Table 2. Likert scale weights

Likert scale	Rating	Range for weights
Very High	1	[0.9,0.8)
High	2	[0.8,0.6)
Normal	3	[0.6,0.5)
Low	4	[0.5,0.3)
Very Low	5	[0.3,0.2]

In this study Variable Returns to Scale(VRS) model is used because a different sector industries are considered. Hence traditional Constant Returns to Scale(CCR) model does not give us the ideal results. The weights are assigned based on the Likert scale ratings. VRS model is applicable when firms are not operating at an optimal scale.

4. Data collection

MSME stands for Micro, Small, and Medium Enterprises. This category includes start-ups and other business ventures with a limited budget and operations. MSME sector has evolved into a exciting and active section of India in the last fifty years. MSMEs not only assist to modernise rural and undeveloped regions, decreasing regional disparities and ensuring a more equal distribution of government income, but they also help achieve these objectives at a lower capital cost than major enterprises. MSMEs act as support units for larger businesses, and they contribute significantly to the country's socioeconomic development. Tamil Nadu does have the third-largest population of MSMEs in the country, with roughly five million businesses and an 8% stake. It also has the biggest number of non-farm units, accounting for almost 15.24 percent of India's micro-enterprises.

A survey was conducted by administering a questionnaire to collect data from thirty six(36) MSME's from various business sectors like pump manufacturing, valve manufacturing, foundries, battery manufacturing, Industrial machine manufacturing and spare parts manufacturing. We chose One of most suitable approach for conducting research from a big population seems to be surveys. (Wilson, 2014) and to test hypotheses. For collecting data, Dillman's (2000) non-experimental survey was used. The questionnaire consisted of three (3) sections of Twenty (20) questions that aimed at providing answers to the research questions. The first section (Part A) was designed to build the company profile of the participants. There were open-ended questions about name, phone number, and email address, as well as category questions about annual spending and the number of workers in the firm, along with other things. A mix of Likert-scale questions, closed-ended questions, multiple choice questions, and open-ended questions were used in the second (Part B) and third (Part C) sections to get the participants' opinions; closed-ended questions were used to limit the respondent to precise and potential answers so that a comparison study of descriptive explanations could be done easily; multiple choice questions were used to avoid overlap in the choices; and open-ended questions were used to pave way for lengthy answers where applicable. (Wilson, 2014). To produce replies from a wider spectrum of people and increase the respondents, a

multi-mode method was used — a combination of online and physical survey was used when conducting the survey. (Yun and Trumbo, 2000).

5. Results and discussion

Based on the responses from the survey. The data was consolidated and analysed using DEA and results were found. An example of the data from the survey is taken and given below in Table 3. and Table 4. for a sample case. The example taken here is a pump manufacturing company. It can be seen in Table 3. that only input 1 has a value of 0.2 and the other inputs have received a value of 0.8 which implies that the input 1 which is the volume of returned products is very less in the company. In the output data in Table 4. Output 1 which is the operational cost receives the most importance as it has more impact in the organization's performance and reverse logistics process.

Table 3. Sample Input data

DMU	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13
Company 1	0.2	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Table 4. Sample Output data

DMU	O-1	O-2	O-3	O-4	O-5	O-6	O-7	O-8	O-9	O-10
Company 1	0.9	0.5	0.3	0.5	0.1	0.5	0.5	0.1	0.1	0.1

The goal of this approach is to maximise the weighted total of company k's outputs. There are two limits to consider. To begin, firm j's weighted sum of inputs minus weighted sum of outputs must be greater than or equal to zero. Second, the weighted sum of firm k's inputs must equal one. In Excel Solver the objective function and constraints are entered and the input and output weights are found.

5.1 Numerical results

The ratio of the sum of a firm's weighted outputs to the sum of its weighted inputs is known as its efficiency (Thanassoulis et al.,2008). Efficiency is calculated to identify the benchmark companies. Table 5. shows the ranking and efficiency of the companies obtained using DEA.

Table 5. Efficiency of DMUs

DMU - (company no.)	Score	Rank
1,2,4,5,6,7,9,10,11,12,13,14,15,17,18,20,21,22,23,24,23,27,32,33,36	1	1
34	0.9693	2
19	0.9616	3
8,16	0.9518	4
3	0.9437	5
29	0.8975	6
26,18	0.8377	7
31,35	0.8372	8
30	0.7881	9

For each unproductive organisation, DEA locates the nearest productive enterprises on the frontier. The most efficient businesses are those that compare themselves to their peers and standards. If inefficient firms want to improve their performance, they need to look at what their rivals are doing. There are 25 companies with efficiency score of 1 and are ranked one. The remaining 11 companies have efficiency score less than 1 and are considered inefficient. Sample input and output weights assigned for company 36 using DEA analysis is shown in Table 6. and Table 7.

Table 6. Input weights sample

DMU	Score	v1	v2	v3	v4	v5	v6	v7	v8	v9	v10	v11	v12	v13
Company 35	0.84	0.02	0.00	0.00	0.20	0.00	0.59	0.00	0.20	0.00	0.00	0.00	0.00	0.00

Table 7. Output weights sample

DMU	Score	u1	u2	u3	u4	u5	u6	u7	u8	u9	u10
Company 35	0.84	0.00	0.00	0.00	0.10	0.00	0.24	0.00	0.00	0.00	0.00

5.2 Graphical results

In the 36 companies which were surveyed some of them were pump manufacturers, valve manufacturers, foundries, automobile spare parts manufacturers and heavy industrial equipment manufacturers.
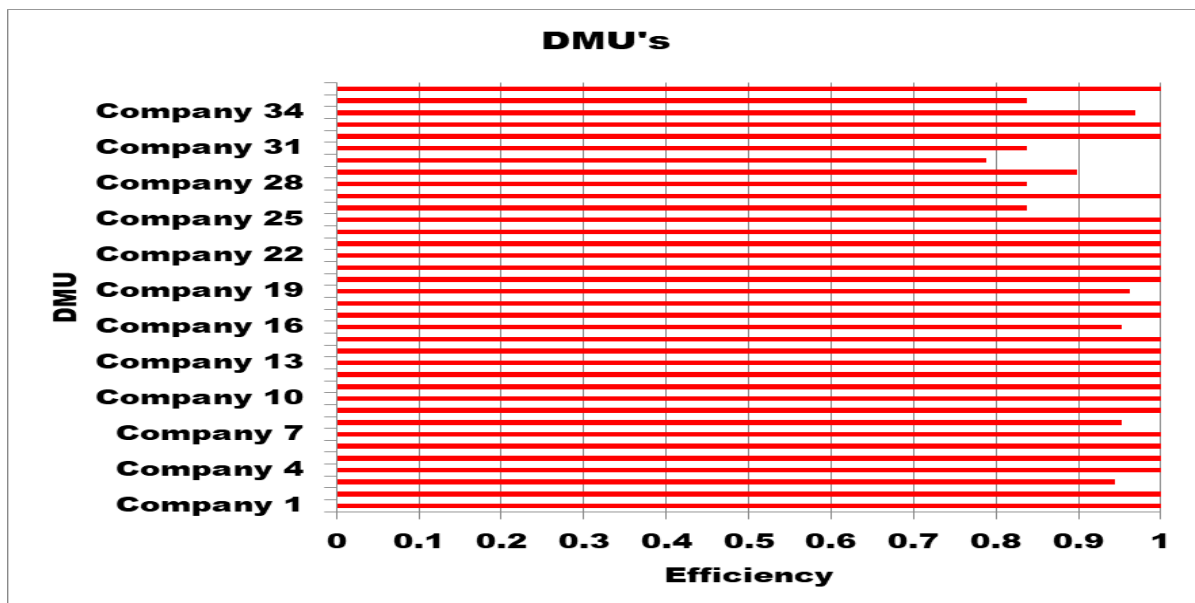

Figure 1. Efficiency graph

It can be observed from Figure 1 that Companies 30, 35 and 31 have the least efficiency scores. From weights assigned to the inputs and outputs it is clear that volume of products, financial investment in the economic aspect, waste generation in environment aspect, Top level management support and lack of awareness in social aspect and performance management system in technical aspect receive the highest weights and the companies which are inefficient can improve these areas so that they can perform well and become efficient like the benchmark companies.

5.3 Proposed improvements

It is evident from the results that financial investment plays an inevitable role when it comes implementing reverse logistics and MSMEs in that case face a tough time overcoming that obstacle. To bridge this gap either government can take some initiatives by providing relevant schemes and incentives for companies to implement reverse logistics practises so that the company can benefit from it through reduced costs and increase customer value and government can benefit from it through reduced raw material usage and preserving the environment. From our direct interaction with the top level management and employees in the industries it was clear that they practise only the repair aspect of reverse logistics and only the companies in pump manufacturing sector have implemented the remanufacturing and refurbishing practises to some extent. Initially when the respondents were questioned about reverse logistics, they were not sure what is it even though they were practising it. Hence they lack proper awareness regarding the long term benefits of reverse logistics. Proper training can be given to employees regarding the reverse logistics practises so that they can know the environmental benefits from it. As stated to establish a well-defined performance management system factors like financial investment and top level management support is essential. Hence all the factors are dependent on each other. MSMEs can initially start by

focussing on improving their waste management practises like proper disposal of scrap material and reusing the used products and slowly develop their reverse supply chain to become more efficient and productive among their competitors.

6. Conclusion and Future work

Among 36 companies surveyed and studied, 25 of them were found to be efficient and the rest 11 was inefficient. 14 of the companies were pump manufacturers and 6 of them can improve their reverse logistics practises to match the benchmark companies. Other sectors like foundries, battery manufacturing and spare parts manufacturing practise reverse logistics in an optimised way and function as benchmark DMU's. Key performance Areas such as Performance management system, Latest technologies, Volume of products, Financial investment are the key performance inputs to be given more importance for the inefficient companies to become efficient. Awareness of Reverse logistics, Complexity of operation and third party logistics are the output variables to be concentrated for the inefficient companies to match the benchmark companies. Sectors like valve manufacturing, and industrial equipment manufacturers can concentrate on the above mentioned factors and gain a competitive edge in the market.

This study was conducted and limited to around 36 Small and Medium Scale Enterprises (MSMEs) in Tamil Nadu. It can be further extended to other states and countries so as to make cumulative study among the region. It should be emphasised that this research had a restricted amount of time for data collection, hence the survey had a minimal number of respondents. Because this is a preliminary study, it aims to learn more about MSMEs' reverse logistics methods. In recent times we find that there is a rapid growth in electric mode of transportation, so focus on battery manufacturing and electric vehicles segment would be good extension to this study. With the limited time available we limited our study to only 36 companies, increasing the number of companies would more precise and yield better results.

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